Bijlage 1 Randomized controlled trials

(per paragraaf en onderwerp met hyperlinks)

Bijlage 1.1 Walking ability and mobility-related activities

RCTs investigating very early mobilization (paragraaf F.1.1)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Bernhardt et al 2008*	8	71 (38/33)	Age: 74.6±14.6 yr Type: first/rec isch/hem Time since onset: <24 h Inclusion: satisfied physiologic limits (systolic blood pressure 120-220 mm Hg, oxygen saturation >92% with or without supplementation, heart rate 40-100 bmp, temperature <38.5°), hospital admission <24 h, no detoriation <1 h of admission, no severe heart failure or lower limb fracture preventing mobilization	Comparison: Very early mobilization (VEM) vs. control (C) VEM: Mobilization as soon as practical, goal <24 h after onset. Additional mobilization with aim of assisting patients to be upright and out of bed (sitting or standing) at least twice a day. Physiologic monitoring of blood pressure, heart rate, oxygen saturation, temperature before each mobilization in the first 3 days post stroke. Delivered by nurse and PT first 14 days or until discharge. In addition to standard care (6 d/wk). C: Standard care (6 d/wk). Mobilization later than VEM, once a day. Intensity: VEM: early and 2x/d, during 2 wk (167, range 62-305 min). C: 1x/d, during 2 wk (69, range 31-115 min). Treatment contrast: 98 min.	Death (3 mos), serious adverse events (3 mos), falls (14 d, 3 mos), detoriation <7 d, Borg, time to first mobilization, mRS Measured at baseline and 7,14 d, 3, 6, 12 mos	VEM of patients within 24 hours of acute stroke appears safe and feasible.
Cumming et al 2008*	7	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	IDA, IDA subscales Measured at baseline and 7, 14 d, 3, 6, 12 mos	Very early mobilization may reduce depressive symptoms in stroke patients at 7 days post stroke.
Tay-Teo et al 2008*	8	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	Resource utilization, costs of resource Measured at baseline and 3 and 6 mos	These findings provide preliminary evidence that VEM is likely to be cost-effective.
Cumming et al 2009*	6	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	Time to first mobilization, amount of therapy, length of acute hospital stay, discharge destination, mRS Measured at baseline and discharge and 12 mos (mRS)	Early mobilization of patients with neglect was feasible and may contribute to a shorter acute hospital stay.
Sorbello et al 2009*	8	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	Time to first mobilization, amount of therapy, length of acute hospital stay, discharge destination, mRS Measured at baseline, 14 d, 3 and 6 mos	Interventions that promote recovery and reduce complications may consequently reduce length of stay.

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Langhorne et al 2010	8	EM: 32 (16/16) AM: 32 (16/16)	Age: median 64 (IQR 60-72) yr Type: first/rec isch/hem Time since onset: median 27.0 (IQR 24.5-29.8) h Inclusion: <24 h of admission, no full recovery, no severe comorbidities requiring close medical monitoring	Comparison: Early active mobilization (EM) vs. Automated monitoring (AM) vs. control (C) EM: Aimed to get patients up to sit, stand and walk within 24 h of stroke and continue this 4 times a day. In addition to standard care. AM: Protocol-driven approach to continuous monitoring, using ambulatory monitoring, routine monitoring continued for 3 days and could be extended to 7 days if physiological variables were unstable. In addition to standard care. C: Standard care, of multidisciplinary stroke unit, aiming to getting patients up to sit, stand and walk from day of admission, intermittent monitoring (every 4 h), mobilization by PT (30-60 min/d) and nurses. Intensity: ?? Treatment contrast: ??	Time to first mobilization, best level of mobilization activity achieved, physiological abnormalities, early medical complications and adverse events, patient activity, neurological detoriation, NIHSS, RMI, Borg, BI, mRS Measured at baseline and 5 d and 3 mos	We have demonstrated the feasibility of implementing EM and AM for physiological complications in a randomized controlled trial.
Tyedin et al 2010*	8	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	AQoL, AQoL independent living Measured at baseline and 12 mos	VEM may help improve long-term quality of life after stroke, particularly in relation to functional independence, but this requires further examination.
Cumming et al 2011*	7	71 (38/33)	See above, Bernhardt 2008.	See above, Bernhardt 2008.	Days required to return to walking 50 m unassisted, Bi, RMA Measured at baseline and 3 and 6 mos	Earlier and more intensive mobilization after stroke may fast-track return to unassisted walking and improve functional recovery.

RCTs investigating sitting balance (paragraaf F.1.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Dean et al 2007	8	12 (6/6)	Age: 60±7 yr Type: first Time since onset: 21±8 d Inclusion: <3 mos post stroke, no visual problems, MAS* item 3 (sitting balance) ≥3, reach intact arm 140% of arm's length, no left neglect	Comparison: Sitting training (E) vs. control (C) E: Exercises to improve sitting by reaching beyond arm's length using unaffected hand, with focus on smooth coordination of trunk and arm, appropriate loading of affected foot, prevent use maladaptive strategies. Varying distance, direction, thigh support, seat height and task. Progression by reach distance and number of repetitions. C: Sham sitting to improve attention, by completing 11 cognitive-manipulative tasks, supported in chair with back and armrests, forearms on table, workspace distance <50% arm's length. Progression by increasing number of repetitions and cognitive difficulty. Intensity: 10 sessions, 30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	Maximum reach distance, sitting quality, peak vertical force affected foot sitting, peak vertical force standing, 10MWT comf Measured at baseline and 2 wk and 28 wk (follow-up)	The sitting training protocol was both feasible and effective in improving sitting and standing up early after stroke and somewhat effective six months later.
Ibrahimi et al 2010	4	30 (15/15)	Age: >45 yr Type: ?? Time since onset: <3 mos Inclusion: MAS sitting 3, requires many attempts to stand unsupported for 30 s, ability to reach with intact arm distance equivalent to 140% of arm's length; no visual or sensory deficits	Comparison: Sitting training (E) vs. control (C) E: Sitting balance training under varied sensory input. Conventional PT, 1-3 sets of 10-15 reps. Sit on stool without backrest selected, individually standardized for each patient. Placed at distance of 140% of arm length of the wall on which a adhesive tape was placed at shoulder level. Sensory input provided in form of air filled pillows below the buttock as well as feet. Asked to touch marked line on wall in three directons: forward, 45° towards unaffected side and 45° across body towards affected side using unaffected hand. C: Sitting balance training as above without varied sensory input. Intensity: 20-30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	BBS, SSQOL, MAS Measured at baseline and 2 wk	Balance training can be started early in rehabilitation program once sitting is achieved with altered sensory input for improving balance and quality of life.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age + SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Dean et al. 1997	RCT	20 (10 / 10) able to sit unsupported for 20 min 19 completed the study (5% drop-outs)	mean: 67.6 y + 8.2 y	type: all chronic: mean 6.3 y + 4.4 y. after stroke	Yes	Intervention: evaluate the effect of a task-related training program to improve sitting balance: seated reaching beyond arm's length vs reaching within arm's length E: loading of affected leg while practicing reaching tasks using the unaffected hand to grasp objects located beyond arm's length C: received sham training. Subjects seated in a chair with arm and back support and forearms resting on a table. Manipulative tasks using the unaffected hand over small distances (< 50% of arm length) Intensity: Both groups received standardized training programs. Each program consisted of 10 sessions spread over a 2-week period	Maximum distance reached, hand movement time, %bodyweight while reaching, TMW, EMG measured after 2 weeks (end of treatment)	This study provides strong evidence of the efficacy of task-related motor training in improving the ability to balance during seated reaching activities after stroke	7 failure at the questions: 5,6,9
de Seze et al. 2001	RCT	20 (10 / 10) with static imbalance of trunk	mean: 65.6 y + 16 y	type: all postacute: mean 32 d. + 10d. after stroke	Yes	Intervention: comparing a technique based on voluntary trunk control during exploratory retraining vs conventional neurorehabilitation E: use of the 'Bon Saint Côme' device, a technique based on voluntary trunk control during exploratory retraining. A orthosis of the trunk supports a horizontal pole projecting with pointer over wearer's head. The patient pointed (guided by movement of the patients trunk) the targets in front of him. Visual and auditory signals provide feedback to the subject. Exercises initially performed in sitting position without laterally body shifting. Intervention during 1 hrs and also 1 hrs conventional rehabilitation C: conventional rehabilitation include a Bobath-inspired approach and functional therapy during 2 hrs Intensity: phase 1 (first 4 wk) 5d/wk 2 hrs rehabilitation and phase 2 (following 2 mo) both groups only conventional rehabilitation	SEI, UEI, TCT, MI, Ashworth Scale, FAC, Bells neglect test and FIM measured at 30d. and 90d. after start treatment	Voluntary trunk control retraining during spatial exploration with the Bon Saint Côme device appears to be a useful approach for rehabilitation of postural disorders in hemiplegic patients. Postural and neglect tests improved significantly more on day 30 in experimental group. The benefit remained at day 90. Gait improved earlier in experimental group. FIM scores improved equally.	6 failure at the questions: 3,5,6,9
Mudie et al.2002	RCT	40 (10/ 10/ 10/ 10) with asymmetry in sitting 33 (8/ 10 / 9/ 6) at 2 wk follow up (17% drop-outs) and 26 (6/8/7/5) at 16 wk follow up (totally 35% drop-outs in follow up)	mean: 72.4 y + 9 y, range 47-86 y	type: all subacute: mean 2-6 wk after stroke	Yes	Intervention: retraining sitting symmetry after stroke with 3 treatment groups and standard therapy vs a no specific control group E: E1) Monitored weight shift during seated reaching and attempted to return to a symmetrical position after reaching at balance performance monitor (BPM) during 30 s., visual feedback by coloured lights at a computer. E2) task-specific reach (max. 140% of arm length) to both sides with feet flat on the floor and E3) Bobath-training; verbally and manually facilitated by therapist during seated reaching C: the same standard PT and OT as did the 3 treatment groups received Intensity: 5d/wk, 30 min during 2 wk	Mean balance (percentage of total body weight), BI measured each treatment session and at 2 and 12 wk after ending treatment	These preliminary findings suggest that it might be possible to restore postural symmetry in sitting in the early stages of rehabilitation with therapy that focuses on creating an awareness of body position	5 failure at the questions: 3,5,6,8,9

Pollock et al. 2002	RCT	28 (9 / 19) ability of independent sitting for 1 min. and not able to achieve 10 steps 20 (5 / 15) completed the study (29% drop outs)	mean: 69.9 y. + 12.1y	type: all postacute: mean < 6wk after stroke	Yes	Intervention: additional independent practice of sitting balance and standard PT vs standard PT E: moving simple objects seated in chair with force-plates under the feet and in armrests. The objects to be moved with unaffected hand were colour-coded to match guidance lines drawn on the table placed in front the patient C: standard PT based on the Bobath-approach Intensity: 5d/wk during 4 wk	Symmetry of weight distribution during sitting, standing, rise to stand, sitting down and reaching measured at 4and 6 weeks after start intervention	There were no clinically significant differences in measured outcome between the groups. The regime of independent practice had no measured beneficial effect on the balance ability of patients with recently acquired stroke.	6 failure at the questions: 5,6,8,9

RCTs investigating sit-to-stand (paragraaf F.1.3)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Barreca et al 2004	6	48 (25/23)	Age: median 67 (IQR 56-72) yr Type: isch/hem Time since onset: 30 IQR 21-48) d Inclusion: CMMSA postural control ≥3, unable to safe and independent rise from sitting to standing (CMMSA stage 4 postural control item 3)	Comparison: Sit-to-stand (STS) vs. control (C) STS: STS practice sessions in groups of 6-7 participants. Standing from sitting from variety of different surfaces, attempted to complete 3 practice sets of 5 STS until class was over. In addition to regular therapy. C: Recreational therapy, remaining seated in wheelchair. Intensity: 45 min/d, 3 d/wk, during regaining independent STS or discharge. Treatment contrast: 714.15 or 0 min.	General health status satisfaction, QoL satisfaction, independent STS Measured at baseline and weekly till independent STS or discharge	This study supports the importance of repetitive practice in improving STS performance.
Britton et al 2008	4	18 (9/9)	Age: 68.4±13.3 yr Type: ?? Time since onset: 50.8±35.2 d Inclusion: STS with 'stand by' supervision without using hands, STS ≤3 in 10 s (MAS*), impaired upper limb function, not medically unfit	Comparison: Sit-to-stand (STS) vs. control (C) STS: Whole task practice of STS without using arms of support, with emphasis on technique: foot placement, speed, increase weight-bearing affected leg. Instruction and verbal feedback by PT assistant, balance performance monitor performed visual feedback. Aim to maximize number of STS. In case of fatigue strengthening exercises specific to muscle groups and range of movement used in STS. In addition to routine PT and OT. C: Routine PT and OT. Intensity: 30 min/d, during 1 wk. Treatment contrast: 2.5 h.	Time to stand, % weight through affected foot at thighs-off, number of attempts needed for three successful STS, number STS in 1 min Measured at baseline and 1 wk	Task-specific practice given for 30 minutes a day appears promising for patients learning to sit-to-stand.
Tung et al 2010	6	32 (16/16)	Age: 51.0±12.1 yr Type: first Time since onset: 26.9±16.0 mos Inclusion: BBS <50 independent sit-to-stand, no deep sensory deficits or hemineglect	Comparison: Sit-to-stand (E) vs. control (C) E: Sit-to-stand training, using an armless chair with backrest, with increasing difficulty a) regular floor, knee flexion 105°, b) regular floor, knee flexion 90°, c) regular floor, knee flexion 75°, d) spongy floor, knee flexion 105°, e) spongy floor, knee flexion 90°, f) spongy floor, knee flexion 75°. In addition to general PT programme (see below). Progression to next task if average time normal elderly was reached. C: General PT programme, including balance training, gait training, strengthening exercise lower extremities, ADL training (3 d/wk, 4 wk). Intensity: 15 min/d, 3 d/wk, during 4 wk. Treatment contrast: 3 h.	Static balance: weight distribution; Dynamic balance: maximal excursion, directional control, BBS, duration sit-to-stand; Strength: hip extensors, knee extensors, plantar flexors Measured at baseline and 4 wk	Additional sit-to-stand training is encouraged due to effects on dynamic balance and extensor muscles strength in subjects with stroke.
Varoqui et al 2011	6	23 (8/8/7)	Age: 57.49±10.54 yr Type: first Time since onset: 58.50±29.08 d Inclusion: <6 mos post stroke, stand-up without help or support during 60 s, no comorbidity affecting stance	Comparison: Standing balance (E) vs. Biofeedback non affected leg (naBFB) vs. BFB affected leg (aBFB) E: Stand-up task. naBFB: Stand barefoot 3.5 m from projection screen. Keep knees extended, toes and heels in constant contact with floor. Reproduce with body the postural pattern projected on the screen (0° and 180°) with help of customized postural coordination biofeedback system of *non affected leg* by performing ankle and hip flexion-extension movements in sagittal plane, frequency of movements was free. 0°: 4 sessions, during 2 wk. 180°: 4 sessions. aBFT: Like naBFB, but with biofeedback of the *affected leg*. Intensity: 15 min/d, during 2 wk. Treatment contrast: 0 h.	Muscle strength, MAS, PASS, BBS, FAC, FIM Measured at baseline and 28 d	Results suggest that (re)learning the in-phase pattern is possible and seems to improve independence in poststroke patients. (in-phase: ankle-hip relative phase close to 0o for movements of small amplitude and/or executed at low frequency, with tow joints oscillating simultaneously in the same direction; Anti-phase: with ankle-hip relative phase of about 180o for movements of high amplitude and/or executed at high frequency, with joints moving in opposite directions)

RCTs KNGF-guideline 2004

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age ± SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Engardt et al. 1993	RCT	42 (21 / 21) able to stand up independently 40 patients completed the study (5% drop-outs)	mean: 64.9 y. ± 7.9 y.	type: all post-acute: mean 38 d. ± 20 d. after stroke	Yes	Intervention: ground reaction force feedback and PT vs PT while sitting down and rising E: auditory feedback to achieve symmetrical weight bearing while rising and sitting down on balance platform plus conventional PT. C: conventional PT according to MRP-principles EMG/BF-characteristics: Intensity: 3 sessions/d., 15 min 5d/wk for 6 wk.	BI, FMA, MAS and BWD measured after 6 wk	Improvements in physical performance and sit-to-stand tests were greater in experimental (feedback) group. No differences between groups were seen in improvement in performance of daily living.	5 failure at the questions: 3,5,6,7,9
Engardt 1994 (follow-up)	RCT	30 (16 / 14)	mean: 66 y.	33 mo since end of training		-	measured after an average of 33 mo.	The relearned symmetric BWD with auditory feedback had lost in rising as well as in sitting down. Movement time in rising and sitting down, however, was improved	-
Dean et al. 1997	RCT	20 (10 / 10) able to sit unsupported for 20 min 19 completed the study (5% drop-outs)	mean: 67.6 y ± 8.2 y	type: all chronic: mean 6.3 y ± 4.4 y. after stroke	Yes	Intervention: evaluate the effect of a task-related training program to improve tasks including sit to stand vs sham therapy E: loading of affected leg during sit to stand C: received sham training. Intensity: Both groups received standardized training programs. Each program consisted of 10 sessions spread over a 2-week period	Maximum distance reached, hand movement time, %bodyweight while reaching, TMW, EMG measured after 2 weeks (end of treatment)	Subjects significantly increased the load taken trough the affected foot when standing up from sitting	7 failure at the questions: *5,6,9*
Dean et al. 2000	RCT	12 (6 / 6) able to walk 10m. independently with or without assistive device 9 (5 / 4) completed the study (25% drop-outs) 8 (4 / 4) com-pleted follow-up	mean: 64.3 y ± 7.2 y	type: all chronic: mean 1.8 y ± 0.8 y. after stroke	Yes	Intervention: evaluate the immediate and retained effects of a training program on the performance of locomotor-related tasks in chronic stroke E: practice at a series of workstations (strengthen the muscles of affected leg) as well as participating in walking races and relays with other members of the group. C: same workstation training, but training was designed to improve function of the affected upper limb and was considered 'sham 'lower limb training Intensity: 3d/wk for 1 hrs during 4 wk	TMW, 6 minute walk, TUG, step test and sit-to-stand measured at 4 wk and 2 mo after the training (follow-up)	The experimental group demonstrated significant immediate and retained (2-month follow-up) improvement compared with control group in walking speed and endurance, force production through the affected leg during sit-to-stand and the number of repetitions of the step test.	5 failure at the questions: *5,6,7,8,9*
Cheng et al. 2001	RCT	54 (30 / 24) could stand up independently and walk with or without a cane	mean: 62.7 y. + 7.9 y	type: all postacute: mean 2.8 mo + 1.3 mo after stroke	Yes	Intervention: additional balance training + conventional therapy vs conventional therapy E: while rising to stand and sitting down the mean symmetry of weight distribution is measured by force plates under the feet. Rising to stand and sitting down were divided into 2 distinct phases: the seat-on and seat-off phases. C: conventional stroke rehabilitation including neuromuscular facilitation, FES, mat exercises and other therapeutic exercises. Intensity: 5d/wk for 30 min during 3 wk	Body-weight distribution, postural sway of CoP, time needed to rise and sit and occurrence of falls measured at 3 wk and at follow-up (6 mo)	Symmetrical body-weight distribution training may improve sit-to-stand performance and, consequently, decrease the number of falls by stroke patients	6 failure at the questions: 3,5,6,9

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age ± SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Pollock et al. 2002	RCT	28 (9 / 19) ability of independent sitting for 1 min. and not able to achieve 10 steps 20 (5 / 15) com-pleted the study (29% drop-outs)	mean: 69.9 y. + 12.1y	type: all postacute: mean < 6wk after stroke	Yes	Intervention: additional independent practice of rising to stand and sitting down and standard PT vs standard PT E: moving simple objects seated in chair with force-plates under the feet and in armrests. The objects to be moved with unaffected hand were colour-coded to match guidance lines drawn on the table placed in front the patient C: standard PT based on the Bobath-approach Intensity: 5d/wk during 4 wk	Symmetry of weight distribution during sitting, standing, rise to stand, sitting down and reaching measured at 4 and 6 weeks after start intervention	There were no clinically significant differences in measured outcome between the groups. The regime of independent practice had no measured beneficial effect on the balance ability of patients with recently acquired stroke.	6 failure at the questions: 5,6,8,9

RCTs investigating standing balance (paragraaf F.1.4)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Morioka et al 2003	6	26 (12/14)	Age: 62.6±13.3 yr Type: first/rec isch/hem Time since onset: 65.4±18.6 d Inclusion: hemiplegia, standing maintenance was becoming independent; no higher brain dysfunction, dementia	Comparison: Perceptual learning (E) vs. control (C) E: Perceptual learning exercise to discriminate hardness of sponge rubber placed under sole of the foot while standing. Three 30-cm square rubbers (5, 10, 15 mm) with hardness of resp. 2425 nM, 1875 nM, 1500 Nm in random order. Verbal feedback. In addition to PT and OT (see below). C: PT and OT, including ordinary postural control exercises. Intensity: 10 d, during 2 wk. Treatment contrast: ??	Postural sway (eyes open and closed) Measured at baseline and 2 wk	The plantar perception exercise used as a method in this study is considered to be effective as a supplemental exercise for standing balance.
Bagley et al 2005	8	140 (71/69)	Age: 75.8±11.5 yr Type: first/rec Time since onset: 19.5±12.1 d Inclusion: sit in chair >30 min, GCS ≥11	Comparison: Standing frame (E) vs. control (C) E: Standing in Oswestry standing frame. Additional therapy as required. C: Treatment without Oswestry standing frame, but tilt table was available if required for safe handling. Centered around Bobath approach, but also including task-specific techniques. Intensity: during 14 d. Treatment contrast: 0 h.	RMI, BI, HAD anxiety, HADS depression, NEADL, RMA, MAS* balanced sitting, MAS* sitting to standing, TCT, resources Measured at baseline and 6 wk and 3 and 6 mos (follow-up)	Use of the Oswestry standing frame did not improve clinical outcome or provide resource savings for this severely disabled patient group.
Bayouk et al 2006	4	16 (8/8)	Age: 68±7.1 yr Type: ?? Time since onset: 7.1±12.5 yr Inclusion: >6 mos post stroke	Comparison: Exercise (E) vs. control (C) E: Exercise class with main objective to strengthen the hemiparetic side by practice of functional exercises, secondary objective to improve balance, gait and coordination. 10 tasks, with no. 1-5 performed under normal conditions (20 min) and no. 6-10 with manipulation of proprioception of feet and ankles and/or vision: 1) eyes open, firm surface (i.e. foam mat), 2) eyes open, soft surface, 3) eyes closed, firm surface, 4) eyes closed, soft surface; progression by increase number of repetitions, height of exercise step and ankle weight (30 min). Cool-down period with flexibility, ROM exercises in seated position with focus on quadriceps, hamstrings, hips, lower and upper back, and neck; 10 min). C: Same exercises but with eyes open and on a hard regular surface. Intensity: 1 h/d, 2 d/wk, during 8 wk. Treatment contrast: 0 h.	Postural sway during double-legged stance for 10 s and sit-to-stand from a chair, 10MWT max Measured at baseline and 8 wk	A task-oriented exercise program, assisted by sensory manipulation, is more effective at improving the standing balance of stroke subjects than a conventional task-oriented program.
Allison et al 2007	7	17 (7/10)	Age: 72.4±17.9 yr Type: ?? Time since onset: 20.6±20.5 d Inclusion: no unstable comorbidity	Comparison: Standing practice (E) vs. control (C) E: Standing practice, typically involving use of either standing frames, tilt tables or standing at tables to provide support when enabling standing to occur, encouraged to be active while standing, practicing reaching tasks, sit-to-stand movements. Rest periods as necessary. In addition to conventional physiotherapy, including strengthening, improving movement, mobility, and upper limb function (45 min/d, 5 d/wk). C: Conventional physiotherapy (see above). Intensity: 45 min/d, 5 d/wk, during 2 wk. Treatment contrast: 450 min.	RMA GF, TCT, BBS Measured at baseline, 1 and 2 wk and 12 wk (follow-up)	A larger study is required to establish the value of additional standing practice after stroke. This pilot demonstrates that the RMAg and BBS would be useful in such a study. Fatigue may be a significant barrier to ability to participate in more intensive porgrammes so screening participants for severe fatigue may be useful.

RCTs investigating balance with visual feedback from a forceplate (paragraaf F.1.5)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Chen et al 2002	3	41 (23/18)	Age: 58.70±10.19 yr Type: first Time since onset: 3 mos Inclusion: no severe spasticity, orthopedic/ peripheral neuropathy, visual field or hemineglect problems	Comparison: Balance platform (E) vs. control (C) E: Visual feedback training with SMART Balance Master, encouraged to maintain posture steadily and symmetric weight bearing while adapting to different static sensory conditions through verbal or tactile cues. Practice controlling weight shifts by tracing moving targets on screen in every main direction within 50% of limits of stability. In addition to conventional therapy (see below). C: Conventional therapy, PT, OT, including muscle strengthening, therapeutic exercise, ADL training. Intensity: 20 min/d, 5 d/wk, during 2 wk. Treatment contrast: 200 min.	FIM, static stability, dynamic stability Measured at baseline and 6 mos (follow-up)	Dynamic balance function of patients in the visual feedback training group had significant improvements when compared with the control group. ADL function in self-care also had significant improvements at 6 months of follow-up in the trained group.
Kerdoncuff et al 2004	4	25 (11/14)	Age: 60±17 yr Type: first isch/hem Time since onset: 44.1±21.2 d Inclusion: stand without help ≥51.2 s, <3 mos post stroke; no comorbidity affecting balance, severe bilateral visual deficits	Comparison: Balance platform (E) vs. control (C) E: Visual biofeedback with progression per week if possible. Wk 1: stabilization exercises; wk 2: transferring center of pressure; wk 3: postural control exercises. In addition to traditional training, including spasticity reduction, motor facilitation, balance with open and closed eyes, stable and instable plinth, walking (30 min). C: Traditional training (see above). Intensity: 2x/d, 15-20 or 30 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	10MWT, Orgogozo (neurological), FMA balance, number of walkers, walking distance, number of patients able to walk stairs, BI, FIM Measured at baseline and 3 wk	The use of biofeedback training incorporated into functional physiotherapy affords added benefits probably by a best integration of proprioceptive information.
Heller et al 2005	4	26 (13/13)	Age: 69.46±6.97 yr Type: isch/hem Time since onset: 24.85±10.91 d Inclusion: little voluntary movement lower extremity and/or sensibility problems; no correct use legs at admission, previous stroke other side, Parkinson, Alzheimer, orthopedic or rheumatic disease lower extremity, lumbar deformity, poly-pathology, severe neglect	Comparison: Biofeedback (BF) vs. control (C) BF: Use of visual biofeedback with a force plate system (BPM Monitor SMS Healthcare), start with static stance with feet on same level. Followed by lateral weight shifts. Start BF when patient could walk 10 m with or without assistance or aid. In addition to conventional therapy (see below). C: Conventional therapy based on NDT (2x/d, 1.5 h). Intensity: 30 min/d, during 30 d. Treatment contrast: 900 min.	FMA, MAS, PASS, FIM, FAC, gait variables Measured at baseline, when the patient could walk 10 m with or without assistance/ aid and 30 days later	Both groups demonstrated improvement in the rehabilitation unit. The benefits of visual biofeedback by force plate system training suggest particular improvement of anticipation equilibrium with conventional therapy.
Yavuzer et al 2006	6	41(22/19)	Age: 59.8±11.6 yr Type: first isch/hem Time since onset: 11.1±24.6 mos Inclusion: ability to stand with or without assistance and take ≥1 step with or without assistance; no medical contraindication walking, conditions affecting balance, neglect	Comparison: Balance training (E) vs. control (C) E: Balance training using Nor-Am Target Balance Training System with dual force plate and visual representation of person's center of gravity in standing stability mode with maintain or shifting weight in sagittal and frontal plane as appropriate. Exercise with eyes open, support devices or personal assistance when needed. In addition to conventional rehabilitation, consisting of NDT/PNF/Brunnstrom movement techniques, PT (positioning, ROM, progressive resistive exercise, endurance, walking, ADL, postural control), OT, speech therapy (2-5 h/d, 5 d/wk, during 8 wk). C: Conventional rehabilitation (see above). Intensity: 15 min/d, 5 d/wk, during 3 wk. Treatment contrast: 3.45 h.	Walking speed comf, cadence, step length, single-support time, step length asymmetry ratio, single-support time asymmetry ratio, kinematics Measured at baseline and 3 wk	Balance training using force platform biofeedback in addition to a conventional inpatient stroke rehabilitation programme is beneficial in improving postural control and weight-bearing on the paretic side while walking late after stroke.
Eser et al 2008	5	41 (22/19)	Age: 59.8±11.6 yr	Comparison: Balance training (E) vs. control (C)	Brunnstrom stages, RMI, FIM	In our group of stroke patients, balance

[= Yavuzer et al 2006]			Type: first isch/hem Time since onset: 11.1±24.6 mos Inclusion: ability to stand with or without assistance and take ≥1 step with or without assistance, no medical contraindication walking, no conditions affecting balance, no neglect	E: Balance training using Nor-Am Target Balance Training System with dual force plate and visual representation of person's center of gravity in standing stability mode with maintain or shifting weight in sagittal and frontal plane as appropriate. Exercise with eyes open, support devices or personal assistance when needed. In addition to conventional rehabilitation, consisting of NDT/PNF/Brunnstrom movement techniques, PT (positioning, ROM, progressive resistive exercise, endurance, walking, ADL, postural control), OT, speech therapy (2-5 h/d, 5 d/wk, during 8 wk). C: Conventional rehabilitation (see above). Intensity: 15 min/d, 5 d/wk, during 3 wk. Treatment contrast: 3.45 h.	Measured at baseline, 1, 2 and 3 wk	training combined with a conventional rehabilitation program does not provide additional benefit in terms of lower extremity motor recovery, mobility and activity level.
Gok et al 2008	6	30 (15/15)	Age: 55.1±11.4 yr Type: first isch/hem Time since onset: 460.0±90.4 d Inclusion: ability to stand without assistance ≥1 min, no condition affecting balance, no neglect, no impaired vision, no medical contraindication to exercise	Comparison: Kinaesthetic ability trainer (KAT) vs. control (C) KAT: Stand with boot feet on feedback platform without holding on to handrails, shift weight forward, backward, left or right in order to keep cursor on monitor central (static pattern) or follow moving cursor (dynamic pattern). In addition to conventional stroke rehabilitation consisting of NDT techniques, PT, OT and speech therapy (2-3 h/d, 5 d/wk, 4 wk). PT focused on positioning, postural control, ROM and progressive resistive exercises, endurance, gait in which elements of Brunnstrom's movement therapy, Bobath NDT and PNF techniques were combined. C: Conventional stroke rehabilitation (see above). Intensity: 20min/d, 5 d/wk, during 4 wk. Treatment contrast: 400 min.	FIM motor, FIM locomotion, FMA leg, FMA balance, KAT balance index static, KAT balance index dynamic Measured at baseline and 4 wk	Kinaesthetic ability training in addition to a conventional rehabilitation programme is effective in improving balance late after stroke. However, this improvement is not reflected in individual functional status.
Goljar et al 2010	6	44 (22/22)	Age: 61±8.9 yr Type: first isch/hem Time since onset: 3.2±2.0 mos Inclusion: walk 10 m	Comparison: Balance trainer (E) vs. Control (C) E: Conventional PT (45 min), including supervised balance training (20 min) using a balance trainer, with stabilizing forces acting at the level of the pelvis in the sagittal and frontal planes of motion, assisting the balancing activity of ankle and hip muscles. Level of supporting forces can be varied. C: Conventional PT (45 min), including balance training (20 min) with the PT in charge of the patient's safety and physical management. Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FIM total, FIM motor, FIM cognitive, BBS, one-leg standing, TUG, 10MWT Measured at baseline and 4 wk	Both conventional balance training and training balance in the balance trainer equally improved balance in subacute stroke patients. The balance trainer cannot replace a physiotherapist but it is a safe and efficient supplementary method.
Varoqui et al 2011	6	23 (8/8/7)	Age: 57.49±10.54 yr Type: first Time since onset: 58.50±29.08 d Inclusion: <6 mos post stroke, stand-up without help or support during 60 s; no comorbidity affecting stance	Comparison: Biofeedback non affected leg (naBFB) vs. BFB affected leg (aBFB) vs. control (C) naBFB: Stand barefoot 3.5 m from projection screen. Keep knees extended, toes and heels in constant contact with floor. Reproduce with body the postural pattern projected on the screen (0^o and 180^o) with help of customized postural coordination biofeedback system of *non affected leg* by performing ankle and hip flexion-extension movements in sagittal plane, frequency of movements was free. aBFT: Like naBFB, but with biofeedback of the *affected leg*. C: Stand-up task. Intensity: 15 min/d, 0^o: 4 sessions, during 2 wk. 180^o: 4 sessions, during 2 wk. Treatment contrast: 0 h.	Muscle strength, MAS, PASS, BBS, FAC, FIM Measured at baseline and 28 d	Results suggest that (re)learning the in-phase pattern is possible and seems to improve independence in poststroke patients. (in-phase: ankle-hip relative phase close to 0o for movements of small amplitude and/or executed at low frequency, with tow joints oscillating simultaneously in the same direction; Anti-phase: with ankle-hip relative phase of about 180o for movements of high amplitude and/or executed at high frequency, with joints moving in opposite directions)

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Shumway-Cook et al. 1988	RCT	16 (8 / 8) able to stand unassisted for 1 min.	mean: 65.6 y. + 5.5y.	type: ? post-acute: mean 37 d. + 12 d. after stroke, range 16-56 d.)	Yes	Intervention: postural sway biofeedback vs conventional PT E: standing balance retraining using the static force platform biofeedback system. C: standard PT balance training including verbal and mirror cues to practice symmetry BF-characteristics: controlling postural sway visual feedback; maintain cross within a central rectangular area also displayed in the center of the screen Intensity: during regular therapy 2 sessions/d of 15 min BF or conventional balance training for 2 wk	Postural sway characteristics measured before and after each session for 2 wk	Postural sway BF was more effective than conventional PT practices in reducing mean lateral displacement of sway. This was associated with increased loading of affected side. Post treatment changes in total sway were not significantly different between experimental and control groups.	4 failure at the questions: 3,4,5,6,7,9
Wong et al. 1997	RCT	60 (30 / 30) 55 CVA and 5 head-injury 0% drop-outs	mean: 51.3 y. +13.9 y.	type: first stroke ??: mean ?? after stroke	No	Intervention: standing training. Comparison of standing biofeedback trainer (SBT) vs standing training table (STT) E: maintain symmetry while standing with visual and auditory feedback on a balance platform C: maintain symmetry in upright stance in standing table, while performing pushing and pulling a load with arms Feedback-characteristics: In SBT visual weight bearing feedback and auditory alarm (computer spoken text) Intensity: 5 d/wk, 60 min/d, during 3-4 wk	Postural symmetry measured at 4 wk	SBT had a positive training effect on symmetry in hemiplegic subjects. No significant difference between subjects with right or left hemiplegia	5 failure at the questions: 3,5,6,7,9
Lee et al. 1996	RCT	60 (30 / 30) 50 CVA and 10 head-injury	mean: 49.1 y +15.2 y	type: ? mean ?? after stroke		Intervention: Same intervention (Wong et al 1997)	SSI (= same definition as postural symmetry)	Weight bearing biofeedback on balance platform demonstrates better results for hemiplegia patients than conventional training devices	
Grant et al. 1997	RCT	16 (8 / 8) which could adversely affect balance	mean: 65 y. + 3y.	type: ? post-acute: mean 33 d. + 5 d. after stroke	Yes	Intervention: visual feedback vs conventional therapy for balance retraining following stroke E: standing balance retraining using the Balance Master as force plate, tasks aimed at attaining symmetrical weight distribution, shifting the CoG towards the perimeter of LoS. Progression also included tasks such as reaching and stepping in place C: conventional PT balance training based on symmetrical weight distribution, weight shifting, reaching and finally performing functional activities challenging balance was followed Feedback-characteristics: visual feedback; shifting a cursor representing the CoG within theoretical LoS Intensity: 30 min/d for 5 d/wk (minimum 2 wk) as inpatients and 2 d/wk as outpatients for maximum of 8 wk (average of 19 sessions)	Postural sway and standing symmetry, BBS, TUG and (maximum) gait speed Measured at the end of the training and 1 mo after has ceased (follow up)	Visual feedback provides no differential benefit over conventional balance retraining when each is provided to regular rehabilitation. There were no between group differences on any outcome measure at any time, although the conventionally trained group tended to perform better on tasks involving gait	5 failure at the questions: 3,5,6,9, 11

Sackley & Lincoln 1997	RCT	26 (13 / 13) able to stand for 1 min. and with stance asymmetry 24 completed the study (8% drop-outs)	mean: 65.7y + 11.4y, range 41-85y	type: all post-acute: mean 19.5 wk + 17.4 wk after stroke, range 4-63 wk	Yes	Intervention: feedback training at balance platform vs placebo programme. First 20 min (preparation for standing) and third 20 min. (practising new skills) were for both groups the same E: Middle 20 min: visual feedback based on BWD in stance at balance platform (2 changing columns) C: Middle 20 min: same activities but with placebo visual feedback (2 unchanging columns) Intensity: 3 d/wk 60 min for 4 wk (12 sessions), the middle 20 min differed between the groups.	Stance symmetry and sway (NBP), RMA and NEAI measured at 4 and 12 wk after baseline	Significant improvements were seen in the treatment group in measures of stance symmetry and sway and motor and ADL functions. Between group differences had disappeared at 3 mo.	6 failure at the questions: 3,5,6,9
Lin & Chung 1998	RCT	10 (5 / 5)	mean: 56.9 y., range 38-73y	type: ? chronic: mean 17.5 mo + 11mo after stroke	?	Intervention: BF balance training + PT vs PT E: visual feedback to achieve symmetrical weight bearing on balance platform plus conventional PT. C: conventional PT Feedback-characteristics: ? Intensity: 1 mo	Static standing ability, standing symmetry, locomotor performance, gait pattern and interlimb coordination measured after 4 wk	The subjects with BF training showed significant improvement in static standing ability than those subjects without the feedback training.	? failure at the questions:
Walker et al. 2000	RCT	46 (16/16/14), could stand unassisted for 1 minute 46 of 54 submitted to the study (15% drop-outs)	mean: 64.5y. +12.2 y. range 30-85y.	type: ?? first stroke post-acute: mean 39 d. after stroke, range 8-80d.	Yes	Intervention: visual feedback + regular PT+OT vs balance exercises + regular PT+OT vs regular PT+OT E: E1: visual feedback while moving their CoG (Balance Master); E2: conventional therapy with verbal and tactile cues to encourage symmetrical stance and weight shifting. Feedback-characteristics: visual feedback-moving their CoG and observed corresponding cursor at computer screen (Balance Master). C: regular therapy (PT and OT) Intensity 3 groups 2 hrs/d;E1+E2:additional balance training 5 d/wk 30 min/d for 3-8 wk or until discharge.	Postural sway measurements (Balance Master), BBS, TUG, gait speed measured at discharge or after 8 wk, whichever came first and follow up 1 mo later	No between-group differences were detected in any of the outcome measures. Visual feedback or conventional balance training in addition to regular therapy affords no added benefit when offered in the early stages of rehabilitation following stroke	4 failure at the questions: 3,5,6,7,8,9
Geiger et al. 2001	RCT	13 (7 / 6) could stand with or without device for at least 2 min.	mean: 60.4 y. +15.4 y. range 30-77y.	type: ?? post-acute: mean 116 d. + 149d. after stroke, range 15-538d.	Yes	Intervention: additional visual BF/ forceplate training and PT vs PT (balance and mobility training) E: stability and balance training with visual feedback on Balance Master (PT 35 min and BF 15 min) C: standard PT, including improving muscle force, ROM, balance and mobility (50 min) Intensity: 2-3d/wk a session of 50 min during 4 wk	TUG and BBS measured after 4 wk	Although both groups demonstrated improvement following 4 weeks of PT interventions, no additional effects were found in the group that received visual BF/ forceplate training combined with other PT.	5 failure at the questions: 3,5,6,7,9

RCTs investigating balance training during various activities (paragraaf F1.6)

	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Bonan et al 2004	7	20 (10/10)	Age: 49.5 IQR 10 yr Type: first Time since onset: 20.5±25 mos Inclusion: walk without human assistance, no anesthesia of position joint sense in lower limb	Comparison: Vision-deprived balance program (E) vs. free-vision balance program (C) E: Balance program with visual cue deprivation by a mask, starting with spasticity inhibition (5 min), followed by improving balance (30 min): wk 1 in supine or prone position, wk 2 sitting position, wk 3 on all fours or kneeling, wk 4 in upright position. Balance training on treadmill and stationary bicycle (20 min) and walking on foam rubber track with obstacles (10 min). C: Same program as E but without visual deprivation. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	Sensory organization test, timed stair climbing, ease of gait, walking speed comf, NHP Measured at baseline and 4 wk	Balance improved more after rehabilitation with visual deprivation than with free vision. Visual overuse may be a compensatory strategy for coping with initial imbalance exacerbated by traditional rehabilitation.
McClellan et al 2004	6	26 (15/11)	Age: 69±13 yr Type: ?? Time since onset: median 6.5 IQR 5.5 yr Inclusion: discharge from PT service, living in community, MAS* item 5 >0 and <6, MAS* item 7 or 8 <6; no uncontrolled cardiac symptoms, pacemaker	Comparison: Home-based mobility program (E). vs. control (C) E: Exercises while looking at videotape to improve mobility in standing and walking, by prescribed first five exercise that subject could not perform successfully from a list of 23 predetermined hierarchically exercises. Progression by decreasing base of support and increasing perturbations. Exercises were videotaped (PT, patient, feedback from PT, modification of environment or assistance from carers), and reviewed at wk 2 and 4. Keep logbook. C: Exercises while looking at videotape to improve function of affected upper limb, by prescribed first five exercise that subject could not perform successfully from a list of 39 predetermined hierarchically exercises. Progression by increasing number of joints involved. Exercises were videotaped (PT, patient, feedback from PT, modification of environment or assistance from carers), and reviewed at wk 2 and 4. Keep logbook. Intensity: 2x/d, 7 d/wk, during 6 wk. Treatment contrast: 0 h.	FR, MAS* item 5, SA-SIP30 Measured at baseline and 6 wk and 14 wk (follow-up)	The six-week, resource-efficient mobility program was effective in improving some of the mobility in people after stroke rehabilitation. The provision of resource-efficient programs is recommended whenever possible so that people affected by stroke may continue rehabilitation for longer.
Howe et al 2005	6	35 (17/18)	Age: 71.5±10.9 yr Type: first/rec isch/hem Time since onset: 26.5±15.7 d Inclusion: no conditions affecting balance, no 'pusher syndrome'	Comparison: Lateral weight transference exercises (E) vs. control (C) E: Exercises aimed at improving lateral weight transference in sitting and standing based on work of Davies. Including repetition of self-initiated goal-oriented activities in various postures, with manual guidance and verbal encouragement. In addition to usual care, including PT. C: Usual care, including PT. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	Lateral reach sitting, standing up, sitting down, static standing balance Measured at baseline and 4 wk, and 8 wk (follow-up)	A training programme aimed at improving lateral weight transference did not appear to enhance the rehabilitation of acute stroke patients. Improvements observed in postural control in standing and sitting may be attributable to usual care or natural recovery.
Marigold et al 2005	6	48 (22/26)	Age: 68.1±9.0 yr Type: first Time since onset: 3.6±1.8 yr Inclusion: >12 mos post stroke, ability to walk with or without assistive device for >10 m, activity tolerance of 60 min with rest intervals, medically stable, BBS ≤52	Comparison: Agility program (E) vs. control (C) E: Program challenging dynamic balance with progressively increase task difficulty, emphasizing agility and multisensory approach. Warm up of walking and light stretching (5 min), tasks including standing in various postures and walking with various challenges. Additional exercises sit-to-stand, rapid knee raise while standing, standing perturbations. Eyes-closed conditions and foam surfaces incorporated in many tasks. 1:3 instructor:participant ratio in local community center. C: Focus on slow, low-impact movements consisting of stretching and weight shifting incorporating tai chi-like movements and reaching tasks. Stretching of major muscle groups while standing and on mats on the floor. Getting down and up from floor was also an exercise itself. Intensity: 60 min/d, 3 d/wk, during 10 wk. Treatment contrast: 0 h.	BBS, TUG, ABC, NHP, standing postural reflexes, falls during platform translations Measured at baseline and 10 wk and 1 mos (follow-up)	Group exercise programs that include agility or stretching/weight shifting exercises improve postural reflexes, functional balance, and mobility and may lead to a reduction of falls in older adults with stroke.
Yelnik et al 2008	7	68 (33/35)	Age: 55.5±11.6 yr Type: first isch/hem Time since onset: 217.2±92.9 d Inclusion: unable to walk for 2 wk to 3 mos, walk ≥50 m with orthosis or	Comparison: Multisensorial training (E) vs. control (C) E: Physical rehabilitation based on manipulation of sensor information required to maintain balance. Emphasis on amount of exercise, most conducted in visual deprivation. C: Global sensorimotor rehabilitation based on NDT, targeting control of weight bearing and shifting in erect stance and quality of gait. Intensity: 5 d/wk, during 4 wk.	BBS, 10MWT comf, double stance phase, time to climb 10 steps, daily time of walking, security sensation during walking, number of falls, FIM, NHP	No evidence was found for the superiority of a multisensorial rehabilitation program in ambulatory patients with impairments beyond the time of inpatient therapy.

			cane but without human assistance, no history of vestibular disorder	Treatment contrast: 0 h.	Measured at baseline and 4 wk and 3 mos (follow-up)	
Verheyden et al 2009	7	33 (17/16)	Age: 55±11 yr Type: first isch/hem Time since onset: 53±24 d Inclusion: hemiparesis, no disorders affecting motor performance, no maximum trunk performance score	Comparison: Trunk exercises (E) vs. control (C) E: Selective movements of upper and lower part of the trunk in supine and sitting, gradually introduced and number of repetitions determined on performance. In addition to conventional multidisciplinary stroke rehabilitation (see below). C: Conventional multidisciplinary stroke rehabilitation, consisting mainly of PT, OT, cursing care. If needed neuropsychological and speech therapy. Main emphasis on NDT and motor relearning strategies. Intensity: 30 min/d, 4 d/wk, during 5 wk. Treatment contrast: 10 h.	TIS, TIS static sitting balance, TIS dynamic sitting balance, TIS coordination Measured at baseline and 5 wk	Our results suggest that, in addition to conventional therapy, trunk exercises aimed at improving sitting balance and selective trunk movements have a beneficial effect on the selective performance of lateral flexion of the trunk after stroke.
Askim et al 2010	7	62 (30/32)	Age: 75.4±7.9 yr Type: isch/hem Time since onset: 14.4±7.4 d Inclusion: pre-existent mRS <3, BBS <45, SSS >14, MMSE >20; no serious cardiac diseases, other functional impairments	Comparison: Intensive motor training (IMT) vs. control (C) IMT: Early supported discharge, with additional sessions of motor training, including reaching tasks in sitting and standing position, sit-to-stand, step tasks, walking tasks. Individually adapted and varied. Repeat as many repetitions of each task as tolerated. Home exercises consisting of 4 tasks individually chosen, 10 reps and each exercise 2x/d, 6 d/wk. In addition to standard conventional therapy. C: Conventional therapy. Intensity: 30-50 min, 3 d/wk, during 4 wk. Treatment contrast: 480 min.	BBS, MAS*, BI, step test, SIS mobility, SIS recovery, 5MWT max Measured at baseline and 4 wk and 12 and 26 wk (follow-up)	In this randomized, controlled trial, a community-based intensive motor training program, doubling the amount of physical therapy during the first 4 weeks after discharge, did not show significant improvement of balance or any other functional outcomes.
Holmgren et al 2010 A, B	8	34 (15/19)	Age: 77.7±7.6 yr Type: first/rec Time since onset: 139.7±37.7 d Inclusion: 3-6 mos post stroke, fall risk, walk 10 m with or without walking aid, not able to walk outdoors independently, no severe vision or hearing impairment	Comparison: High-intensive exercise program (E) vs. control (C) E: Individualized group training (6 sessions over 3 d/wk), focus on physical activity and functional performance. First session (45 min) focus on strength and balance, followed by 30 min rest. Next session (45 min) of activities related to real-life situations. Strength ≥2 sets with 8-12 maximum repetitions, balance close to balance maximum, rest not more than necessary, If Borg RPE <15 then exercises were increased. Educational group discussions about fall risk and security aspects (1 h session/wk). Individualized home-based exercise program consisting of maximum of three different exercises to perform between wk 5 and 3 mos (3 d/wk). C: Educational group discussion about hidden dysfunctions after stroke and how to cope, including communication difficulties, fatigue, depressive symptoms, mood swings, personality changes, dysphagia. No special focus on risks of falling (1 h session/wk). Intensity: during 5 wk. Treatment contrast: 30 h.	SF-36, GDS-15 Measured at baseline and 5 wk BBS, BI, FES-I, FAI Measured at baseline and 5 wk and 3 and 6 mos (follow-up)	Based on these data, it is concluded that high-intensive functional exercises implemented in real-life situations should also include education on hidden dysfunctions after stroke instead of solely focus on falls and safety aspects to have a favorable impact on HRQoL. This study suggests that our program consisting of HIFE implemented in real-life situations together with educational discussions may improve performance of everyday life activities and improve falls efficacy in stroke subjects with risk of falls.
Karthikbabu et al 2011	8	30 (15/15)	Age: 59.8±10.5 yr Type: first isch/hem Time since onset: 11.8±8.1 d Inclusion: sit independently 20 sec, no neurological disease affecting balance, no disease of lower limbs affecting motor performance	Comparison: Physio ball (E) vs. control (C) E: Trunk exercises on an unstable support (i.e. physio ball) consisting of task-specific movements of upper and lower part of trunk in both supine and sitting position (Supine: pelvic bridge, unilateral bridge, flexion rotation upper and lower trunk. Sitting: selective flexion extension/ lateral flexion/ rotation of upper and lower trunk, weight shifts, forward/ lateral reach). Initiated with moderate assistance and progressed to no assistance. Intensity increased by reducing base of support, increasing lever arm, advancing balance limits, increasing hold time. In addition to regular acute-phase PT, e.g. tone facilitation, ROM. C: Same trunk exercises, but on stable surface (i.e. plinth), in addition to regular PT. Intensity: 1 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	TIS, BBA Measured at baseline and 3 wk	The trunk exercises preformed on the physio ball are more effective than those performed on the plinth in improving both trunk control and functional balance in acute stroke patients, suggesting a task-specific effect and also a carry-over effect.
Merkert et al 2011	4	66 (33/33)	Age: 74.5±8.3 yr Type: ?? Time since onset: 92.4±284.6 d Inclusion: decreased stability of trunk or lower limb, no pacemaker or defibrillators, body weight <150 kg	Comparison: Whole body vibration and balance training (E) vs. control (C) E: Vibroshpere training on round vibrating platform consisting of two repetitions of three exercises: supine bridging, seated, standing. In addition to conventional comprehensive geriatric rehabilitation with each training interval 15-90 sec, frequency vibration 35 Hz. C: Conventional comprehensive geriatric rehabilitation. Intensity: 15 sessions Treatment contrast: ??	BBS, functional test of the lower back, BI, TG, TUG Measured at baseline and after 15 sessions	Ultimately, the highly significant improvements in functional status found in this study indicate that combined vibration and balance training using Vibrosphere may be a useful addition to current rehabilitation of stroke patients.

RCTs investigating Body-weight supported treadmill training (paragraaf F.1.7)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Da Cunha Filho et al 2001	4	12 (6/6)	Age: 57.83±5.56 yr Type: ?? Time since onset: 15.67±7.66 d Inclusion: <6 wk post stroke, gait speed ≤36 m/min, FAC ≤2, stand with or without assistance, take ≥1 step with or without assistance; no comorbidity or disability preclude gait training, myocardial infarction ≤4 wk, uncontrolled health condition, seveer lower extremity joint disease, obesity	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: BWSTT as part of PT; BWS start at 30%, progressively decreased if support required to facilitate proper trunk and limb alignment and transfer of weigth onto hemiparetic leg was good, knee <15^o flexion in stance phase. Increase speed, starting at 0.01 m/s with increments of 0.01 m/s, when usual step length could be taken at higher speed. Stair climbing, locomotion on uneven surface, training on how to handle walkingdevices allowed during regular intervention. PT, kinesiotherapy and OT 3 h/d. C: Gait training as part of PT; stair climbing, locomotion on uneven surface, training on how to handle walking devices allowed during regular intervention. PT, kinesiotherapy and OT 3 h/d. Intensity: 20 min/d during PT, 5 d/wk, till discharge (2-3 wk). Treatment contrast: 0 h.	FAC, FIM locomotion, VO_{2max}, HR, systolic blood pressure, diastolic blood pressure, workload, total time Measured at baseline and discharge	This pilot study suggests that supported treadmill training intervention is a promising technique for acute stroke rehabilitation.
Sullivan et al 2002	5	24 (8/8/8)	Age: 64.4±13.4 yr Type: ?? Time since onset: 27.2±13.7 mos Inclusion: >6 mos post stroke, live in community, ambulate 10 m with or without assistive device and no more than standby physical assistance, walking speed reported slower than before stroke	Comparison: Body weight-supported treadmill training (BWSTT) fast vs. BWSTT slow vs. BWSTT variable BWSTT fast: BWSTT train at 0.89 m/s (on average above self-selected overground speed), in 4 periods of 5 minutes, with additional rest if neccessary. Up to 40% BWS and progressively decreased as activity tolerance increased and prober limb kinematics maintained with therapist's assistance. One person proved proximal stability at the hips and monitor upright position, pelvic position, weight shift; second person positioned hemiparetic lower limb and provided assistance with stepping and limb control during stance and swing. BWSTT slow: BWSTT as BWSTT fast, but on averabe below self-selected overground speed, at speed of 0.22 m/s. BWSTT variable: BWSTT as BWSTT fast, but at variable speeds of 0.22, 0.45, 0.67 and 0.89 m/s. Intensity: 20 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	10MWT comf Measured at baseline, 2 wk, 4 wk and 1 and 3 mos (follow-up)	Training at speeds comparable with normal walking velocity was more effective in improving self-selected walking velocity than training at speeds at or below the patient's typical overground walking velocity.
Werner et al 2002	7	30 (15/15)	Age: 60.3±8.6 yr Type: first isch/hem Time since onset: 6.93±2.09 wk Inclusion: 4-12 wk post stroke, FAC ≤2, sit unsupported edge of bed, stand ≥10 sec with help, hip or knee extension deficit <20^o, passive dorsiflexion ankle to neutral position; no evidence of cardiac ischemia, arrhythmia or decompensation, max HR >190 bpm-age of patient, systolic blood pressure	Comparison: Gait trainer (E) vs. control (C) GT: Harness-secured in gait trainer, stance-swing phase ratio 60-40%, velocity from 0-2.5 km/h. Support reduced when patient could extend hips and carry weight sufficiently on affected lower limb. Target velocity 0.25-0.40 m/s. Physical help according to individual needs. In addition to comprehensive rehabilitation program, containing at least daily individual, 45 min, PT and OT sessions following Bobath approach. C: Body-weight supported treadmill training with modified parachute harness. Treatment conditions as gait trainer. In addition to comprehensive rehabilitation program. Intensity: 15-20 min/d, 5 d/wk, 2 wk. Treatment contrast: 0 h.	FAC, MAS, 10MWT max Measured at baseline and 2 wk	The newly developed gait trainer was at least as effective as treadmill therapy with partial body weight support while requiring less input from the therapist.

			rest 200 mm Hg.			
Eich et al 2004	8	50 (25/25)	Age: 62.4±4.8 yr Type: first isch Time since onset: 6.10±2.2 wk Inclusion: walk ≥12 m with intermittent help or stand-by while walking, BI 50-80, cardiovascular stable	Comparison: Body-weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Graded treadmill training, harness secured and minimally supported (≤15%) according to patients' needs at defined training heart rate (HRmax–HRrest)*0.6HRrest (30 min). If necessary help with setting paretic limb or assisting weight-shifting and hip extension. Warm-up and cool-down period of 1-2 min, optional two short pauses. PT following Bobath approach, including tone-inhibiting and gait preparatory maneuvers, walking practice on the floor and on the stairs. Necessary orthoses and walking aids were provided (30 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. C: PT (60 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. Intensity: 60 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	10MWT maximum, 6MTW, RMA, walking quality Measured at baseline and 6 wk and 6 mos (follow-up)	Aerobic treadmill plus Bobath walking training in moderately affected stroke patients was better than Bobath walking training alone with respect to the improvement of walking velocity and capacity.
Yagura et al 2006	5	49 (23/26)	Age: 62.9±7.4 yr Type: first isch/hem Time since onset: 57.0±11.0 d Inclusion: physical assistance for gait after 4 wk of inpatient rehabilitation, no myocardial infarction <1 yr, no uncontrolled hypertension, no symptomatic orthostatic hypotension, no atrial fibrillation with uncontrolled rate	Comparison: Body-weight-supported treadmill training + facilitation technique (BWSTT FT) vs. BWSTT BWSTT FT: BWSTT with therapists assisting swing and stance of paretic leg using a facilitation technique: flexion of the knee for the initiation of the swing phase, prevent pelvis from being hitched up by handling the hip and pelvis, severe impaired had initially additionally mechanical assistance both in the unaffected and affected leg. BWS 0-50%, speed increased progressively. Included in the ordinary PT sessions 3 d/wk. Usual rehabilitation (PT and OT 40 min/d, 5d/wk; speech-language pathology therapy 5 d/wk). BWSTT: BWSTT as BWSTT FT, but with therapists assisting swing and stance of paretic leg mechanically. Intensity: 20 min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, FMA leg, FIM, FIM gait, FIM motor, 10MWT Measured at baseline and 6 wk and 12 wk (follow-up)	The FT did not add significantly to locomotor outcome of BWSTT in nonambulatory patients with stroke but it did require more therapists' assistance.
Sullivan et al 2007	7	80 (20/20/20/20)	Age: 60.6±13.7 yr Type: isch/hem Time since onset: 27.5±16.1 mos Inclusion: ambulate ≥14 m FAC ≥2, self-selected walking speed ≤1.0 m/s, no health condition which intervenes with safe participation or exercise program, no serious medical conditions, no resting systolic blood pressure >180 mm Hg, no resting diastolic blood pressure >110 mm Hg, no resting heart rate >100 bpm	Comparison: Four combinations of: Body-weight-supported treadmill training (BWSTT), limb-loaded resistive leg cycling (CYCLE), LE muscle-specified progressive-resistive exercises (LE-EX), upper-extremity ergometry (UE-EX) with intensity ≤80% of age-predicted maximum heart rate. BWSTT/UE-EX: - BWSTT: walk on treadmill with harness for four 5-minute training bouts, speed range 1.5-2.5 mph to achieve 20 accumulated min of walking over 1-hour session. Gait instruction in an overground setting over a 15 m distance. - UE-EX: Cycle with arms on Endorphin EN-300 Hand Cycle, with resistance to level to complete 10 sets of 20-RM. Forward and backward cycling alternated, assistance with hemiparetic limb by PT if necessary. CYCLE/UE-EX: - CYCLE: cycle on modified Biodex semi-recumbent cycle with releasable seat enabling to slide along a linear track where 10-lb bungee cords can be attached to produce extensor muscle resistance similar to a leg press machine, with goal to pedal while keeping the sliding seat from moving out of the target "exercise region." 10 sets of 15-20 revolutions in each session, ≥2 minutes rest between sets. - UE-EX: see above. BWSTT/CYCLE: - BWSTT and CYCLE: see above. BWSTT/LE-EX: - BWSTT: see above. - LE-EX: Isotonically exercise the affected leg using external resistance (e.g. gravity, resistive tubing, cuff weights) following exercise algorithm accounted for strength and movement synergy level to determine a 10-RM for 6 groups (hip flexors, hip extensors, knee flexors, knee extensors, ankle dorsiflexors,	10MWT comf and max, 6MWT Measured at baseline, 3 and 6 wk and 6 mos (follow-up)	After chronic stroke, task-specific training during treadmill walking with body-weight support is more effective in improving walking speed and maintaining these gains at 6 months than resisted leg cycling alone.

				ankle plantar flexors). Each muscle group exercised for 3 sets of 10 repetitions at 80% of the 10-RM. Intensity: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: 0 h.		
Yen et al 2008	7	14 (7/7)	Age: 57.30±16.44 yr Type: isch/hem Time since onset: 1.97±0.61 yr Inclusion: walk ≥10 m with or without assistance, no pacemaker, no severe cardiac problems, no metallic implant materials in the head, not walk with normal gait pattern	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Treadmill training with body weight supported <40% and decreased to maximum extent possible based on ability to carry remaining load on paretic leg with <15^o of knee flexion during single-support phase. Purpose to normalize gait pattern in terms of maintaining neutral position of ankle joint during swing phase and knee extension during stance phase to maximum possible extend. Not allowed to wear lower-extremity orthosis during training, and refrain from holding handrail if possible. Encouraged to use reciprocal arm swing. In addition to PT (2-5 sessions/wk) involving stretching, muscle strengthening, balance, and overground walking training. C: PT (see above). Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	BBS, walking speed max, cadence, step length, motor threshold, size cortical motor output area Measured at baseline and 4 wk	Additional gait training may improve balance and gait performance and may induce changes in corticomotor excitability.
Franceschini et al 2009	5	97 (52/45)	Age: 65.5±12.2 yr Type: isch/hem Time since onset: 28.9±12 d Inclusion: sit with legs hanging freely and without help of arms ≥30 s, MAS leg ≤1, stable cardiovascular condition (Class B of ACSM), walk without aids ≥3 m or ≥6 m with aid of cane or tripod	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Treadmill training with gradually declining body weight support (≤40%), with help of 1-2 PTs (effectively 20 min). Speed start from 0.1 m/s aiming at ≥1.2 m/s. Followed by conventional training, with no specific indications to the rehabilitation team (40 min). C: Conventional training, with no specific indications to the rehabilitation team (60 min). Intensity: 60 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	MI arm and leg, TCT, mRS, BI, FAC, MAS, Token test, Albert test, proprioceptive sensibility, 10MWT, 6MWT, Borg, Walking handicap scale Measured at baseline, 2 and 4 wk and 6 wk and 6 mos (follow-up)	In subacute patients with stroke, gait training on a treadmill with body weight support is feasible and as effective as conventional gait training.
Westlake et al 2009	6	16 (8/8)	Age: 58.6±16.9 yr Type: first isch/hem Time since onset: 43.8±26.8 mos Inclusion: >6 mos post stroke, walking speed >0.3 m/s; no unstable cardiovascular/ orthopedic/ neurological conditions, uncontrolled diabetes	Comparison: Gait trainer (GT) vs. Control (C) 2-3 minute rest period was provided after 15 min. Speed <0.69 m/s in slow group and above 0.83 in fast group. Progress speed with increments of 0.2 km/hr every 5 min as long as good gait quality was observed. BWS initiated at 35% and decreased with increments of 5% if maximal speed was reached. Train without ankle-foot orthosis, reduced assistance once safety was no longer a concern, and rest periods provided if gait quality detoriated, use handrail strongly discouraged. Visual feedback via full-length mirror GT: Train in Lokomat with robotic orthosis, 100% bilateral guidance, verbal encouraged to actively step in conjunction with the movement presented.. C: BWSTT with 1-2 PTs who provided manual guidance throughout gait cycle, and verbal and visual cues to normalize stepping kinematics. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Walking speed comf and max, step length, 6MWT, FMA leg, BBS, short physical performance battery Measured at baseline and 4 wk	Results suggest that Lokomat training may have advantages over manual-BWSTT following a modest intervention dose in chronic hemiparetic persons and further, that our training speeds produce similar gait improvements.
Dean et al 2010, Ada et al 2010	8	126 (64/62)	Age: 70±9 yr Type: first Time since onset: 18±8 d Inclusion: <28 d post stroke, MAS* item 5 (walking) ≤1; no brainstem signs, unstable cardiac status, pre-morbid conditions precluding them from rehabilitation	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: BWSST with initial support that knee was <15^o extension in mid-stance, initial speed so that therapist could assist leg to swing while maintaining reasonable step length. Of too disabled: step on spot. Reduce BWS if 1) swing affected leg without help; 2) maintain straight knee during stance phase without hyperextension; 3) maintain adequate step length without help. Speed of 0.4 m/s without BWS, 10 min devoted to overground walking. In addition to intervention for lower limb (e.g. strengthening, sitting, standing up) up to 60 min/d and multidisciplinary rehabilitation. C: Assisted overground walking, aids were part of intervention. If too disabled to walk: standing, weight shifting, stepping forwards and backwards. Increase speed and reduce assistance if participant could walk with one therapist. In addition to intervention for lower limb (e.g. strengthening, sitting, standing up)	10MWT, 6MWT, walking perception, falls, AAP (community participation), independent gait, discharge destination Measured at baseline and 6 mos	Treadmill training with body weight support results in better walking capacity and perception of walking compared to overground walking without deleterious effects on walking quality. Treadmill walking with body weight support is feasible, safe, and tends to result in more people walking independently and earlier after stroke.

				up to 60 min/d) and multidisciplinary rehabilitation. Intensity: <30 min/d, 5 d/wk, till independent gait was reached or discharge. Treatment contrast: 0 h.		
Moore et al 2010	5	20 (??/??)	Age: 50±15 yr Type: first isch/hem Time since onset: 13±8 mos Inclusion: 6 mos post stroke, walk >10 m overground without physical assistance, comf speed ≤0.9 m/s, primary stated goal to improve walking ability, enroll approx 1 mos before termination of PT services, no lower extremity contractures, no cardiovascular instability	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: High-intensity stepping practice on motorized treadmill while wearing a harness with up to 40% BWS for subjects with a <0.2 m/s overground walking speed, reduced in 10% increments. Walk at highest tolerable speed with increase velocity in 0.5 km/h increments until HR was 80-85% or Borg 17. Hold on handrail for balance, PT did not provide manual assistance. Focus on increasing intensity and amount of stepping practice. C: No intervention. Intensity: 2-5 d/wk, during 4 wk. Treatment contrast: ??	Walking speed comf, walking speed max, 12MWT, O_2cost (gait efficiency), peak treadmill speed, VO_2peak, BBS, TUG Measured at baseline and 4 wk	Intensive locomotor training results in improved daily stepping gin individuals poststroke who have been discharged from PT because of a perceived plateau in motor function. These improvements may be related to the amount and intensity of stepping practice.
Takami et al 2010	5	36 (12/12/12)	Age: 66.1±6.3 yr Type: isch/hem Time since onset: 13.2±8.4 d Inclusion: walk 10 m with brace or cane, <5 wk post stroke, FIM locomotion ≤5, BBS RMI score perfect; no 10MWT max ≤4 sec, uncontrolled health conditions, parkinsonism, orthopedic and other gait-influencing diseases	Comparison: Body weight-supported treadmill training (BWSTT) backward vs. BWSTT forward vs. control (C) BWSTT backward: Walk backwards on treadmill with 30% BWS for 10 min. wk 1 0.8 h/m, 2x 3 min with 4 min rest; wk 2 1.0 km/h 2x4 min with 3 min rest; wk 3 1.3 km/h 2x 4 min with 3 min rest. Conventional training i.e. overground training of walking 150-200 m based on distance covered in the treadmill intervention. In addition to ADL exercise (see below). BWSTT forward: Walk forward on treadmill with 30% BWS for 10 min. Conventional training (30 min/d, 6 d/wk) and ADL exercise (see below). C: Conventional training. In addition to ADL exercise, including strengthening, stretching, PNF, function and mobility activities, other training activities; prohibiting: ergometer cycling, treadmill walking without BWS, walk ≥200 m without rest, climb stairs ≥3 times, other motor tasks requiring ≥3 minutes (40 min/d, 5 d/wk). Intensity: 40 min/d, 6 d/wk, during 3 wk. Treatment contrast: BWSTT backward vs. BWSTT forward: 0 h. BWSTT backward/forward vs. C: 720 min.	BBS, RMI, 10MWT max, cadence, step length Measured at baseline and 3 wk	As a result of 3-week intervention, a significant improvement was observed in walking speed and the RMI, suggesting that partial BWS treadmill backward walking training for patients in the early phase of acute stroke is effective at improving mobility.
Yang et al 2010 Short duration	8	9 (5/4)	Age: 56.8±1.3 yr Type: isch/hem Time since onset: 0.3±0.1 yr Inclusion: onset <6 mos, no cardiac pacemaker or severe cardiovascular problems, no MEPs of ipsilesional hemisphere induced by TMS	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Body weight-supported treadmill training (BWSTT) at comfortable walking speed with <40% support which was decreased to the maximum extent possible, based on ability to carry remaining load on paretic limb with <15° knee flexion during single-support phase (30 min). Assistance with gait pattern and movement of pelvis. Followed by general exercise program, including stretching, strengthening, endurance, and overground walking training (20 min). C: General exercise program (50 min, see above). Intensity: 50 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Motor threshold, map size, FMA leg Measured at baseline and 4 wk	The BWSTT results in similar improvement in motor control but different patterns of treatment-induced cortical reorganization in subjects with different poststroke durations. BWSTT resulted in a decrease in the motor threshold and an increase in the motor map size in subjects with hemiparesis of short duration. Improvement of lower extremity motor control occurred in subjects with hemiparesis of short duration after BWSTT.
Yang et al 2010 Long duration	8	9 (5/4)	Age: 57.5±6.1 yr Type: isch/hem Time since onset: 2.1±0.3 yr Inclusion: onset >12 mos, no cardiac pacemaker or	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: BWSTT at comfortable walking speed with <40% support which was decreased to the maximum extent possible, based on ability to carry remaining load on paretic limb with <15° knee flexion during single-support phase (30 min). Assistance with gait pattern and movement of pelvis. Followed by general exercise program, including stretching, strengthening, endurance, and	Motor threshold, map size, FMA leg Measured at baseline and 4 wk	The BWSTT results in similar improvement in motor control but different patterns of treatment-induced cortical reorganization in subjects with different poststroke durations.

			severe cardiovascular problems, no MEPs of ipsilesional hemisphere induced by TMS	overground walking training (20 min). C: General exercise program (50 min, see above). Intensity: 50 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.		Long duration: An expansion of the motor map size but not the changes in the motor threshold were noted in subjects with hemiparesis of long duration. Improvement of lower extremity motor control occurred in subjects with hemiparesis of long duration after BWSTT.
Duncan et al 2011	8	408 (139/143/126)	Age: 60.1±12.3 yr Type: first isch/hem Time since onset: 64.1±8.3 d Inclusion: residual paresis affected leg, ability to walk 3 m with assistance from no more than 1 person, self-selected speed for walking 10 m <0.8 m/s	Comparison: Early locomotor training (Early LT) vs. Late locomotor training (Late LT) vs. control (C) Early LT: Stepping on treadmill with partial body-weight support and manual assistance as needed, 20-30 min, 3.2 km/h (ranging 0-1.6 km/h, increments by 0.16 km/h). Followed by progressive program of walking over ground, 15 min. Started early. Late LT: As Early LT, but started after 6 mos. C: Control task-specific walking program at home, progression managed by PT. Goals of enhancing flexibility, ROM, strength, coordination, static and dynamic balance. Encouraged to walk daily. Started early. Intensity: 90 min/d, 3 d/wk, during 12-16 wk (30-36 sessions) [applied 83±6, 82±5, 76±10 min] Treatment contrast: Early vs. late: 1620 min. Early vs. C: 0 h.	Functional level of walking, 10MWT (comf), 6MWT, FMA leg, BBS, ABC, ADL-IADL, SIS mobility and participation, activity monitor Measured at baseline and 6 and 12 mos	Locomotor training, including the use of body-weight support in stepping on a treadmill, was not shown to be superior to progressive exercise at home managed by a physical therapist.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age + SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Visintin et al. 1998	RCT	100 (50/50), 21% drop-outs, 79 (43/36) completed the study 100 of 375 pa-tients submitted in study	mean: 67.3 y + 11.7 y	Fist stroke type: ? post-acute: mean 73 d after stroke; range: 27-148 d	Yes	Intervention: Treadmill gait training with BWS vs Treadmill gait training without BWS E: initially 73% of patients using 30% - 40% BWS, progressively decreased till 0% C: 0% BWS Intensity: 4d/wk, max. 20 minutes, during 6 wk	BBS, STREAM, TMW, Over-ground walking endurance Assessments performed at 6 wk after start and at 3 mo after training (follow-up)	Retraining gait in patients with stroke while a percentage of their body weight was supported resulted in better walking abilities and a sustained advantage, than gait training while patients were bearing their full weight	5 failure at questions: 3,5,6,8,9
Kosak et al. 2000	RCT	56 (22/34)	mean: 71 y + 2 SEM	First stroke, all types post-acute: mean 40 d + 3 d after stroke	Yes	Intervention: PBWSTT and PT vs traditional gait training (using knee-ankle combination bracing and hemi-bar if needed) and PT E: initially 30% BWS, progressively decreased till 0%; mean 12.5 treatment sessions C: aggressive bracing assisted walking (ABAW) on the floor using a KAFO or AFO and rigid hemi-bar. Intensity: 5 d/wk; max. 45 minutes gait training and 45 min. traditional PT, during 6 wk	Over-ground walking endurance (max. distance until fatigue) and speed (2min walk) Measured at 2-wk intervals during the study (2, 4, 6 wk)	PBWSTT and ABAW are equally effective gait training techniques except for a subset of patients with major hemisferic stroke who are difficult to mobilize using ABAW alone	4 failure at questions: 3,5,6,7,9,11
Nilsson et al. 2001	RCT, multi-centre design	73 (36/37) 8% drop-outs, 66 (32/34) completed the training, and 60 (28/32) completed the follow-up	mean: 55 y, range 24-67 y	First stroke, all types sub-acute: mean 19 d after stroke, range 8-56 d	Yes	Intervention: Treadmill gait training with BWS vs gait training according the MRP E: initially 64% of patients using 30-64% BWS, gradually reduced till 0% C: gait training according to MRP on the ground Intensity: 5 d/wk, 30 minutes; median treatment time: 67 d (range 3-19 wk)	FIM, TMW, FAC, FMA and BBS, Assessments performed at discharge and at 10-mo follow-up	Treadmill training with BWS at an early stage of rehabilitation after stroke is a comparable choice to walking training on the ground	7 failure at questions: 5,6,9
Da Cunha et al. 2001	RCT	15 (8/7) 20% drop-outs, 12 (6/6) completed the study	mean: 57.8 y + 5.6 y, range 44-75 y	Type: ? sub-acute: mean 15.7 d after stroke + 7.7 d	Yes	Intervention: Supported treadmill ambulation training (STAT) vs Regular gait training on the ground E: initially 30% BWS, progressively decreased till 0% C: regular gait training on the floor Intensity: 5 d/wk; 20 minutes until discharge usually 2-3 wk (minimal of 9 sessions)	Oxygen consumption, total workload and total time pedalling the bike Measured at discharge (2-3 wk after start training)	Significant improvement was found in oxygen consumption during bicycle ergometry in the STAT intervention group compared to the regular therapy group. No other significant benefits in other physiologic or functional measures were found	4 failure at questions: 3,5,6,8,9,11
Sullivan et al. 2002	RCT	24 (8/8/8) 17% drop-outs, 20 (6/6/8) completed the follow-up	mean: 67 y + 12 y, range 34-81 y	types: mca or basilar artery chronic: mean 25.8 mo after stroke + 16 mo	Yes	Intervention: BWSTT at different walking speeds E: two experimental groups E1: walking at fast speed: 0.89 m/s and E2: walking at variable speeds: 0.22 m/s, 0.45 m/s, 0.67 m/s and 0.89 m/s C: walking at slow speed: 0.22 m/s All groups: initially: mean 34% BWS in first session, progressively decreased till mean 13% in 12th session Intensity: 12 sessions over a 4-5 wk-period; each session included four 5-minute walking bouts, total time each session is 20 minutes	TMW measured after the 6th and 12th session and at the 1- and 3-mo follow-up	Training at speeds comparable with normal walking velocity was more effective in improving SSV than training at speeds at or below the patient's typical overground walking velocity.	5 failure at questions: 3,5,6,8,9

RCTs investigating robot-assisted gait training (paragraaf F.1.8)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Werner et al 2002	7	30 (15/15)	Age: 60.3±8.6 yr Type: first isch/hem Time since onset: 6.93±2.09 wk Inclusion: 4-12 wk post stroke, FAC ≤2, sit unsupported edge of bed, stand ≥10 sec with help, hip or knee extension deficit <20^{o}, passive dorsiflexion ankle to neutral position; no evidence of cardiac ischemia, arrhythmia or decompensation, max HR >190 bpm-age of patient, systolic blood pressure rest 200 mm Hg.	Comparison: Gait trainer (E) vs. Control (C) GT: Harness-secured in gait trainer, stance-swing phase ratio 60-40%, velocity from 0-2.5 km/h. Support reduced when patient could extend hips and carry weight sufficiently on affected lower limb. Target velocity 0.25-0.40 m/s. Physical help according to individual needs. In addition to comprehensive rehabilitation program, containing at least daily individual, 45 min, PT and OT sessions following Bobath approach. C: Body-weight supported treadmill training with modified parachute harness. Treatment conditions as gait trainer. In addition to comprehensive rehabilitation program. Intensity: 15-20 min/d, 5 d/wk, 2 wk. Treatment contrast: 0 h.	FAC, MAS, 10MWT max Measured at baseline and 2 wk	The newly developed gait trainer was at least as effective as treadmill therapy with partial body weight support while requiring less input from the therapist.
Peurala et al 2005	6	45 (15/15/15)	Age: 53.3±8.9 yr Type: first isch/hem Time since onset: 2.6±2.4 yr Inclusion: >6 mos post stroke, slow or difficult walking; no unstable cardiovascular disease	Comparison: Electromechanical gait trainer + functional electrical stimulation (GT-FES) vs. GT vs. conventional (C) GT-FES: GT with BWS and motor-driven footplates. FES with surface electrodes for 2 weakest muscles, frequency 25 Hz, pulse width 0.3ms, onset electrically synchronized to gait pattern. Progression by increasing speed, aiming to BWS <20% and decrease stimulation. Verbally or manually guided. In addition to usual PT (55 min/d). GT: GT as GT-FES but without FES. In addition to usual PT (55 min/d). C: Overground walking or over uneven terrain with individual walking aids. Progression by increasing speed. Verbally or manually guided. In addition to usual PT (55 min/d). Intensity: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	10MWT max, 6MWT, postural sway, MAS, MMAS*, FIM Measured at baseline,2 and 3 wk and 6 mos (follow-up)	Both the BWS training and walking exercise training programs resulted in faster gait after the intensive rehabilitation program. Patients' motor performance remained improved at the follow-up.
Tong et al 2006	6	50 (15/15/20)	Age: 61.8±10.8 yr Type: first isch/hem Time since onset: 2.3±1.0 wk Inclusion: <6 wk post stroke, ability to stand upright supported or unsupported for 1 min, FAC 3; no potentially fatal cardiac arrhythmias, pacemaker	Comparison: Electromechanical gait trainer + functional electrical stimulation (GT-FES) vs. GT vs. conventional (C) GT-FES: GT with BWS, optional rest break 1-3 min after first 10 min, stance-swing phase ratio 60-40%, target velocity 0.20-0.60 m/s. Training variables included step length, walking speed, BWS, use of handrail. Assistance with knee extension and verbal cueing. Additional FES on quadriceps and peroneal nerve paretic leg, with self-adhesive electrodes, waveform and pulse width with fixed values. In addition to PT (40 min/d) and multidisciplinary treatments (1.5 h/d). GT: GT as GT-FES but without FES. In addition to PT (40 min/d) and multidisciplinary treatments (1.5 h/d). C: Conventional PT based on proprioceptive neuromuscular facilitation and Bobath concepts, including overground walking depending on abilities. In addition to PT (40 min/d) and multidisciplinary treatments (1.5 h/d). Intensity: 20 min/d, 7 d/wk, during 4 wk. Treatment contrast: 0 h.	EMS, BBS, FAC, MI leg, 5MWT max, FIM Measured at baseline and 4 wk	In this sample with subacute stroke, participants who trained on the electromechanical gait trainer with BWS, with or without FES, had a faster gait, better mobility, and improvement in functional ambulation than participants who underwent conventional gait training.
Dias et al 2007	4	40 (20/20)	Age: 70.35±7.36 yr Type: first Time since onset: 47.10±63.83 mos Inclusion: MI leg <100/ >0, absence of cardiac/ psychological/ orthopedic	Comparison: Gait trainer (GT) vs. Control (C) GT: Harness secured gait trainer (REHA-STIM), stance-swing phase ratio 60-40%, pulley relieves part of body weight as required up to 30% which decreased over time, knee motion corrected manually if necessary (20 min). Joint mobilization and muscle strengthening (20 min). C: Joint mobilization and muscle strengthening (20 min). Balance and gait training using Bobath methods (20 min).	MI leg, TMS, BI, FMA leg, FMA balance, 10MWT (velocity, step length, step cadence), TUG, 6MWT, FAC, RMI, MAS, step test Measured at baseline and 5	Both groups of chronic hemiplegic patients improved after partial body weight support with gait trainer or Bobath treatment. Only subjects undergoing partial body weight support with gait trainer maintained functional gain after 3 months.

			conditions	Intensity: 40 min/d, 5 d/wk, during 5 wk. Treatment contrast: 0 h.	wk and 3 mos (follow-up)	
Husemann et al 2007	7	30 (16/14)	Age: 60±13 yr Type: first isch/hem Time since onset: 79±56 d Inclusion: MRC ≤3 in >2 lower extremity muscle groups, FAC ≤1	Comparison: Robot-driven gait orthosis (GT) vs. control (C) GT: Lokomat version including robotic gait orthosis, BWS system and treadmill. BWS start at 30% and decreased as soon as possible, walk at maximum speed, encouraged to actively move the legs. In addition to usual PT (5 d/wk, during 4 wk). C: Conventional PT, focused on gait rehabilitation, including trunk stability and symmetry, step initiation, weight support paretic leg, walk with help therapist, treadmill training if possible with help of 1-2 PTs. In addition to usual PT (5 d/wk, during 4 wk). Intensity: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FAC, 10MWT max, cadence, stride duration, stance duration, single support time, body weight, body cell mass, fat mass, MAS, MI leg, BI Measured at baseline and 4 wk	This pilot study indicates that Lokomat therapy is a promising intervention for gait rehabilitation. Although there was no difference between groups in gain of functional scores, the Lokomat group showed an advantage of robotic training over conventional physiotherapy in improvement of gait abnormality and body tissue composition.
Mayr et al 2007	6	16 (8/8)	Age: 63.4 yr Type: isch/hem Time since onset: 2.8 mos Inclusion: inability to walk unaided	Comparison: Gait trainer (GT) vs. Control (C) GT: Lokomat training including treadmill, driven gait orthosis, BWS. Parameters adapted to ability, strength and endurance: BWS (start 40%, reduced to 0%), walking duration (up to 30 min), ambulation velocity (start 0.28 m/s increased to 0.83 m/s), guidance force provided by Locomat (start 100% reduced to 15%). Direct feedback about speed, time and distance. No additional overground walking. In addition to OT and speech therapy. C: Conventional physical therapy, consisting of neurophysiological concepts such as Bobath and cortical facilitation techniques according to Perfetti. Emphasis on general bilateral and 3-dimensional movements required for turning, rolling, kneeling, sitting and standing. Facilitation of selective movement, integration of selective movement in functional activity, exercises for improving balance, overground walking with emphasis on gait quality. In addition to OT and speech therapy. Intensity: up to 30 min/d, during 3 wk. Treatment contrast: 0 h.	EU WS, RMA gross function, 10MWT max, 6MWT, MRC, MI, MAS Measured at baseline and 3, 6 and 9 wk	Despite the small number of patients, the present data suggest that the Lokomat robotic assistive device provides innovative possibilities for gait training in stroke rehabilitation while eliminating prolonged repetitive movements in a nonergonomic position on the part of the physical therapist.
Pohl et al 2007, Mehrholz et al 2007	8	155 (77/78)	Age: 62.3±12.0 Type: first isch/hem Time since onset: 4.2±1.8 wk Inclusion: sit unsupported with feet supported, not walk or required help of 1 or 2 therapists, no unstable cardiovascular condition, no restricted ROM major lower limb joints, no diseases impairing walking ability	Comparison: Gait (GT) vs. control (C) GT: Repetitive locomotor therapy on gait trainer with step length 48 cm, cadence individually adjusted, velocity 1.4-1.8 km/h, BWS 10-20% and reduced as rapidly as possible (20 min). Initially PT in front of patient to assist paretic knee control. Followed by PT exclusively concentrated on restoration of stance and gait (25 min). C: PT exclusively concentrated on restoration of stance and gait. Intensity: 45 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FAC, BI, RMI, 10MWT max, 6MWT, MI, HR during program Measured at baseline and 4 wk and 6 mos (follow-up)	Intensive locomotor training plus physiotherapy resulted in a significantly better gait ability and daily living competence in subacute stroke patients compared with physiotherapy alone. Higher heart rate intensities during gait-training of non-ambulatory post-stroke patients may improve walking function.
Hornby et al 2008	5	48 (27/21)	Age: 57±10 yr Type: isch/hem Time since onset: 50±51 mos Inclusion: >6 mos post stroke, walk >10 m overground without physical assistance at speeds ≤0.8 m/s at self-selected velocity, no significant cardiorespiratory/ metabolic disease	Comparison: Robotic-assisted (GT) vs. control (C) BWS 30-40% decreased with 10% increments per session as tolerated without substantial knee buckling or toe drag. Start at 2.0 km/h, increased by 0.5 km/h every 10 min as tolerated to 3.0 km/h and remained there for subsequent visits. Bloodpressure <220/110 mm Hg and 85% age predicted HR. Rest breaks provided as necessary. GT: Continuous symmetrical stepping assistance using Lokomat, with visual feedback of bilateral hip and knee torques, encouraged to generate maximal effort. C: PT provided manual facilitation at paretic limb, only if necessary to ensure continuous walking. Visual feedback from mirror and verbal encouragement. Lower extremity orthosis removed if stepping could proceed within minimal risk of orthopedic injury. Intensity: 12 sessions, 30 min/d. Treatment contrast: 0 h.	Walking speed comf and max, single limb stance time, step length asymmetry, 6MWT, mEFAP, BBS, FAI, SF-36 physical Measured at baseline and after 12 sessions and 6 mos (follow-up)	Therapist-assisted locomotor training facilitates greater improvements in walking ability in ambulatory stroke survivors as compared to a similar dose of robotic-assisted locomotor training.
Ng et al 2008	6	54 (16/17/21)	Age: 62.0±10.0 yr Type: first isch/hem Time since onset: 2.3±1.1 wk Inclusion: ability to stand	Comparison: Gait trainer (GT) + Functional electrical stimulation (FES) vs. GT vs. control (C) GT: Electromechanical gait trainer, body weight partially supported by a harness which was decreased by 5 kg, gait cycle ratio 60-40% between stance and swing phase, gait speed increase 0.1 m/s if possible. Therapist gave	EMS, BBS, FAC, MI leg, gait speed, FIM, BI Measured at baseline and 4 wk and 6 mos (follow-up)	For the early stage after stroke, this study indicated a higher effectiveness in poststroke gait training that used an electromechanical gait trainer compared with conventional overground gait

			upright (supported or unsupported) for 1 minute, FAC <3; no skin allergy, ; cardiac pacemaker, ; aphasia or cognitive deficit with inability to follow commands, ; severe hip/knee/ankle contracture or orthopedic problem influencing PROM	assistance of knee extension, verbal cueing head and trunk movements. Optional rest beak of 1-3 minutes. GT + FES: GT as above, with FES simultaneously of quadriceps and peroneal nerve. Rectangular pulse, pulse width 400 µs with rising edge and falling edge ramp set as 0.3 seconds, intensity adjusted. C: Conventional therapy, including stretching exercise based on PNF and Bobath concepts, cardiovascular exercises, strengthening exercise, ADL training, overground walking with or without walking aid or orthosis and with manual assistance from therapist depending on subject's abilities. Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.		training. The training effect was sustained through to the 6-month follow-up after the intervention.
Hidler et al 2009	4	63 (33/30)	Age: 59.9±11.3 yr Type: first isch/hem Time since onset: 110.9±62.5 d Inclusion: <6 mos post stroke, ambulate 5 m without physical assistance at self-selected speed 0.1-0.6 m/s, no severe cardiac disease (New York Heart Association classification II-IV), no uncontrolled hypertension/ seizures/ diabetes	Comparison: Robotic-assisted (GT) vs. control (C) GT: Lokomat training initially with BWS 40%, foot lifter and 1.5 km/h. Instructed to follow the stepping patterns. Intensity increased by progressively changing walking speed, level of BWS and duration of continuous walking. Ultimate goal to walk for 45 min, no BWS at 3.0 km/h and 0% guidance. Biofeedback and verbal encouragement provided. C: Conventional gait training with goal to facilitate improvements in walking ability, characterized by improved walking speed, endurance, postural stability, and symmetry. Impaired individuals: static and dynamic postural tasks, trunk positioning, improving lower and upper extremity ROM, overground walking. Higher functioning: higher-level balance and gait activities. Treadmill training up to 15 minutes as deemed appropriate. Intensity: max 24 sessions, 45 min/d, 3 d/wk, during 8-10 wk. Treatment contrast: 0 h.	5MWT comf, 6MWT, BBS, FAC, NIHSS, MAS*, RMI, FAI, SF-36, cadence Measured at baseline, 12 and 24 sessions and 3 mos (follow-up)	For subacute stroke participants with moderate to severe gait impairments, the diversity of conventional gait training interventions appears to be more effective than robotic-assisted gait training for facilitating returns in walking ability.
Lewek et al 2009 Subgroup Hornby et al 2008	5	19 (10/9)	Age: 52±12 yr Type: isch/hem Time since onset: 45±56 mos Inclusion: >6 mos post stroke, walk >10 m overground without physical assistance at speeds ≤0.8 m/s at self-selected velocity, no significant cardiorespiratory/ metabolic disease	Comparison: Robotic-assisted (GT) vs. control (C) BWS 30-40% decreased with 10% increments per session as tolerated without substantial knee buckling or toe drag. Start at 2.0 km/h, increased by 0.5 km/h every 10 min as tolerated to 3.0 km/h and remained there for subsequent visits. Bloodpressure <220/110 mm Hg and 85% age predicted HR. Rest breaks provided as necessary. GT: Continuous symmetrical stepping assistance using Lokomat, with visual feedback of bilateral hip and knee torques, encouraged to generate maximal effort. C: PT provided manual facilitation at paretic limb, only if necessary to ensure continuous walking. Visual feedback from mirror and verbal encouragement. Lower extremity orthosis removed if stepping could proceed within minimal risk of orthopedic injury. Intensity: 12 sessions, 30 min/d. Treatment contrast: 0 h.	Walking speed comf, cadence, stride length, joint kinematics Measured at baseline and after 12 sessions	Coordination of intralimb kinematics appears to improve in response to locomotor training with therapist assistance as needed. Fixed assistance, as provided by this form of robotic guidance during locomotor training, however, did not alter intralimb coordination.
Peurala et al 2009	5	47 (17/20/10)	Age: 65.7±9.2 yr Type: first/rec* isch/hem Time since onset: 8.6±2.3 d Inclusion: FAC ≤3, voluntary movement affected leg, BI 25-75, no unstable cardiovascular disease	Comparison: Gait trainer (GT) vs. overground walk (WALK) vs. control (C) GT: Walk 20 min in 1 h with a GT with BWS and motor-driven footplates, progressed by increasing speed and decreasing amount of BWS. In addition to gait-oriented PT (55 min/d). WALK: Walk overground for 20 min in 1 h with 1-2 PTs using individual walking aid, progressed by increasing speed and decreasing amount of manual guidance and reliance on walking aids. In addition to gait-oriented PT (55 min/d). C: Often transferred to health centre, where they received 1-2 PT sessions daily, but not with same intensity. Intensity: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: GT vs. WALK: 0 h. GT/WALK vs. C: ??	FAC, 10MWT max, MMAS*, RMA gross movements, RMA lower limb function plus trunk control, 6MWT, RMI Measured at baseline and 3 wk and 6 mos (follow-up)	Exercise therapy with walking training improved gait function irrespective of the method used, but the time and effort required to achieve the results favor the gait trainer exercise. Early intensive gait training resulted in better walking ability than did conventional treatment.
Schwartz et al 2009	6	67 (37/30)	Age: 62±8.5 yr Type: first isch/hem Time since onset: 21.6±8.7 d Inclusion: pre stroke independent ambulation, NIHSS 6-20, <3 mos post stroke; no prior stroke,	Comparison: Gait trainer (GT) vs. Conventional (C) GT: Lokomat, maximum speed tolerated, BWS 50% decreasing 10% per session as tolerated without substantial knee buckling or toe drag. In addition to regular PT (30 min/d, 5 d/wk, during 6 wk). C: Gait training focusing on trunk stability and symmetry, step initiation, weight support on paretic leg, walk some steps with help of therapist. In addition to regular PT (30 min/d, 5 d/wk, during 6 wk). Intensity: GT and gait training: 30 min/d, 3 d/wk, during 6 wk.	FAC, NIHSS, FIM, SAS 10MWT max, TUG, 2MWT, stair climb test Measured at baseline and 6 wk	At the end of a 6-week trial, locomotor therapy with the use of robot-assisted gait training combined with regular PT produced promising effects on functional and motor outcomes in patients after subacute stroke as compared with regular physiotherapy alone.

			hemodynamic instability, pressure sores lower limbs	Treatment contrast: 0 h.		
Westlake et al 2009	6	16 (8/8)	Age: 58.6±16.9 yr Type: first isch/hem Time since onset: 43.8±26.8 mos Inclusion: >6 mos post stroke, walking speed >0.3 m/s, no unstable cardiovascular/ orthopedic/ neurological conditions, no uncontrolled diabetes	Comparison: Gait trainer (GT) vs. Control (C) 2-3 minute rest period was provided after 15 min. Speed <0.69 m/s in slow group and above 0.83 in fast group. Progress speed with increments of 0.2 km/hr every 5 min as long as good gait quality was observed. BWS initiated at 35% and decreased with increments of 5% if maximal speed was reached. Train without ankle-foot orthosis, reduced assistance once safety was no longer a concern, and rest periods provided if gait quality detoriated, use handrail strongly discouraged. Visual feedback via full-length mirror. GT: Train in Lokomat with robotic orthosis, 100% bilateral guidance, verbal encouraged to actively step in conjunction with the movement presented. C: Body weight-supported treadmill training with 1-2 PT's who provided manual guidance throughout gait cycle, and verbal and visual cues to normalize stepping kinematics. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Walking speed comf and max, step length, 6MWT, FMA leg, BBS, short physical performance battery Measured at baseline and 4 wk	Results suggest that Lokomat training may have advantages over manual-BWSTT following a modest intervention dose in chronic hemiparetic persons and further, that our training speeds produce similar gait improvements.
Fisher et al 2011	6	20 (10/10)	Age: 60±14 yr Type: ?? Time since onset: 57±73 d Inclusion: 18-80 yr; no diseases that impair mobility, severe congestive heart failure with ejection fraction <30%, unstable angina requiring medications, intarthecal baclofen pump implantation <6 wk, active infection, >135 kg, pregnancy	Comparison: Gait trainer (GT) vs. Conventional (C) GT: Start with goal-oriented PT (30 min, see below), followed by robot-assisted gait training with HealthSouth AutoAmbulator. C: Goal-oriented PT consisting of stretching and strengthening exercises affected lower extremity, overground walking exercises, using neurofacilitation techniques (60 min). PT applying appropriate manual assistance when needed. Intensity: 24 sessions, 60 min/d, 5 d/wk, during 6 wk. Reduced to 3 d/wk when discharged. Treatment contrast: 0 h.	8MWT, 3MWT, Tinetti balance Measured at baseline and 6 wk	Robot-assisted gait training may provide improvements in balance and gait comparable with conventional physical therapy.
Morone et al 2011	5	48 (12/12/12/12)	Age: 55.58±13.35 yr Type: first/rec isch/hem Time since onset: 19.54±12.53 d Inclusion: FAC <3	Comparison: Electromechanically assisted training (GT) vs. control (C) GT: Robotic sessions with BWS in which 1 PT manually assisted knee flexion and extension and verbally encouraged to perform a task with correct posture. Walking sped initially 1-1.5 km/h and increased as soon as possible in accordance with comfortable gait. BWS 0-50%, hands on rail for balance. Rest period if required. In addition to standard PT focused on facilitation of movements paretic side, upper-limb exercises, improving balance, standing, sitting and transferring (5 d/wk). C: Walking training, with focus on trunk stabilization, weight transfer to the paretic leg, walk between parallel bars, if necessary helped by 1-2 PT and walking aids. In addition to standard PT (5 d/wk). Intensity: 30 min, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FAC, MAS, RMI, TCT, CNS, BI, mRS, 6MWT, 10MWT comf Measured at baseline and 4 wk and discharge (follow-up)	Robotic therapy combined with conventional therapy may be more effective than conventional therapy alone in patients with greater motor impairment during inpatient stroke rehabilitation.
Chang et al 2012	6	37 (20/17)	Age: 55.5±12.0 yr Type: first isch/hem Time since onset: 16.1±4.9 d Inclusion: <1 mos post stroke, FAC <2; not meet criteria for contraindications by ACSM, Lokomat, no musculoskeletal disease lower limb	Comparison: Gait trainer (GT) vs. control (C) GT: Gait training using Lokomat. Levels of body-weight support, treadmill speed and guidance force were adjusted for maintenance of the knee extensor on the weak side during stance phase. BWS decreased from 40-0% and guidance force from 100-0%. Speed start at 1.2 km/h, increased to 0.2-0.4 km/h per session to max 2.6 km/h. Also motor power, muscle tone, gait coordination and gait quality were considered. In addition to conventional PT session (see below; 60 min). C: Conventional therapy based on NDT techniques. Patients with poor function began with sitting and standing balance training, active transfer, sit-to-stand training, strengthening exercise. As function improved, functional gait training with device, dynamic standing balance while continuing strengthening exercises. Intensity: actual training time 40 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	VO2 peak, RER at peak, cardiovascular response (HR rest, HR peak, Peak O2 pulse, systolic blood pressure, diastolic blood pressure, RPE, VE peak, VE vs. VCO2 slope), FMA leg, MI leg, FAC Measured at baseline and 2 wk	Patients can be trained to increase their VO2 and lower-extremity strength using a robotic device for stepping during inpatient rehabilitation. This training has the potential to improve cardiopulmonary fitness in patients who are not yet independent ambulators, but that may require more than 2 weeks of continued, progressive training.

RCTs investigating Treadmill training (paragraaf F.1.9)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Pohl et al 2002	6	60 (20/20/20)	Age: 58.2±10.5 yr Type: isch/hem Time since onset: 16.2±16.4 wk Inclusion: impaired gait, hemiparesis >4 wk, MAS 0-1, FAC 3, 10MWT 5-60 sec; no exercise risk C or D ACSM criteria, heart disease, heart failure, nonsustained or sustained ventricular tachycardia, previous treadmill training, movement disorders, orthopedic or other gait influencing disorders	<u>Comparison</u>: Speed-dependent treadmill training (STT) vs. limited progressive treadmill training (LTT) vs. control (C) <u>STT</u>: STT with unweighted safety belt, no assistance in actual performance of movements. Maximum overground walking speed determined before first session. On treadmill: warm-up 5 min of half of maximum walking speed. Phase 1: belt speed increased 1-2 min to highest speed at which patient could walk safely and without stumbling, maximum speed held for 10 sec. Recovery period: pulse returned to resting level. Phase 2: if patient maintained speed and felt safe, belt increased by 10%, held for 10 sec, followed by recovery period, etc for 5 times. Belt increased every time 10%, if patient was unable, the speed was decreased during the next phase by 10%.Incine 0%. Body-weight support only allowed first 3 sessions with weight bearing no more than 10%. In addition to conventional PT (see below). <u>LTT</u>: LTT with speed increased to more than 5% of maximum initial walking speed each week. Therapist directly assisted patients in executing the walking cycle. Incline 0%. Body-weight support only allowed first 3 sessions with weight bearing no more than 10%. In addition to conventional physiotherapy (see below). <u>C</u>: Gait therapy based on principles of PNF and Bobath. In addition to conventional PT, gait training allowed (45 min/d, 2 d/wk). <u>Intensity</u>: STT/LTT: 30 min/d, 3 d/wk, during 4 wk. C: 45 min/d, 3 d/wk, during 4 wk. <u>Treatment contrast</u>: STT vs. LTT: 0 h. STT/LTT vs. C: 3 h.	10MWT max, stride length, cadence, FAC Measured at baseline, 2 and 2 wk	Structured STT in poststroke patients resulted in better walking abilities than LTT or C.
Macko et al 2005 [= Ivey 2007, 2010] [= Luft 2008]	5	61 (32/29)	Age: 63±10 yr Type: isch Time since onset: >6 mos Inclusion: no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia; ≥3 consecutive minutes treadmill walking at ≥0.22 m/s	<u>Comparison</u>: Treadmill training (TT) vs. control (C) <u>TT</u>: Treadmill training, start with 40-50% HRR for 10-20 min, progressing with 5 min and 5% HRR every 2 weeks as tolerated, to 60-70% HRR for 40 min, by increasing velocity by 0.05 m/s and incline by 1%. <u>C</u>: 13 supervised stretching movements (35 min) and low-intensity treadmill walking at 30-40% HRR (5 min). <u>Intensity</u>: ≈40 min/d, 3 d/wk, during 6 mos. <u>Treatment contrast</u>: ≈0 h.	30ft walk comf and max, 6MWT, RMI, WIQ VO_2 peak Measured at baseline, 3 and 6 mos	TT improves both functional mobility and cardiovascular fitness in patients with chronic stroke and is more effective than reference rehabilitation common to conventional care.
Ivey et al 2007	4	46 (26/20)	Age: 63±9 yr Type: ?? Time since onset: >6 mos Inclusion: asymmetry of gait with reduced stance, or reduced stance and increased swing in affected limb, with preserved capacity for ambulation with assistive device; no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia	<u>Comparison</u>: Treadmill training (TT) vs. control (C) <u>BWSTT</u>: Treadmill training with handrail, harness support and heart rate monitoring. Target aerobic intensity, start with 40-50% HRR for 10-20 min, progressing to 60-70% HRR for 40 min. <u>C</u>: Conventional PT, 13 targeted active and passive supervised movements of upper and lower body. <u>Intensity</u>: ≈40 min/d, 3 d/wk, during 6 mos. <u>Treatment contrast</u>: ≈0 h.	VO_2 peak, body weight, body fat, fat free mass, glucose values Measured at baseline and 6 mos	These preliminary findings suggest that progressive aerobic exercise can reduce insulin resistance and prevent diabetes in hemiparetic stroke survivors.
Luft et al 2008	5	71 (37/34)	Age: 63.2±8.7 yr	<u>Comparison</u>: Treadmill training vs. control (C)	10MWT max, 6MWT, VO_2	TT improves walking, fitness and recruits

			Type: first isch Time since onset: 62.5 (range 36.0-88.9) mos Inclusion: no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia; ≥3 consecutive minutes treadmill walking at ≥0.09 m/s	TT: Treadmill training with handrail, harness support and, start with 40-50% HRR for 10-20 min, progressing with 5 min and 5% HRR every 2 weeks as tolerated, to 60-70% HRR for 40 min, by increasing velocity by 0.05 m/s and incline by 1%. C: 13 supervised traditional stretching movements actively if possible or passively with a therapists' assistance. Including quadriceps, calf, hip and hamstring stretch, low back rotation and stretch, chest stretch, bridging, shoulder shrugs, abduction, and flexion, heel slides and short arc of quadriceps. Intensity: ≈40 min/d, 3 d/wk, during 6 mos. Treatment contrast: ≈0 h.	peak, fMRI Measured at baseline and 6 mos	cerebellum-midbrain circuits, likely reflecting neural network plasticity. This neural recruitment is associated with better walking. These findings demonstrate the effectiveness of TT rehabilitation in promoting gait recovery of stroke survivors with long-term mobility impairment and provide evidence of neuroplastic mechanisms that could lead to further refinements in these paradigms to improve functional outcomes.
Ivey et al 2010	4	53 (29/24)	Age: 62±8 yr Type: ?? Time since onset: >6 mos Inclusion: mild-moderate hemiparetic gait; ambulation with assistive device; no history of vascular surgery, disorders lower extremities, symptomatic peripheral arterial occlusive disease	Comparison: Treadmill training (TT) vs. control (C) TT: Walk on treadmill with handrail and harness support. Start at 40-50% HRR (10-20 min), gradually progressed to 60-70% HRR. C: Performance of PT exercises common to stroke, 13 active and passive supervised stretching movements of upper and lower body. Intensity: 40 min/d, 3 d/wk, during 6 mos. Treatment contrast: 0 h.	Blood flow leg Measured at baseline and 6 mos	Peripheral hemodynamic function improves with regular aerobic exercise training after disabling stroke.
Langhammer et al 2010	8	39 (21/18)	Age: 74±13.3 yr Type: first/rec Time since onset: 419±1034 d Inclusion: no unstable cardiac status, no problems that would prevent walking	Comparison: Treadmill (TT) vs. outdoor (O) TT: Treadmill training in flat position with hand railings. Speed started on lowest level, and increased within first minutes to working level, i.e. felt comfortable and not feeling insecure in balance or discomfort otherwise. In addition to usual PT including balance, strength, coordination training (30 min), circle training with focus on endurance, strength, flexibility and balance (60 min), group exercise training in sitting position (20 min), relaxation group (20 minutes, 2 d/wk), encouraged to do exercises on their own (30 min), group therapy session with focus on coping. O: Outdoor walking at comfortable speed and continuous with use of ordinary assistive devices when necessary. In addition to usual PT. Intensity: 30 min/d, 5 d/wk, during ±2.5 wk. Treatment contrast: 0 h. [Total applied: treadmill 106.9±136.4 min; outdoor 315.5±210.7 min]	Motor assessment scale, 6MWT max (length, speed), 10MWT max, pulse Measured at baseline and discharge	The results indicate that treadmill walking improves spatial and temporal gait characteristics more effectively than walking outdoors.
Kuys et al 2011	8	30 (15/15)	Age: 63±14 yr Type: first Time since onset: 52±32 d Inclusion: at least able to walk with stand-by help (Motor assessment scale walking item ≥2), walking speed ≤1.2 m/s, no cardiovascular problems or neurological or musculoskeletal conditions affecting walking	Comparison: Treadmill training (TT) vs. control (C) TT: Walking on treadmill (30 min excl rest) with intensity 40-60% HRR or Borg 11-14. Commenced at 40% HRR, progressing each week aiming for a 5-10% increase until 60% HRR was reached. Encouraged to use handrail, PT provided assistance if required. In addition to usual PT intervention using a task-oriented approach targeting impairments and activity limitations (60 min). C: Usual PT. Intensity: TT: 30 min/d, 3 d/wk, during 6 wk. Treatment contrast: 9 h.	10MWT comf and max, 6MWT Measured at baseline and 6 wk and 18 wk (follow-up)	Higher-intensity treadmill walking during rehabilitation after stroke is feasible and not detrimental to walking pattern and quality in those newly able to walk.
Lau et al 2011	6	26 (13/13)	Age: 69.5±11.1 yr Type: first isch Time since onset: 12.9±5.3 d Inclusion: MAS lower limb ≤1, walk on level ground without physical assistance, walk treadmill	Comparison: Speed-dependent treadmill training (SDT) vs. steady-speed treadmill training (STT) SDT: Short intervals of locomotion training with treadmill, with harness for safety, minimal hand support of rail. Initial speed based on 10MWT each session. Walk 30 s, 2 min rest, etc. If trial was completed safely, belt speed increased with 10%, if not the speed was decreased with 10%. Usually 7-8 trials in 4 minutes, speed increased with a maximum of 5 increments within one session. In addition to rehabilitation (90 min), including motor relearning,	10MWT max (velocity, cadence, stride length), BBS Measured at baseline and 2 wk	Speed-dependent treadmill training in patients with subacute stroke resulted in larger gains in gait speed and stride length compared with steady speed.

			with ≥2.2 cm/s for 30 s, no active cardiovascular disease, no comorbidity affecting gait performance	neurodevelopment techniques, integrated sensory stimulation, conventional gait training. STT: Walk on treadmill with speed adjusted according to fastest over-ground speed. No adjustment of speed throughout the session. In addition to rehabilitation. Intensity: 10 sessions, 30 min/d, during 2 wk. Treatment contrast: 0 h.		
Olawale et al 2011	4	60 (20/20/20)	Age: 56.8±6.4 yr Type: ?? Time since onset: 10.2±6.9 mos Inclusion: walk 10 m independently with or without a walking aid	Comparison: Treadmill (TT) vs. overground (O) vs. control (C) TT: Treadmill walking exercise training at a pre-determined natural safe walking speed (25 min) in addition to conventional therapy consisting of active and passive ROM, strength training and balance training, as applicable (35 min). O: Overground walking exercise training at a natural safe speed in addition to conventional therapy (35 min). C: Conventional therapy (60 min). Intensity: 60 min/d, 3 d/wk, during 12 wk. Treatment contrast: 0 h.	10MWT comf, 6MWT comf Measured at baseline, 4, 8 and 12 wk	This study indicated that treadmill and overground walking exercise training programmes, combined with conventional rehabilitation, improved walking function in an African group of adult stroke survivors.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Richards et al. 1993	RCT	27 (10/8/9) 27 of 215 patients submitted	mean: 69.1 y	iCVA sub-acute: mean 10 d + 1.9 d after stroke	Yes	Intervention: Intensive Treadmill gait training vs Intensive conventional therapy vs Routine conventional, not intense therapy E: early, intensive therapy on a treadmill and E2: early, intensive and conventional C: two control groups: C1: early, intensive and conventional therapy and C2: routine conventional, not intense therapy Intensity: E: 2 session/day (time: 1,74+ 0,15 hrs/d), C1: 2 sessions/day (time: 1,79 + 0,10 hrs/d), without locomotor activities and C2: 1 session/day (time: 0,72 + 0,10 hrs/d). During 5 wk for all groups.	FMA, BI, BBS and FMW measured at 6 wk	Early muscle and early gait retraining facilitated gait recovery; no differences between conventional groups	5 failure at questions: 3,5,6,8,9
Liston et al. 2000	RCT, A-B cross-over design	18 (8/10)	mean: 79.1 y + 6.8 y	all types chronic: days after stroke: ?	Yes	Intervention: Treadmill re-training vs conventional PT E+C: 4 wk baseline period and then in cross-over design, 4 wk of treadmill re-training and 4 wk of conventional physiotherapy (randomised order) Intensity: 3d/wk; each session lasting up to 60 min. during 12 wk (3 x 4-wk-period)	SST, TMW, OLST, NHPT and EADL,; Measured weekly during the 12-wk study-period and at 6 wk after ending	No difference between the effects of conventional physiotherapy and treadmill re-training on the gait of patients with higher-level gait disorders associated with cerebral multi-infarct states	7 failure at questions: 3,5,6
Laufer et al. 2001	RCT	29 (15/14) 14% drop-outs, 25 (13/12) completed the study; 29 of 71patients submitted in the study	mean: 68 y +7.7 y	First stroke: iCVA and hCVA post-acute: mean: 34.2 + 19.3 d after stroke	Yes	Intervention: Treadmill training without PBWS vs Floor walking without PBWS E+C: gait training at a comfortable speed Intensity: 5d/wk during 3 wk (=15 sessions); 4-8 minutes (excluding rest periods)	FAC, SBT, TMW and gait parameters (stride length, % of swing and stance periods) measured twice at 3 wk interval (pre- and post intervention)	Acute stroke patients with very limited gait abilities are well able to tolerate treadmill training without the use of BWS and treadmill training may be more effective than conventional gait training for improving some gait parameters	6 failure at questions: 3,5,6,9

Pohl et al. 2002	RCT	60 (20/20/20) 60 of 81 patients submitted	mean: 59 y + 11.7 y	iCVA + hCVA post-acute: mean 16 wk after stroke + 18.5 wk	Yes	Intervention: Treadmill gait training vs conventional gait training E: two experimental groups: E1: speed-dependent treadmill training (STT) and E2: limited progressive treadmill training (LTT) C: conventional gait training (CGT) Intensity: All groups + 3x/wk, 30-45 min. during 4 wk (total 12 training sessions)	TMW, cadance, stride length and FAC measured after 2 wk and at the end (4 wk)	Structured STT (Interval training) in post stroke patients resulted in better walking abilities than LTT or CGT	6 failure at questions: 3,5,6,9

RCTs investigating overground walking (paragraaf F.1.10)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Wall et al 1987	4	20 (5/5/5/5)	Age: 45-70 yr Type: ?? Time since onset: 18 mos – 20 yr Inclusion: discharge from rehabilitation, walk with or without cane but had reduced support phase time affected lower limb; no serious or unstable medical condition, major central sensory disorders, homonymous hemianopia, incontinence	Comparison: Exercises with different supervision A: At PT facility 10 exercises, designed hierarchically in terms of complexity. Each exercise 5 min: 2x 1.75 min 10 reps, 45 sec rest. 5 min rest after 5th and 8th exercise. At 1 mos interval most basic exercise was dropped and additional more demanding exercise was added. PT provided feedback and corrected patient. B: Identical exercises but at subject's home with supervision and correction from spouse or companion. Instructional videotapes shown to patients and companions when they visit laboratory for assessment. Booklet describing exercises. C: PT facility once a week, other time exercise at home with supervision and correction from spouse or companion. D: No therapy. Intensity: A, B, C: 1 h, 2 d/wk, during 6 mos. Treatment contrast: A vs. B. vs. C: 0 h. A, B, C vs. D: 52 h.	Walking speed, single support time, single support asymmetry ratio Measured at baseline, 1, 2, 3, 4, 5 and 6 mos and 7, 8, 9 mos (follow-up)	When each group was compared to pretest data, only walking speed was found to increase significantly, but even this improvement, seen only in the treatment groups, was inconsistent and not maintained.
Wade et al 1992	6	94 (49/45)	Age: 72 yr Type: first/rec isch/hem Time since onset: 4.7 yr Inclusion: outpatients, with reduced mobility	Comparison: Treatment (E) vs. no treatment (C) E: Treated. C: Untreated. Intensity: 5 min/d, during 3 mos. Treatment contrast: 450 min.	BI, NEADL, FAI, NHPT, RMI, 10MWT, FAC Measured at baseline, 6 wk and 3 and 6 mos.	Intervention of an experienced PT late after stroke specially improves mobility, albeit by small amount, but the effects did not seem to be maintained, perhaps because there is an underlying decline in mobility in these patients.
Dean et al 2000	5	12 (6/6)	Age 64.3±7.2 yr Type: first Time since onset: 2.1±0.5 yr Inclusion: >3 mos post stroke, able to walk 10 m independently with or without assistive device	Comparison: Circuit class leg vs. circuit class arm Leg: Practice at a series of workstations (strengthen the muscles of affected leg) as well as participating in walking races and relays with other members of the group. Arm: Same workstation training, but training was designed to improve function of the affected upper limb and was considered 'sham' lower limb training. Number of participants per group: 6. Staff: 2 PTs. Intensity: 1 h/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	10MWT, 6MWT, TUG, Step test, STS Measured at 4 wk and 2 mos (follow-up)	The experimental group demonstrated significant immediate and retained (2-month follow-up) improvement compared with control group in walking speed and endurance, force production through the affected leg during sit-to-stand and the number of repetitions of the step test.
Da Cunha Filho et al 2001	4	12 (6/6)	Age: 57.83±5.56 yr Type: ?? Time since onset: 15.67±7.66 d Inclusion: <6 wk post stroke, gait speed ≤36 m/min, FAC ≤2, stand with or without assistance, take ≥1 step with or without assistance; no comorbidity or disability preclude gait training, myocardial infarction ≤4 wk, uncontrolled health condition, severe lower extremity joint disease, obesity	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: BWSTT as part of PT; BWS start at 30%, progressively decreased if support required to facilitate proper trunk and limb alignment and transfer of weight onto hemiparetic leg was good, knee <15° flexion in stance phase. Increase speed, starting at 0.01 m/s with increments of 0.01 m/s, when usual step length could be taken at higher speed. Stair climbing, locomotion on uneven surface, training on how to handle walking devices allowed during regular intervention. PT, kinesiotherapy and OT 3 h/d. C: Gait training as part of PT; stair climbing, locomotion on uneven surface, training on how to handle walking devices allowed during regular intervention. PT, kinesiotherapy and OT 3 h/d. Intensity: 20 min/d during PT, 5 d/wk, till discharge (2-3 wk). Treatment contrast: 0 h.	FAC, FIM locomotion, VO_{2max}, HR, systolic blood pressure, diastolic blood pressure, workload, total time Measured at baseline and discharge	This pilot study suggests that supported treadmill training intervention is a promising technique for acute stroke rehabilitation.

Green et al 2002	8	170 (85/85)	Age: 72 yr Type: first/rec isch/hem Time since onset: >1 yr Inclusion: associated persisting mobility problems	<u>Comparison</u>: PT treatment (E) vs. control (C) <u>E</u>: Treated at home or in outpatient rehabilitation centres. <u>C</u>: No treatment. <u>Intensity</u>: 30 min/d, minimum 3 contacts, max 13 wk. <u>Treatment contrast</u>: ??	BI, GHQ, NEADL Measured at baseline and 6 and 12 mos after discharge	Community PT treatment for patients with mobility problems 1 year after stroke leads to significant, but clinically small, improvements in mobility and gait speed that are not sustained after treatment ends.
Lin et al 2004	6	19 (9/10)	Age: 61.4±11.2 yr Type: first/rec isch/hem Time since onset: 44.0±29.6 mos Inclusion: 1 yr post stroke, BI 5-14	<u>Comparison</u>: Home-based PT vs. control (C) <u>Home-based PT</u>: Low-intensity home based PT, mainly consisting of motor facilitation, postural control training, functional ambulation training with gait correction, ADL training. Daily exercise programs, primary caregiver counseling to foster treatment compliance. <u>C</u>: No intervention. <u>Intensity</u>: 50-60 min/d, 1 d/wk, during 10 wk. <u>Treatment contrast</u>: 550 min.	BI, STREAM Measured at baseline and 10 wk	Low-intensity home-based physical therapy specifically improves motor function in lower limbs in chronic stroke survivors. However, there are non-significant improvements in motor function in upper limbs, mobility and ADL performance.
Salbach et al 2004	8	91 (44/47)	Age: 71±12 yr Type: first/rec isch/hem Time since onset: 239±83 d Inclusion: residual walking deficit, walk 10 m independently using aid or orthotic with or without supervision, residence in community, ≤1 yr post stroke	<u>Comparison</u>: Mobility intervention vs. control (C) <u>Mobility intervention</u>: 10 walking-related tasks designed to strengthen lower extremities and enhance walking balance, speed and distance in a progressive manner: walking on treadmill, standing up, walking to, and sitting down on a chair, kicking a soccer ball against the wall, walking along a balance beam, performing step-ups, walking an obstacle course, walking while carrying an object, walking at maximal speed, walking backwards, walking up and down stairs. Challenged to maximize performance, rest when necessary. <u>C</u>: Functional upper extremity tasks done while sitting, recommended to practice these tasks at home. <u>Intensity</u>: ?? min/d, 3 d/wk, during 6 wk. <u>Treatment contrast</u>: 0 h.	6MWT, 5MWT, TUG, BBS Measured at baseline and 6 wk	Study findings support the efficacy of a task-oriented intervention in enhancing walking distance and speed in the first year post stroke, particularly in people with moderate walking deficits.
Salbach et al 2005 (=Salbach et al 2004)	8	83 (41/42)	Age: 71±11 yr Type: first/rec isch/hem Time since onset: 227±80 d Inclusion: residual walking deficit, walk 10 m independently using aid or orthotic with or without supervision, residence in community, ≤1 yr post stroke	<u>Comparison</u>: Mobility intervention vs. control (C) <u>Mobility intervention</u>: 10 walking-related tasks designed to strengthen lower extremities and enhance walking balance, speed and distance in a progressive manner: walking on treadmill, standing up, walking to, and sitting down on a chair, kicking a soccer ball against the wall, walking along a balance beam, performing step-ups, walking an obstacle course, walking while carrying an object, walking at maximal speed, walking backwards, walking up and down stairs. Challenged to maximize performance, rest when necessary. <u>C</u>: Functional upper extremity tasks done while sitting, recommended to practice these tasks at home. <u>Intensity</u>: ?? min/d, 3 d/wk, during 6 wk. <u>Treatment contrast</u>: 0 h.	ABC, 6MWT, 5MWT, BBS, TUG Measured at baseline and 6 wk	Task-oriented walking retraining enhances balance self-efficacy in community-dwelling individuals with chronic stroke. Benefits may be partially the result of improvement in walking capacity.
Pang et al 2005, 2006	8	63 (32/31)	Age: 65.8±9.1 yr Type: first isch/hem Time since onset: 5.2±5.0 yr Inclusion: >1 yr post stroke, walk >10 m independently with or without walking aid, live at home, no serious cardiac disease, no uncontrolled blood pressure (systolic >140, diastolic >90), pedal 60 rpm and raise heart rate to ≥60% of maximal heart rate	<u>Comparison</u>: Exercise program vs. control (C) <u>Exercise program</u>: Community-based fitness and mobility exercise program in groups of 9-12 participants supervised by PT, OT and exercise instructor. Including cardiorespiratory fitness and mobility (10 min, increment 5 min/wk, up to 30 min of continuous exercise; intensity started at 40-50% HRR with increment of 10% HRR ever 4 wk up to 70-80% HRR as tolerated), mobility and balance (progressed by reducing arm support, increasing speed of movement or both), leg muscle strength (progressed by increasing number of repetitions from 2x10 to 3x15, reducing arm support or both). <u>C</u>: Upper extremity program, involving training of shoulder muscle strength, elbow/wrist muscle strength and ROM, hand activities. <u>Intensity</u>: 1 h/d, 3 d/wk, during 19 wk. <u>Treatment contrast</u>: 0 h.	VO_2max, 6MWT, knee extension strength, BBS, PASIPD, femoral neck BMD Measured at baseline and 19 wk	The fitness and mobility exercise program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke. This study provided some evidence that the 19-week comprehensive exercise program could have a positive impact on bone parameters at the tibia for individuals with chronic stroke.
Peurala et al 2005	6	45 (15/15/15)	Age: 53.3±8.9 yr Type: first isch/hem	<u>Comparison</u>: Overground (O) vs. electromechanical gait trainer + functional electrical stimulation (GT-FES) vs. GT	10MWT max, 6MWT, postural sway, MAS, mMAS*, FIM	Both the BWS training and walking exercise training programs resulted in

			Time since onset: 2.6±2.4 yr Inclusion: >6 mos post stroke, slow or difficult walking, no unstable cardiovascular disease	<u>O</u>: Overground walking or over uneven terrain with individual walking aids. Progression by increasing speed. Verbally or manually guided. In addition to usual PT (55 min/d). <u>GT-FES</u>: GT with BWS and motor-driven footplates. FES with surface electrodes for 2 weakest muscles, frequency 25 Hz, pulse width 0.3ms, onset electrically synchronized to gait pattern. Progression by increasing speed, aiming to BWS <20% and decrease stimulation. Verbally or manually guided. In addition to usual PT (55 min/d). <u>GT</u>: GT as GT-FES but without FES. In addition to usual PT (55 min/d). <u>Intensity</u>: 20 min/d, 5 d/wk, during 3 wk. <u>Treatment contrast</u>: 0 h.	Measured at baseline,2 and 3 wk and 6 mos (follow-up)	faster gait after the intensive rehabilitation program. Patients' motor performance remained improved at the follow-up.
Yang et al 2005	6	25 (13/12)	Age: 63.38±7.7 yr Type: first Time since onset: 5.45±3.03 mos Inclusion: Brunnstrom stage 3-4, walk 11 m with or without walking aid or orthosis, stable medical, no comorbidity precluding gait training, no uncontrolled health condition contraindicating exercise, no gait-influencing diseases	<u>Comparison</u>: Backward training (E) vs. control (C) <u>E</u>: Backward walking according to Davies (1990): 1) take step backwards within parallel bars therapist provides assistance to move leg in correct pattern with reducing assistance, 2) subject takes over actively with only slight help, therapist facilitates walking backwards between parallel bars, 3) walk backward actively away from parallel bars, distance and speed of walking progressively increased. In addition to conventional stroke rehabilitation programme (see below). <u>C</u>: Conventional stroke rehabilitation programme, focused on strengthening, function and mobility activities, gait training, gait preparatory training takes approx 20-30% of each sessions time (40 min/d, 3 d/wk, 3 wk). <u>Intensity</u>: 30 min/d, 3 d/wk, during 3 wk. <u>Treatment contrast</u>: 4.5 h.	Walking speed comf, cadence, stride length, gait cycle (time), symmetry index Measured at baseline and 3 wk	This study demonstrated that asymmetric gait pattern in patients post stroke could be improved from receiving additional backward walking therapy.
Yang et al 2007	7	25 (13/12)	Age: 59.46±11.83 yr Type: ?? Time since onset: 4.08±3.13 yr Inclusion: ≥1 yr post stroke, gait velocity >58 cm/s, walk 10 m independently without an assistive device, functional use involved upper extremity, no uncontrolled health condition for which exercise is contraindicated	<u>Comparison</u>: Ball exercise training vs. control (C) <u>Ball exercise training</u>: Training based on dual-task concept, walking while manipulating either 1 or 2 balls. Variable practice for walking condition involved walking forward, backward, circular route, S-shaped route. <u>C</u>: No rehabilitation training. <u>Intensity</u>: 20 min/d, 3 d/wk, during 4 wk. <u>Treatment contrast</u>: 4 h.	Walking speed comf, cadence, stride time, stride length, temporal symmetry index [tested at two conditions: 1. preferred waling, 2. walking while carrying a tray with glasses] Measured at baseline and 4 wk	The dual-task-based exercise program is feasible and beneficial for improving walking ability in subjects with chronic stroke.
Hidler et al 2009	4	63 (33/30)	Age: 59.9±11.3 yr Type: first isch/hem Time since onset: 110.9±62.5 d Inclusion: <6 mos post stroke, ambulate 5 m without physical assistance at self-selected speed 0.1-0.6 m/s, no severe cardiac disease (New York Heart Association classification II-IV), no uncontrolled hypertension/ seizures/ diabetes	<u>Comparison</u>: Robotic-assisted (GT) vs. control (C) <u>GT</u>: Lokomat training initially with BWS 40%, foot lifter and 1.5 km/h. Instructed to follow the stepping patterns. Intensity increased by progressively changing walking speed, level of BWS and duration of continuous walking. Ultimate goal to walk for 45 min, no BWS at 3.0 km/h and 0% guidance. Biofeedback and verbal encouragement provided. <u>C</u>: Conventional gait training with goal to facilitate improvements in walking ability, characterized by improved walking speed, endurance, postural stability, and symmetry. Impaired individuals: static and dynamic postural tasks, trunk positioning, improving lower and upper extremity ROM, overground walking. Higher functioning: higher-level balance and gait activities. Treadmill training up to 15 minutes as deemed appropriate. Intensity: max 24 sessions, 45 min/d, 3 d/wk, during 8-10 wk. <u>Treatment contrast</u>: 0 h.	5MWT comf, 6MWT, BBS, FAC, NIHSS, MAS*, RMI, FAI, SF-36, cadence Measured at baseline, 12 and 24 sessions and 3 mos (follow-up)	For subacute stroke participants with moderate to severe gait impairments, the diversity of conventional gait training interventions appears to be more effective than robotic-assisted gait training for facilitating returns in walking ability.
Peurala et al 2009	5	47 (17/20/10)	Age: 65.7±9.2 yr Type: first/rec* isch/hem Time since onset: 8.6±2.3	<u>Comparison</u>: Gait trainer (GT) vs. overground walk (WALK) vs. control (C) <u>GT</u>: Walk 20 min in 1 h with a GT with BWS and motor-driven footplates, progressed by increasing speed and decreasing amount of BWS. In addition to	FAC, 10MWT max, mMAS*, RMA gross movements, RMA lower limb function plus trunk	Exercise therapy with walking training improved gait function irrespective of the method used, but the time and effort

			d Inclusion: FAC ≤3, voluntary movement affected leg, BI 25-75, no unstable cardiovascular disease	gait-oriented PT (55 min/d). WALK: Walk overground for 20 min in 1 h with 1-2 PT's using individual walking aid, progressed by increasing speed and decreasing amount of manual guidance and reliance on walking aids. In addition to gait-oriented PT (55 min/d). C: Often transferred to health centre, where they received 1-2 PT sessions daily, but not with same intensity. Intensity: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: GT vs. WALK: 0 h. GT/WALK vs. C: ??	control, 6MWT, RMI Measured at baseline and 3 wk and 6 mos (follow-up)	required to achieve the results favor the gait trainer exercise. Early intensive gait training resulted in better walking ability than did conventional treatment.
Dean et al 2010, Ada et al 2010	8	126 (64/62)	Age: 70±9 yr Type: first Time since onset: 18±8 d Inclusion: <28 d post stroke, MAS* item 5 (walking) ≤1; no brainstem signs, unstable cardiac status, pre-morbid conditions precluding them from rehabilitation	Comparison: Overground walking (O) vs. body weight-supported treadmill training (BWSTT) O: Assisted overground walking, aids were part of intervention. If too disabled to walk: standing, weight shifting, stepping forwards and backwards. Increase speed and reduce assistance if participant could walk with one therapist. In addition to intervention for lower limb (e.g. strengthening, sitting, standing up) up to 60 min/d) and multidisciplinary rehabilitation. BWSTT: BWSST with initial support that knee was <15° extension in mid-stance, initial speed so that therapist could assist leg to swing while maintaining reasonable step length. Of too disabled: step on spot. Reduce BWS if 1) swing affected leg without help; 2) maintain straight knee during stance phase without hyperextension; 3) maintain adequate step length without help. Speed of 0.4 m/s without BWS, 10 min devoted to overground walking. In addition to intervention for lower limb (e.g. strengthening, sitting, standing up) up to 60 min/d and multidisciplinary rehabilitation. Intensity: <30 min/d, 5 d/wk, till independent gait was reached or discharge. Treatment contrast: 0 h.	10MWT, 6MWT, walking perception, falls, AAP (community participation), independent gait, discharge destination Measured at baseline and 6 mos	Treadmill training with body weight support results in better walking capacity and perception of walking compared to overground walking without deleterious effects on walking quality. Treadmill walking with body weight support is feasible, safe, and tends to result in more people walking independently and earlier after stroke.
Sungkarat et al 2010	7	35 (17/18)	Age: 52.12±7.12 yr Type: first Time since onset: 3.94±4.79 mos Inclusion: OPS 3.2-5.2, walk ≥10 m without assistance, no comorbidity precluding gait training, MAS <3, no neglect	Comparison: Insole show wedge (E) vs. control (C) E: Conventional stroke rehabilitation programme including neuromuscular facilitation techniques, therapeutic exercises, balance and functional training (30 min). Gait training including pre-gait activities, stepping, strengthening of lower extremities and practice of walking overground with and without manual and verbal guidance, with use of Insole Shoe Wedge and Sensors which provides somatosensory and auditory feedback during standing (weight bearing) and gait training (amount of time non-paretic limb in swing phase) (30 min). C: Conventional stroke rehabilitation programme and gait training (see above), but without insole wedge. Intensity: 60 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Walking speed comf, step length asymmetry, single support time, BSS, TUG, loading paretic leg during stance Measured at baseline and 3 wk	Gait retraining using the Insole Shoe Wedge and Sensors set-up was more effective in restoration of gait speed, standing and walking symmetry and balance than a conventional treatment programme. These results indicate the benefit of implementing feedback during gait retraining.
Chang et al 2011	6	37 (20/17)	Age: 55.5±12.0 yr Type: first isch/hem Time since onset: 16.1±4.9 d Inclusion: <1 mos post stroke, FAC <2; not meet criteria for contraindications by ACSM, Lokomat, no musculoskeletal disease lower limb	Comparison: Conventional gait training (C) vs. Gait trainer (GT) C: Conventional therapy based on NDT techniques. Patients with poor function began with sitting and standing balance training, active transfer, sit-to-stand training, strengthening exercise. As function improved, functional gait training with device, dynamic standing balance while continuing strengthening exercises. GT: Gait training using Lokomat. Levels of body-weight support, treadmill speed and guidance force were adjusted for maintenance of the knee extensor on the weak side during stance phase. BWS decreased from 40-0% and guidance force from 100-0%. Speed start at 1.2 km/h, increased to 0.2-0.4 km/h per session to max 2.6 km/h. Also motor power, muscle tone, gait coordination and gait quality were considered. In addition to conventional PT session (see below; 60 min). Intensity: actual training time 40 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	VO_2 peak, RER at peak, cardiovascular response (HR rest, HR peak, Peak O_2 pulse, systolic blood pressure, diastolic blood pressure, RPE, VE peak, VE vs. VCO_2 slope), FMA leg, MI leg, FAC Measured at baseline and 2 wk	Patients can be trained to increase their VO2 and lower-extremity strength using a robotic device for stepping during inpatient rehabilitation. This training has the potential to improve cardiopulmonary fitness in patients who are not yet independent ambulators, but that may require more than 2 weeks of continued, progressive training.
Morone et al 2011	5	48 (12/12/12/12)	Age: 55.58±13.35 yr Type: first/rec isch/hem Time since onset: 19.54±12.53 d Inclusion: FAC <3	Comparison: Conventional gait training (C) vs. Electromechanically assisted training (GT) C: Walking training, with focus on trunk stabilization, weight transfer to the paretic leg, walk between parallel bars, if necessary helped by 1-2 PT and walking aids. In addition to standard PT (5 d/wk).	FAC, MAS, RMI, TCT, CNS, BI, mRS, 6MWT, 10MWT comf Measured at baseline and 4 wk and discharge (follow-up)	Robotic therapy combined with conventional therapy may be more effective than conventional therapy alone in patients with greater motor impairment during inpatient stroke rehabilitation.

				GT: Robotic sessions with BWS in which 1 PT manually assisted knee flexion and extension and verbally encouraged to perform a task with correct posture. Walking sped initially 1-1.5 km/h and increased as soon as possible in accordance with comfortable gait. BWS 0-50%, hands on rail for balance. Rest period if required. In addition to standard PT focused on facilitation of movements paretic side, upper-limb exercises, improving balance, standing, sitting and transferring (5 d/wk). Intensity: 30 min, 5 d/wk, during 4 wk. Treatment contrast: 0 h.		
Olawale et al 2011	4	60 (20/20/20)	Age: 56.8±6.4 yr Type: ?? Time since onset: 10.2±6.9 mos Inclusion: walk 10 m independently with or without a walking aid	Comparison: Overground (O) vs. treadmill (TT) vs. control (C) O: Overground walking exercise training at a natural safe speed in addition to conventional therapy (35 min). TT: Treadmill walking exercise training at a pre-determined natural safe walking speed (25 min) in addition to conventional therapy consisting of active and passive ROM, strength training and balance training, as applicable (35 min). C: Conventional therapy (60 min). Intensity: 60 min/d, 3 d/wk, during 12 wk. Treatment contrast: 0 h.	10MWT comf, 6MWT comf Measured at baseline, 4, 8 and 12 wk	This study indicated that treadmill and overground walking exercise training programmes, combined with conventional rehabilitation, improved walking function in an African group of adult stroke survivors.
Patil et al 2011	2	16 (8/8)	Age: ?? Type: first Time since onset: >6 mos Inclusion >6 mos, Brunnstrom stage 3-5, ambulatory	Comparison: Thera-Band elastic resistance-assisted gait training (E) vs. control (C) E: Thera-band Elastic Resistance Assisted Gait training with a special technique of the Thera-band wrapped around the distal foot, lower leg, back of the knee and front of the tigh to assist in the swing phase, foot placement in stance phase, dorsiflexion and eversion. Therapist continues to guard the patient by holding the gait belt, opposite hand free to manage the resistive band. In addition to OT (see below). C: Gait activities working on different phases of gait or walking with assistance of the therapist. OT based on NDT techniques: preparation, facilitate movements, weight bearing unaffected leg, pelvic tilts, trunk rotations, bridging, activities for isolated movements (45 min/d, 3 d/wk, during 6 wk). Intensity: 15 min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	WGS, RMI Measured at baseline, 3 and 6 wk	The use of Thera-Band Elastic Resistance-Assisted Gait Training contributed to faster recovery as compared to the control group. Functionally patients showed improvement as compared to conventional therapy.

RCTs investigating rhythmic auditory stimulation (RAS) (paragraaf F.1.11)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Schauer et al 2003	3	23 (12/11)	Age: 59±12 yr Type: ?? Time since onset: 53 d Inclusion: MCA stroke, execute at least 7 tasks of RMA gf, walk 20 min without assistive device	Comparison: Musical motor feedback (MMF) vs. control (C) MMF: MMF device, consisting of sensor insoles and MIDI standard fixed to the belt. Music was played at an adjustable speed, estimated from time interval between two consecutive heel-strikes. Music presented via plugged headphones. In addition to PT (see below). C: Warming up and common exercises, e.g. slow walking with support of parallel bars and handrails, stepping sideways and backwards. PT according to NDT principles (45 min/d). Intensity: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Gait speed, stride length, cadence, symmetry deviation, heel-on-to-off distance Measured at baseline and 3 wk	MMF improves the stroke patient's walk in selected parameters more than conventional gait therapy.
Argstatter et al 2007	4	40 (20/20)	Age: 69.2±9.5 yr Type: isch/hem Time since onset: 20.7±10.2 d Inclusion: isch/hem	Comparison: Rhythmic auditory stimulation (RAS) vs. control (C) E: Music therapy to improve walking, consisting of 1) walk in synchronization to rhythm on basis frequency, 2) increase rhythm 5-10% during walking, 3) systematic fading of rhythm, and if applicable 4) advanced gait training. In addition to conventional therapy (30 min/d, daily). C: PT gait training, in addition to conventional therapy. Intensity: 30 min/d, daily, during 3 wk. Treatment contrast: 0 h.	Walking speed, cadence, stride length, gait cycle, symmetry Measured at baseline and 3 wk	RAS proved to be an efficient rehabilitative intervention.
Jeong et al 2007	5	33 (16/17)	Age: 58.0±7.192 yr Type: isch/hem Time since onset: 5.437±4.530 yr Inclusion: >6 mos post stroke, MRC 2-4, intact auditory function; no previous participation in rehabilitation program	Comparison: Rhythmic auditory stimulation (RAS) vs. control (C) RAS: RAS music-movement program at public health center, including 1) preparatory activities; 2) main activity, dynamic rhythmic motions involving whole body, starting with the upper and lower limbs and moving toward the upper body, main exercise incorporated repetitive movements such as sitting on a chair, standing up, walking, walking in a circle, shaking an egg shaker and playing percussion instruments; 3) wrap-up activities with feedback and instruction on how to continue RAS at home, share feelings and concerns; 4) telephone follow-up once a week, given RAS tape and instructions. C: Referral information about usual care available in surrounding community. Intensity: 2 h/wk, during 8 wk. Treatment contrast: ??	ROM, mood states, interpersonal relationships, QoL Measured at baseline and post intervention	Participants in the experimental group gained a wider range of motion and flexibility, had more positive moods, and reported increased frequency and quality of interpersonal relationships.
Thaut et al 2007	7	78 (43/35)	Age: 69.2±11 yr Type: isch/hem Time since onset: 21.3±11 d Inclusion: complete 5 stride cycles with handheld assistance	Comparison: Rhythmic auditory stimulation (RAS) vs. control (C) RAS: Walk using metronome and specifically prepared music tapes. After initial cadence assessment, cuing frequencies were matched to gait cadence for (15 min), increased in 5% increments as kinematically indicated without compromising postural and dynamic stability (15 min), practice adaptive gait patterns (15 min), fading cues intermittently to train for independent carryover (15 min). C: Train walking following NDT and Bobath principles and similar instructions about gait parameters to practice, but without RAS. Intensity: 30 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Walking speed, stride length, cadence, symmetry Measured at baseline and 3 wk	The data show that after 3 weeks of gait training, RAS is an effective therapeutic method to enhance gait training in hemiparetic stroke rehabilitation. Gains were significantly higher for RAS compared to NDT/Bobath training.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age + SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Mandel et al. 1990	RCT	37 (13 / 13 / 11) with various classifications of lower limb deficits and who no longer receiving any treatment aimed at improving their gait	mean: 56.5 y. + 13.4 y., range 22-80y.	type: all chronic: mean 32 mo. + 24.3 mo. after stroke	No	Intervention: comparison of additional rhythmic positional BF and EMG BF vs no-treatment. E: 2 experimental groups received standardized BF sessions during 6 wk while sitting, standing and walking; difference between groups being the nature of BF (EMG or RP) in the second 6 wk - period: E1) EMG feedback during active ankle movements, E2) received RP feedback only at the precise points of heel-off and swing-through to reinforce the timing. C: after assessment no treatment during 12 wk RP-characteristics: the frequency of pacing, in cycles per second, was set upon the rate of alternation of dorsiflexion and plantar flexion excursions. Intensity: 2x/wk,min=?, 2 x 6 wk; 24 sessions in 12 wk	Active ROM (ankle) and gait speed measurements at 6 and 12 wk and at 3 mo follow-up	The subjects receiving rhythmic positional biofeedback significantly increased their walking speeds relative to other groups at 12 wk and after follow-up (3 mo), without any increase in subjectively reported energy cost.	3 failure at the questions: 3,4,5,6,8,9, 11
Thaut et al. 1997	RCT	20 (10 / 10) with lower limb spasticity	mean: 73.3 y. + 7.5 y.	type: iCVA and hCVA sub-acute: mean 16 d. + 4 d. after stroke	Yes	Intervention: comparison of additional rhythmic auditory stimulation and conventional PT vs conventional PT E: gait training by using a metronome or specifically prepared music tapes played over headsets. C: conventional PT for gait training based on NDT RAS-characteristics: the rhythm frequency was matched to the gait cadence of the patient for the 1st quarter of the session; during 2nd and 3rd the frequency increased 5-10% and the last quarter was spent with RAS intermittently faded to train for independent carry-over of improved gait patterns. Intensity: 2x/d, 30 min. each, 5d/wk for 6 wk	Stride parameters, BI, FMA and BBS measured at 6 wk	RAS is an efficient tool to enhance efforts in gait rehabilitation with acute stroke patients. Rhythmic facilitation of gait training significantly improved gait velocity and stride length relative to gait training without rhythmic facilitation. There is also an improvement of stride symmetry, but this was not significant different.	3 failure at the questions: 3,5,6,7,8,9, 11

RCTs investigating community walking (paragraaf F.1.12)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Lord et al 2008	6	30 (14/16)	Age: 60.7±17.6 yr Type: first/rec Time since onset: 80.3±33.0 d Inclusion: walk to letterbox and no further, independent community ambulation as primary rehabilitation goal, no medical contraindications to intensive exercise	<u>Comparison</u>: Community intervention (E) vs. control (C) <u>E</u>: Whole-task practice of functional gait activities in community environments relevant to participant. PT assistant provided treatment, PT's role to advice assistant on progression and resolve clinical issues beyond scope assistant. <u>C</u>: PT in hospital outpatient setting based on motor relearning approach, including balance, open and closed-chain exercises, selective components of the gait cycle, walking tasks, treadmill training. <u>Intensity</u>: 2 d/wk, during 7 wk. <u>Treatment contrast</u>: 0 h.	10MWT comf, 6MWT comf, ABC, SIPSO Measured at baseline and 7 wk and 6 mos (follow-up)	A community-based gait recovery programme appears a practicable alternative to routine physiotherapy, however independent community ambulation is a challenging rehabilitation goal.
Park et al 2011	6	25 (13/12)	Age: 59.38±8.46 yr Type: isch/hem Time since onset: 28.08±12.59 mos Inclusion: 6 mos – 5 yr post stroke, walking speed <0.7 m/s, no auditory or visual deficits, no conditions that may interfere with study	<u>Comparison</u>: Community training (E) vs. control (C) <u>E</u>: Community-based ambulation training, consisting of four phases in various community situations, increasing distance covered and environmental demands. In addition to functional training based on Bobath, consisting of standing up from sitting, guided movement of trunk and lower limb to simulate normal walking, forward and backward stepping, stair climbing (1 h/d, 5 d/wk). <u>C</u>: Functional training (see above), no specific walking training. <u>Intensity</u>: 1 h/d 3 d/wk, during 4 wk. <u>Treatment contrast</u>: 12 h.	10MWT max, 6MWT, community walk test, walking ability questionnaire, ABC Measured at baseline and 4 wk	The findings demonstrate that community-based ambulation training can be helpful in improving walking ability of patients with poststroke hemparesis and may be used as a practical adjunct to routine rehabilitation therapy.
Langhammer et al 2010	8	39 (21/18)	Age: 74±13.3 yr Type: first/rec Time since onset: 419±1034 d Inclusion: no unstable cardiac status, no problems that would prevent walking	<u>Comparison</u>: Outdoor walking (O) vs. treadmill training (TT) <u>O</u>: Outdoor walking at comfortable speed and continuous with use of ordinary assistive devices when necessary. In addition to usual PT. <u>TT</u>: Treadmill training in flat position with hand railings. Speed started on lowest level, and increased within first minutes to working level, i.e. felt comfortable and not feeling insecure in balance or discomfort otherwise. In addition to usual PT including balance, strength, coordination training (30 min), circle training with focus on endurance, strength, flexibility and balance (60 min), group exercise training in sitting position (20 min), relaxation group (20 minutes, 2 d/wk), encouraged to do exercises on their own (30 min), group therapy session with focus on coping. <u>Intensity</u>: 30 min/d, 5 d/wk, during≈2.5 wk. <u>Treatment contrast</u>: 0 h. [Total applied: treadmill 106.9±136.4 min; outdoor 315.5±210.7 min]	MAS*, 6MWT, 10MWT max, pulse Measured at baseline and discharge	The results indicate that treadmill walking improves spatial and temporal gait characteristics more effectively than walking outdoors.

RCTs investigating virtual reality leg (paragraaf F.1.13)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Jaffe et al 2004	5	20 (10/10)	Age: 63.2±8.3 yr Type: first Time since onset: 3.6±2.6 yr Inclusion: >6 mos post stroke, walk independently or with guard, asymmetric gait pattern, short step-length; no unstable condition precluding exercise or uncontrolled; no blindness or visual field deficit	Comparison: Virtual training (VR) vs. real training (C) Instructed to step over 10 identical stationary obstacles of a selected height and length. PT guarded and provided suggestions and encouragement, 12 trials over these 10 obstacle each session. VR: Walk on motorized treadmill at self-selected speed, harness for safety, hold handrail. Wear head-mounted display and 'rain shoe covering with foot switches', step over virtual obstacles with each foot, vibrotactile feedback by pager vibrator units directed to heel or toe of the foot that caused collision, also audio feedback. C: Wear gait-belt and step over foam obstacles in a hallway, spaced at intervals of 15-22 inch. Intensity: 6 sessions, 1h/session, during 2 wk. Treatment contrast: 0 h.	Balance, obstacle test, walking speed comf, walking speed max, gait asymmetry (comf/max), stride length (comf/max), 6MWT, step length (comf/max) Measured at baseline and 2 wk and 2 wk (follow-up)	Results demonstrate preliminary evidence for clinical effectiveness of obstacle training for improving gait velocity poststroke. In addition, these results provide evidence for enhanced clinical performance with virtual obstacle training.
You et al 2005	5	10 (5/5)	Age: 54.60±SEM 3.01 Type: isch/hem Time since onset: 11.20± SEM 2.27 mos) Inclusion: ≥1 yr post stroke, plateau max motor recovery, knee extension >60^{o}; no MAS >2, severe visual impairments	Comparison: Virtual reality (VR) vs. control (C) VR: VR system with television monitor, video camera, cyber gloves, virtual objects, scenes and large screen. Games of stepping up/down, shark bait, snowboard, to facilitate ROM, balance, mobility, stepping, ambulation skills. Exercising 1 or multiple aspects of trunk, pelvis, hip, knee and ankle movement. Each game played 5x. KR (e.g. error rate, resistive force) and KP (e.g. movement quality) at end of each game, gradually lessened. Progression by increase resistive force or speed of stimulus. C: No intervention. Intensity: 60 min/d, 5 d/wk, during 4 wk. Treatment contrast: 20 h.	FAC, mMAS* walking, fMRI Measured at baseline and 4 wk	Findings suggest that VR could induce cortical reorganization from aberrant ipsilateral to contralateral primary sensorimotor cortex. This enhanced cortical reorganization might play an important role in recovery of locomotor function in patients with chronic stroke.
Lam et al 2006	6	58 (20/16/22)	Age: 70.8±15.55 yr Type: ?? Time since onset: 4.20±3.92 yr Inclusion: no psychiatric history, consistent volitional motor response, good visual tracking, discrimination ability, figure-grounding skills, sustained attention span ≥10 min	Comparison: 2-dimensional virtual reality-based transportation skills programme (2DVR) vs. video modeling (VM) vs. control (C) 2DVR: Improve skills in using mass transit railway (MTR), by various cognitive functions and training in cognitive components skills for transfer to real-life situations using VR. VM: Improve skills in using MTR, by psycho-educational modeling, including instruction, video-modeling, demonstration, role-playing, coaching, feedback. C: No treatment. Intensity: 10 sessions. Treatment contrast: ??	MTR skills, MTR self-efficacy scale Measured at baseline and after 10 sessions	Though both training programmes were effective in training the patients with stroke, they demonstrated differential improvements in MTR skills and related self-efficacy.
Yang et al 2008	6	20 (11/9)	Age: 55.45±12.15 yr Type: first Time since onset: 5.93±4.17 yr Inclusion: ≥6 mos post stroke, limited household walker/ unlimited household walker/ most-limited community walker; no visual field deficit, comorbidity precluding gait training, uncontrolled health condition which	Comparison: Virtual reality (VR) vs. control (C) VR: VR training using visual screen with wide field of view, three-dimensional acceleration graphic card and three-dimensional auditory outputs. Walking on motorized treadmill, start at comfortable walking speed, increased by 5% each session of speed was maintained for 20 s and felt safe. Therapist beside patient, subject allowed to grasp handrail. Environment designed to simulate typical community: lane walking, street crossing, obstacles striding across, park stroll. Progression by faster walking, obstacle heights, surface slopes, increasing decision-making opportunities. C: Treadmill walking, executing different tasks: simulate stepping over obstacle, uphill and downhill walking, fast walking. Intensity: 20 min/d, 3 d/wk, during 3 wk. Treatment contrast: 0 h.	10MWT max, community walk time, WAQ, ABC Measured at baseline and 3 wk and 1 mos (follow-up)	Our results support the perceived benefits of gait training programs that incorporate virtual reality to augment the community ambulation of individuals with stroke.

			contraindicated exercise			
Kim et al 2009	7	24 (12/12)	Age: 52.42±10.09 yr Type: first isch/hem Time since onset: 25.91±9.96 mos Inclusion: ≥1 yr post stroke, plateau max motor recovery, stand 30 min, walk indoors independently about 30 m; no severe visual impairment	Comparison: Virtual reality (VR) vs. control (C) VR: VR system to empower motivation and static and dynamic balance performance associated with gait. Comprising TV monitor, video camera, cyber gloves and virtual objects, scenes and large screen. 3 games, each practiced 5 times: stepping up/down, sharkbait, snowboard game to increase ROM, balance, mobility, stepping and ambulation skills. Progression with motor-relearning principles of specificity and hierarchy of balance and locomotion. Increased resistive force, speed of stimulus, decrease of knowledge of performance and knowledge of results. In addition to conventional PT (see below). C: Conventional PT involving neurofacilitation technique (40 min/d, 4 d/wk, 4 wk). Intensity: 30 min/d, 4 d/wk, during 4 wk. Treatment contrast: 8 h.	BBS, 10MWT, mMAS*, static balance, dynamic balance, cadence, step time, swing time, stance time, single support time, double support time, step length, stride length Measured at baseline and 4 wk	This study demonstrates that virtual reality has an augmented effect on balance and associated locomotor recovery in adults with hemiparetic stroke when added to conventional therapy.
Mirelman et al 2009 and 2010	6	18 (9/9)	Age: 61.8±9.94 yr Type: ?? Time since onset: 37.7±25 mos Inclusion: partial antigravity dorsiflexion, walk 50 ft without assistance of person	Comparison: Robotic + virtual reality (VR) vs. robotic (C) VR: Sit in chair and perform (a combination of) ankle dorsiflexion/plantarflexion/inversion/eversion with six-degree of freedom force-feedback robot interfaced with a virtual reality simulation with desktop computer. Feedback by KP and KR, augmented by PT cues for direction of timing. KP every 30 seconds (direction, timing, excursion), KR end of every trial (duration performance, repetitions). Session consisted of warm-up, endurance, speed, strengthening and coordination exercises and emphasized direction of movement and timing of segmental motion. C: Similar robot exercises but without virtual reality. Intensity: 1 h/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Walking speed comf, 6MWT, PAM, gait kinematics (ROM), ankle kinetics Measured at baseline and 4 wk	Lower extremity training of individuals with chronic hemiparesis using a robotic device coupled with VR improved walking ability in the laboratory and the community better than robot training alone.

RCTs investigating circuit class training (paragraaf F.1.14)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Dean et al 2000	5	12 (6/6)	Age 64.3±7.2 yr Type: first Time since onset: 2.1±0.5 yr Inclusion: >3 mos post stroke, able to walk 10 m independently with or without assistive device	Comparison: Circuit class leg vs. circuit class arm Leg: Practice at a series of workstations (strengthen the muscles of affected leg) as well as participating in walking races and relays with other members of the group. Arm: Same workstation training, but training was designed to improve function of the affected upper limb and was considered 'sham' lower limb training. Number of participants per group: 6. Staff: 2 PT's. Intensity: 1 h/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	10MWT, 6MWT, TUG, Step test, STS Measured at 4 wk and 2 mos (follow-up)	The experimental group demonstrated significant immediate and retained (2-month follow-up) improvement compared with control group in walking speed and endurance, force production through the affected leg during sit-to-stand and the number of repetitions of the step test.
Blennerhasset et al 2004	8	30 (15/15)	Age: 53.9±19.8 yr Type: first/rec isch/hem Time since onset: 36.0±25.1 d Inclusion: ability to walk 10 m with close supervision (with or without walking aids)	Comparison: Mobility vs. Upper limb Mobility: Supervised task-related practice in circuit class format. 10 five-minute work stations, with up to four subjects in each session. Warm-up and endurance tasks using stationary bikes and treadmills, followed by functional tasks such as sit-stand, step-ups, obstacle course walking, standing balance, stretching as required and strengthening using traditional gymnasium equipment. In addition to usual interdisciplinary rehabilitation, which included PT. Upper limb: Supervised task-related practice in circuit class format. 10 five-minute workstations, with up to four subjects in each session. Warm-up (arm-ergometer) followed by functional tasks to improve reach and grasp, hand-eye coordination activities, stretching as required, and strengthening using traditional gymnasium equipment. Therapist-assisted exercises were incorporated for subjects with limited control of arm or hand movement. In addition to usual interdisciplinary rehabilitation, which included PT. Number of participants per group: ?? Staff: 1 PT. Intensity: PT: 1 h/d, 5 d/wk. Task training: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	6MWT, TUG, Step test, JTHFT, MAS* upper arm, MAS* hand Measured at baseline, 4 wk and 6 mos (follow-up)	Our findings support the use of additional task-related practice during inpatient stroke rehabilitation. The circuit class format was a practical and effective means to provide supervised additional practice that led to significant and meaningful functional gains.

Marigold et al 2005	6	48 (22/26)	Age: 68.1±9.0 yr Type: first Time since onset: 3.6±1.8 yr Inclusion: >12 mos post stroke, ability to walk with or without assistive device for >10 m, activity tolerance of 60 min with rest intervals, medically stable, BBS ≤52	Comparison: Agility program (E) vs. control (C) E: Program challenging dynamic balance with progressively increase task difficulty, emphasizing agility and multisensory approach. Warm up of walking and light stretching (5 min), tasks including standing in various postures and walking with various challenges. Additional exercises sit-to-stand, rapid knee raise while standing, standing perturbations. Eyes-closed conditions and foam surfaces incorporated in many tasks. 1:3 instructor:participant ratio in local community center. C: Focus on slow, low-impact movements consisting of stretching and weight shifting incorporating tai chi-like movements and reaching tasks. Stretching of major muscle groups while standing and on mats on the floor. Getting down and up from floor was also an exercise itself. Number of participants per group: instructor:participant ratio 1:3. Staff: 1 PT, 1 kinesiologist, 1 recreation therapist. Intensity: 60 min/d, 3 d/wk, during 10 wk. Treatment contrast: 0 h.	BBS, TUG, ABC, NHP, standing postural reflexes, falls during platform translations Measured at baseline and 10 wk and 1 mos (follow-up)	Group exercise programs that include agility or stretching/weight shifting exercises improve postural reflexes, functional balance, and mobility and may lead to a reduction of falls in older adults with stroke.
Pang et al 2005, 2006	8	63 (32/31)	Age: 65.8±9.1 yr Type: first isch/hem Time since onset: 5.2±5.0 yr Inclusion: >1 yr post stroke, walk >10 m independently with or without walking aid, live at home, no serious cardiac disease, no uncontrolled blood pressure (systolic >140, diastolic >90), pedal 60 rpm and raise heart rate to ≥60% of maximal heart rate	Comparison: Exercise program vs. control (C) Exercise program: Community-based fitness and mobility exercise program, rotate through 3 stations: 1) cardiorespiratory fitness and mobility (10 min, increment 5 min/wk, up to 30 min of continuous exercise; intensity started at 40-50% HRR with increment of 10% HRR ever 4 wk up to 70-80% HRR as tolerated); 2) mobility and balance (progressed by reducing arm support, increasing speed of movement or both); 3) leg muscle strength (progressed by increasing number of repetitions from 2x10 to 3x15, reducing arm support or both). C: Prevent learned nonuse, Improve upper extremity function through self-directed exercises. Warming-up (5 min) and cool down in which participants performed upper-extremity stretches and active or self-assisted ROM exercises. Rotate through 3 stations: 1) shoulder theraband exercises; 2) ROM, weight bearing activities and elbow/wrist exercises; 3) hand activities and	VO_2max, 6MWT, knee extension strength, BBS, PASIPD, femoral neck BMD Measured at baseline and 19 wk	The fitness and mobility exercise program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke. This study provided some evidence that the 19-week comprehensive exercise program could have a positive impact on bone parameters at the tibia for individuals with chronic stroke.

				functional training, with FES if necessary. More self-directed as trial progressed. Number of participants per group: 9-12. Staff: 1 PT, 1 OT, 1 exercise instructor. Intensity: 1 h/d, 3 d/wk, during 19 wk. Treatment contrast: 0 h.		
Yang et al 2006	8	48 (24/24)	Age: 56.8±10.2 yr Type: first Time since onset: 62.7±27.4 mos Inclusion: ?1 yr post stroke, walk 10 m dependently without an assistive device, no uncontrolled health condition for which exercise was contraindicated	Comparison: Task-oriented resistance strength training vs. control (C) Task-oriented: Task-oriented progressive resistance strength training in circuit class format. Workstations designed to strengthen muscles in bilateral lower limbs in a functionally relevant way, each workstation 5 minutes, encouraged to work as hard as possible. Given verbal feedback and instructions aimed at improving performance. Progression by increasing number of repetitions and increasing complexity. C: No rehabilitation training. Number of participants per group: ?? Staff: 1 PT. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	Muscle strength, walking speed comf, cadence, stride length, 6MWT Measured at baseline and 4 wk	The task-oriented progressive resistance strength training programme could improve lower extremity muscle strength in individuals with chronic stroke and could carry over to improvement in functional abilities.
Mead et al 2007	8	66 (32/34)	Age: 72.0±10.4 yr Type: first/rec isch/hem Time since onset: median 171 (IQR 55-287) d Inclusion: independently ambulatory, no medical contraindications to exercise training	Comparison: Exercise training (E) vs. control (C) E: Endurance and resistance training. Warm-up (15-20 min). 1) Endurance: circuit of cycle ergometry, raising and lowering 1.4-kg, 55-cm exercise ball, shuttle walking, standing chest press, stair climbing and descending (starting in wk 4), march in place between each circuit station. Duration increased from 9 min to 21 min by wk 12. Cycling increased by pedaling resistance, cadence or both with Borg 13-16. Graded cool-down and stretches. 2) Resistance training: seated upper back and triceps with elastic resistance training bands, progress repetitions from 4 using lowest-resistance band to 10 using highest-resistance band by wk 12. Pole-lifting while standing, progressing from 4 repetitions with 0.22-kg pole to 15 repetitions with 3.6-kg pole by wk 12; sit-to-stand exercise progressing from 4 to 10 repetitions by wk 12, increasing difficulty by manipulating length of pauses, angle of the knee and upper body levers. Cool-down and flexibility exercises (10-15 min). Groups up to 7	FIM, NEADL, RMI, FR, SF-36 domains, HADS, leg extensor power affected leg, leg extensor power unaffected leg, walking speed comf, walking economy (oxygen uptake), TUG, STS Measured at baseline and 3 mos and 7 mos (follow-up)	Exercise training for ambulatory stroke patients was feasible and led to significantly greater benefits in aspects of physical function and perceived effect of physical health on daily life.

				patients. C: Relaxation classes, including seated deep breathing and progressive muscular relaxation, increasing duration from 20 min to 49 min. Number of participants per group: ≤7. Staff: 1 advanced exercise instructor. Intensity: 1h15, 3 d/wk, during 12 wk. Treatment contrast: ??		
Mudge et al 2009	7	58 (31/27)	Age: median 76.0 (range 39.0-89.0) yr Type: first/rec Time since onset: median 3.33 (range 0.6-13.3) mos Inclusion: walk independently, residual gait difficulty (<1 on at least 1 of walking items of SF-36 physical function scale), no significantly health problem affecting walking ability, ≤2 falls previous 6 mos, unstable cardiac condition, uncontrolled hypertension, no congestive heart failure	Comparison: Circuit exercise group (E) vs. control (C) E: Train in groups up to 9 participants, led by 1 PT and 2 PT-students. 15 stations containing either a task-oriented gait or standing balance activity or strengthening of a lower extremity muscle to improve gait, graded to ability and progressed as tolerated. 2 min per station, followed by stretching. C: Social (4) and educational (4) sessions with up to 8 participants led by OT. Number of participants per group: ≤9. Staff: 1 PT, 2 PT-students. Intensity: E: 50-60 min, 3 d/wk, during 4 wk. C: 90 min/d, 2 d/wk, during 4 wk. Treatment contrast: 0 h.	Steps a day, 10MWT comf, 6MWT, ABC, RMI, PADS Measured at baseline and 4 wk and 3 mos (follow-up)	Circuit-based rehabilitation leads to improvements in gait endurance but does not change the amount or rate of walking performance in usual environments. Clinical gains made by the exercise group were lost 3 months later.
Holmgren et al 2010 A, B	8	34 (15/19)	Age: 77.7±7.6 yr Type: first/rec Time since onset: 139.7±37.7 d Inclusion: 3-6 mos post stroke, fall risk, walk 10 m with or without walking aid, not able to walk outdoors independently, no severe vision or hearing impairment	Comparison: High-intensive exercise program (E) vs. control (C) E: Individualized group training (6 sessions over 3 d/wk), focus on physical activity and functional performance. First session (45 min) focus on strength and balance, followed by 30 min rest. Next session (45 min) of activities related to real-life situations. Strength ≥2 sets with 8-12 maximum repetitions, balance close to balance maximum, rest not more than necessary, If Borg RPE <15 then exercises were increased. Educational group discussions about fall risk and security aspects (1 h session/wk). Individualized home-based exercise program consisting of maximum of three different exercises to perform between wk 5 and 3 mos (3 d/wk). C: Educational group discussion about hidden dysfunctions after stroke and how to cope, including communication difficulties, fatigue, depressive symptoms, mood swings, personality changes, dysphagia. No special focus on risks of falling (1 h session/wk).	SF-36, GDS-15 Measured at baseline and 5 wk BBS, BI, FES-I, FAI Measured at baseline and 5 wk and 3 and 6 mos (follow-up)	Based on these data, it is concluded that high-intensive functional exercises implemented in real-life situations should also include education on hidden dysfunctions after stroke instead of solely focus on falls and safety aspects to have a favorable impact on HRQoL. This study suggests that our program consisting of HIFE implemented in real-life situations together with educational discussions may improve performance of everyday life activities and improve falls efficacy in stroke subjects with risk of falls.

				Number of participants per group: ?? Staff: 1 PT. Intensity: 3 d/wk, during 5 wk. Treatment contrast: 30 h.		

RCTs investigating strength training (paragraaf F.1.15)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Lippert-Grüner et al 1999	2	20 (??/??)	Age: ?? Type: isch/hem Time since onset: 4-6 wk Inclusion: central arm paresis	Comparison: Strength training (E) vs. control (C) E: Training with hand-finger dynamometer of isometric maximal muscle power training of handflexion and handextension, with frequency 5 sec contraction, 5 sec relaxation. In addition to normal rehabilitation. C: Normal rehabilitation. Intensity: 5 min/d, 10 d, during 2 wk. Treatment contrast: 50 min.	Muscle strength Measured at baseline and 2 wk	Additional isometric muscle power training in patients with centrally caused arm paresis can be made efficiently, adding a useful part to therapeutical spectrum.
Kim et al 2001	7	20 (10/10)	Age: 60.4±9.5 yr Type: first isch/hem Time since onset: 4.9±3.3 yr Inclusion: ≥50 yr, ≥6 mos post stroke, walk independently >40 m with rest intervals with or without assistive device, CMMSA leg and foot ≥3, activity tolerance 45 min with rest intervals, medically stable, no significant musculoskeletal problems due due other conditions	Comparison: Maximal isokinetic strength training (E) vs. control (C) E: Warm-up of 5 reps of active alternating flexion/extension hip, knee and ankle in chair (5 min), Mild stretching paretic leg (5 min). Isokinetic strength exercises on Kin-Com Isokinetic Dynamometer, 3x 10 reps of maximal effort concentric hip flexion/extension, knee flexion/extension, ankle dorsiflexion/plantarflexion (30 min). Rest breaks of necessary. Cool down of mild stretching (5 min). C: Same warm-up and cool-down as E, with isokinetic strength exercises replaced by passive ROM exercises on same Kin-Com Isokinetic Dynamometer, with relaxing the limb, 3x 10 reps hip/knee/ankle. Intensity: 45 min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	Muscle strength, walking speed comf, walking speed max, stair climbing comf, stair climbing max, SF-36 physical health, SF-36 mental health Measured at baseline and 6 wk	Intervention aimed at increasing strength did not result in improvements in walking.
Carr et al 2003	2	40 (??/??)	Age: 30-82 yr Type: ?? Time since onset: >6 mos post stroke Inclusion: >6 mos post stroke; no history of abnormal heart conditions, uncontrolled elevated blood pressure	Comparison: Aerobic and strength training (A&ST) vs. aerobic training (C) A&ST: Aerobic training (see below). Eight strength-training exercises, including chest press, seated row, leg press, leg extension, leg curl, triceps press down, biceps curl, shoulder front raise, with free weigths and isokinetic machines. Increase strength 5% of original load at wk 6, increase 10% original load at wk 11. Finish exercise protocol with flexibility exercises. C: Aerobic training on upper and lower body ergometer. Wk 1-5: 40-50% original test Watt for 20 min; Wk 6-10: 50-60% original Watt for 30 min; Wk 11-16: 60-70% original Watt for 40 min. Finish exercise protocol with flexibility exercises. Intensity: 3 d/wk, during 16 wk. Treatment contrast: ??	VO_2max, peak torque, cholesterol, high-density lipoprotein Measured at baseline and 16 wk	Both groups demonstrated significant changes in functional strength, but the A&ST group experienced larger increases.
Moreland et al 2003	6	119 (61/58)	Age: 69.1±14.8 yr Type: first/rec Time since onset: 36.8±27.8 d Inclusion: <6 mos pos stroke, CMMSA leg 3-5, CMMSA foot 2-6; no CMMSA disability inventory >90, active arthritis, joint or muscular problems lower extremities, history spinal fracture due to osteoporosis or other	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: 9 lower extremity progressive resistance exercises with weights at the waist or on the lower extremities. Functional patterns of movements with exception of the ankle exercises. In addition to multidisciplinary treatment (see below). C: Same exercises including frequency and number of repetitions but without resistance. In addition to multidisciplinary treatment, including PT: facilitate and inhibit impaired movement, balance, motor control, stroke mat classes, gait training, gross motor skills. In two centers predominantly NDT, in other three eclectic approach. Intensity: 30 min/d, 3 d/wk, during inpatient rehabilitation. Treatment contrast: 0 h.	CMMSA disability inventory, 2MWT, MAS, adverse events Measured at baseline, 4 wk and discharge and 6 mos (follow-up)	Progressive resistance strengthening exercises as applied in our study were not effective when compared with the same exercises given without resistance.

			condition preventing strengthening exercises, uncontrolled hypertension or cardiac contraindication			
Ouellette et al 2004	7	42 (21/21)	Age: 65.8±2.5 yr Type: first Time since onset: 31.8±3.3 mos Inclusion: ≥50 yr, 6 mos to 6 yr post stroke, mild-moderate stroke (OPS), community dwelling, independent ambulation with or without assistive device, ≥2 limitations SF-36 physical, no myocardial infarction <6 mos, no symptomatic coronary artery disease, no congestive heart failure, no uncontrolled hypertension, no fracture <6 mos, no participation regular strength training or PT	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: Seated bilateral leg press, unilateral paretic and nonparetic limb knee extension on pneumatic resistance training equipment. Unilateral ankle dorsiflexion and plantarflexion using modified weight stack-pulley system. Warm-up 4 reps at 25% of 1RM, 3x 8-10 reps at 70% 1RM. Intensity adjusted biweekly. C: Bilateral ROM and upper body flexibility exercises. Intensity: 3 d/wk, during 12 wk. Treatment contrast: 0 h.	Leg press strength, ankle dorsiflexion strength, ankle plantarflexion strength, 6MWT, stair climb, chair rise, 10MWT comf, 10MWT max, LLFDI domains Measured at baseline and 12 wk	High-intensity PRT improves both paretic and nonparetic lower extremity strength after stroke, and results in reductions in functional limitations and disability.
Winstein et al 2004	6	64 (21/22/21)	Age: <35 yr n=0, 35-75 yr: n=19, ≥75: n=1 Type: first/rec isch/hem/SAB Time since onset: 16.1±7.7 d Inclusion: ??	Comparison: Strength training (ST) vs. Functional task practice (FTP) vs. control (C) ST: Resistance to available arm motion to increase strength of shoulder, elbow, wrist and hand motions, using eccentric, concentric and isometric muscle contractions. Progressed to repetitions against resistance using free weights, Theraband or grip devices for fingers. In addition to standard dose PT and OT. FTP: Systematic and repetitive practice of tasks that could be performed within the level of available voluntary motion. Progressively arranged to account for proximal-to-distal recovery patterns of reaching and grasping actions. Principles of motor learning by provision of knowledge of results and progressed task difficulty. In addition to standard dose PT and OT. C: Muscle facilitation exercises emphasizing NDT, NMS primarily for shoulder subluxation, stretching exercises, ADL including self-care where upper limb was used as assist if appropriate, caregiver training. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: FTP vs. ST: 0 h. FTP/ST vs. C: 20 h.	FIM mobility, FIM self-care, FMA arm FMA ROM, FMA pain, FMA sensory, FTHUE, isometric torque, grasp and pinch force Measured at baseline, 4 wk and 6 and 9 mos (follow-up)	Task specificity and stroke severity are important factors for rehabilitation of arm use in acute stroke. Twenty hours of upper extremity-specific therapy over 4-6 weeks significantly affected functional outcomes. The immediate benefits of a functional task approach were similar to those of resistance-strength approach, however, the former was more beneficial in the long-term.
Boissezon et al 2005	5	36 (21/15)	Age: 57.82±14.6 yr Type: isch/hem Time since onset: 15.94±18.34 mos Inclusion: ??	Comparison: Isokinetic strength training (E) vs. progressive resistance training (PRT) E: Trained using an isokinetic dynamometer in pure eccentric mode. 5 min warm-up, 3x 10 reps of maximal effort at three speeds (60, 90, 120^{o}/ sec). PRT: Conventional isotonic technique for muscular strengthening; series of 10 max repetitions, start with 2 submaximal series at 2/5 and 3/5 of maximal resistance, then as many series as could at 4/5 of maximal resistance. Intensity: 40 min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	Peak torque, MI leg, TMS spasticity, TMS motor, BI, walking speed, stair climbing Measured at baseline and 6 wk and 2.5 mos (follow-up)	Both techniques increase the power of the muscles of the knee, the functional independence without increasing spasticity.
Akbari et al 2006	5	34 (17/17)	Age: 49.3±7.1 yr Type: first Time since onset: 34.5±26.37 mos Inclusion: ≥12 mos post stroke, stand ≥30 sec with	Comparison: Strength program (E) vs. control (C) E: Functional, balance and strengthening exercises. Three parts: 1) standing, sitting balance, functional mobility, gait pattern, aerobic fitness; 2) functional exercise on principle of selective movements; 3) strengthening of sagital and frontal plane muscles affected in gait, concentric isotonic contraction of 70% of 1RM.	Strength, MAS Measured at baseline and 4 wk	Present results, in contrary with current opinions, support the effectiveness of lower limb muscle strength training to reduce the spasticity in addition to improving muscle strength in the chronic stage of stroke.

			eyes open and separate feet, no other PT program	C: Part 1 and 2 (see above). Intensity: 3 h/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.		
Yang et al 2006	8	48 (24/24)	Age: 56.8±10.2 yr Type: first Time since onset: 62.7±27.4 mos Inclusion: >1 yr post stroke, walk 10 m dependently without an assistive device, no uncontrolled health condition for which exercise was contraindicated	Comparison: Task-oriented resistance strength training vs. control (C) Task-oriented: Task-oriented progressive resistance strength training in circuit class format. Workstations designed to strengthen muscles in bilateral lower limbs in a functionally relevant way, each workstation 5 minutes, encouraged to work as hard as possible. Given verbal feedback and instructions aimed at improving performance. Progression by increasing number of repetitions and increasing complexity. C: No rehabilitation training. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	Muscle strength, walking speed comf, cadence, stride length, 6MWT Measured at baseline and 4 wk	The task-oriented progressive resistance strength training programme could improve lower extremity muscle strength in individuals with chronic stroke and could carry over to improvement in functional abilities.
Tihanyi et al 2007 [single session RCT]	6	18 (9/9)	Age: 58.0±5.2 yr Type: first isch/hem Time since onset: 28.1±9.0 d Inclusion: 14-50 d post stroke, FIM admission 60-110; no unstable angina pectoris, congestive heart failure, peripheral arterial disease	Comparison: Whole body vibration vs. sham (C) Whole body vibration: Usual, daily, conventional PT. Then stand on whole body vibration apparatus, both knees flexed 40°, grasp handlebar, shift body mass over the affected leg, and 20 Hz whole body vibration was turned on for six, 1-min bouts separated 2 min of rest. During the rest period patients sat on a chair placed next to the vibration platform. C: Exactly the same procedures, but the vibration was not turned on. Intensity: 1 session. Treatment contrast: 0 h.	Knee extensor strength Measured pre and post session	These results suggest that one bout of whole body vibration can transiently increase voluntary force and muscle activation onf the quadriceps muscle affected by stroke.
Sullivan et al 2007	7	80 (20/20/20/20)	Age: 60.6±13.7 yr Type: isch/hem Time since onset: 27.5±16.1 mos Inclusion: ambulate ≥14 m, FAC ≥2, self-selected walking speed ≤1.0 m/s; no health condition which intervenes with safe participation or exercise program, serious medical conditions, resting systolic blood pressure >180 mmHg, resting diastolic blood pressure >110 mmHg, resting heart rate >100 bpm	Comparison: Four combinations of: Body-weight-supported treadmill training (BWSTT), limb-loaded resistive leg cycling (CYCLE), lower extremity muscle-specified progressive-resistive exercises (LE-EX), upper-extremity ergometry (UE-EX) with intensity ≤80% of age-predicted maximum heart rate. BWSTT/LE-EX: - BWSTT: walk on treadmill with harness for four 5-minute training bouts, speed range 1.5-2.5 mph to achieve 20 accumulated min of walking over 1-hour session. Gait instruction in an overground setting over a 15 m distance. - LE-EX: Isotonically exercise the affected leg using external resistance (e.g. gravity, resistive tubing, cuff weights) following exercise algorithm accounted for strength and movement synergy level to determine a 10RM for 6 groups (hip flexors, hip extensors, knee flexors, knee extensors, ankle dorsiflexors, ankle plantar flexors). Each muscle group exercised for 3 sets of 10 repetitions at 80% of the 10RM. BWSTT/UE-EX: - BWSTT: see above. - UE-EX: cycle with arms on Endorphin EN-300 Hand Cycle, with resistance to level to complete 10 sets of 20RM. Forward and backward cycling alternated, assistance with hemiparetic limb by PT if necessary. BWSTT/CYCLE: - BWSTT: see above. - CYCLE: cycle on modified Biodex semi-recumbent cycle with releasable seat enabling to slide along a linear track where 10-lb bungee cords can be attached to produce extensor muscle resistance similar to a leg press machine, with goal to pedal while keeping the sliding seat from moving out of the target 'exercise region.' 10 sets of 15-20 revolutions in each session, ≥2 minutes rest between sets. Intensity: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: 0 h.	10MWT comf, 10MWT max, 6MWT Measured at baseline, 3 and 6 wk and 6 mos (follow-up)	After chronic stroke, task-specific training during treadmill walking with body-weight support is more effective in improving walking speed and maintaining these gains at 6 months than resisted leg cycling alone.
Bale et al 2008	7	18 (8/10)	Age: 60.8±13.0 yr Type: first isch/hem	Comparison: Functional strength + conventional therapy (FST) vs. conventional (C)	Weight bearing, muscle strength (knee extension,	This pilot study indicates that functional strength training of lower extremities

			Time since onset: 49.4±22.1 d Inclusion: reduced muscle strength affected leg but some motor control, sit without support; no sensory sequels, arrhythmia, uncontrolled angina pectoris or hypertension	FST: FST to improve strength lower extremities (3 d/wk), arm function and ADL (2 d/wk). FST to facilitate appropriate power in weak muscles of the affected leg in graded activities or sequences of activities, most were weight-bearing and also challenged standing balance. 10-15 repetitions maximum. In addition to multidisciplinary rehabilitation. C: Traditional training influenced by Bobath concept, focusing on normalizing muscle tone and movements affected side, symmetrical use body, relearning ADL, often using manual guiding and facilitation techniques. Use excessive muscle power avoided. In addition to multidisciplinary rehabilitation. Intensity: 50 min/d, 5 d/wk, 4 wk. Treatment contrast: 0 h.	flexion), walking speed comf, walking speed max Measured at baseline and 4 wk	improves physical performance more than traditional training.
Flansbjer et al 2008	7	24 (15/9)	Age: 61±5 yr Type: isch/hem Time since onset: 18.9±7.9 mos Inclusion: 40-70 yr, >6 mos post stroke, isolated extension and flexion knee, >15^o reduction strength paretic limb, walk without supervision ≥200 m with or without walking aid, no dysfunction impact knee muscle strength/ gait performance/ perceived participation	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: Progressive resistance training using leg extension/ curl rehab exercise machine. Warm-up stationary cycling (5 min), 5 repetitions without resistance and 5 reps at 25% of maximum load. 6-8 reps in 2 sets at low speed (30-40 s/set) with 80% of maximum load, with 2 min rest between sets. Load adjusted every to 2 wk to remain 80%. First train extensors nonparetic lower limb, followed by paretic lower limb. After 10 min rest, same procedure for flexors. Passively static stretch. PRT effective 6 min. Perform usual daily activities and training but no PRT. C: Continue usual daily activities and other forms of training, but no PRT. Intensity: 90 min/d, 2 d/wk, during 10 wk. Treatment contrast: 1800 min.	Dynamic knee muscle strength, isokinetic knee muscle strength, TUG, walking speed max, 6MWT, SIS participation Measured at baseline and 10 wk	Progressive resistance training is an effective intervention to improve muscle strength in chronic stroke.
Lee et al 2008, 2010	8	48 (12/12/12/12)	Age: 67.2±10.6 yr Type: isch/hem Time since onset: 52.4±2.2 mos Inclusion: >3 mos post stroke, >45 yr, community-based living environment, gait velocity 0.15-1.4 m/s; no significant musculotendinous or bony restrictions, complete hemiplegia leg, contraindication moderate exercise by ACSM guidelines	Comparison: Aerobic + progressive resistance training (PRT) vs. sham aerobic + PRT vs. aerobic vs. sham PRT vs. sham aerobic + sham PRT Aerobic + PRT: Leg cycling on semi-recumbent motorized isokinetic cycle ergometer with calf supports with pedaling cadence 40 rev/min, with HR wk 1-2 at 50% of VO_2peak, increased to 70% VO_2peak wk 4. PRT of lower limb extensors, knee extensors and flexors, ankle plantarflexors using pneumatic resistance equipment. Hip abductors and dorsiflexors using free weights and isometric training. 2x 8 repetitions unilaterally, start 50% basline 1RM progressed to 80% 1RM by wk 2. Sham aerobic + PRT: Sham aerobic exercise of motorized passive leg cycling. Followed by sham resistance training of leg extensors and knee flexors and extensors with minimum resistance to counter weight of machine against gravity, ankle plantarflexors, dorsiflexors and hip abductors trained without resistance Increased after each session (3%). Aerobic + sham PRT: Aerobic training and sham PRT as above. Sham aerobic + sham PRT: Sham aerobic training and sham PRT as above. Intensity: (sham) Aerobic 30 min, (sham) PRT 30 min, 30 sessions, 3 d/wk, during 10-12 wk. Treatment contrast: 0 h.	6MWT, walking speed comf, walking speed max, stair climbing power, peak power output, peak HR, peak oxygen uptake, treadmill walking physical cost index, treadmill walking oxygen cost, 1RM affected leg, 1RM unaffected leg, power affected leg, power unaffected leg, endurance affected leg, endurance unaffected leg Measured at baseline and 12 wk	Single-modality exercises targeted at existing impairments do not optimally address the functional deficits of walking but do ameliorate the underlying impairments.
Page et al 2008	5	7 (4/3)	Age: 61.29±12.3 yr Type: isch Time since onset: 44.43±24.48 mos Inclusion: >18 yr, >12 mos post stroke, PROM legs within normal limits, grade 3 hamstrings and triceps surae/ quadriceps, grade 2 gluteus maximus/ hamstrings, walk 10 m with no more assistance than	Comparison: Reciprocal leg extension exercise (E) vs. control (C) E: Perform coupled reciprocal knee extension while seated on NuStepTRS4000 Recumbent Cross Trainer (NuStep). Warm-up with legs only (6 min), run-time with increasing resistance (level 1-10) and time (10-30 min), warm-down (5 min). C: Home exercise programme written on sheet with pictures, including ankle circumduction, dorsiflexion, plantarflexion, knee extension and flexion, hip adduction and abduction. Intensity: E: 40 min/d, 3 d/wk, during 8 wk. C: 30 min/d, 3 d/wk, during 8 wk. Treatment contrast: 240 min.	FMA leg, BBS Measured at baseline and 8 wk	Impairment reductions and balance gains may be achieved using a resistance-based, reciprocal upper and lower limb locomotor training protocol.

			'close supervision'; no MAS >4, VAS >4, heterotropic ossification, fracture or history of fracture in lower limb, injections of anti-spastic drugs <3 mos, oxygen dependence, severe weight-bearing pain, life expectancy <1 yr, acute medical non-stable comorbidities			
Singh et al 2008	3	30 (15/15)	Age: 40-60 yr Type: ?? Time since onset: 3 mos Inclusion: ambulate independently without walking aids, full ROM hip/knee/ankle; no MAS >1	Comparison: Closed kinematic chain (CKC) vs. open kinematic chain (OKC) CKC: Closed chain exercises, 3x10 reps, 1 min rest between set. 3 sec rest between reps. Exercises included double one-third knee bend, single one-third knee bend, step up and down exercise. OKC: Open chain exercises, each exercise held isometrically for 6 se, with 3 sec rest between reps. Exercises included maximal static quadriceps contractions, straight leg raising, leg adduction exercises. Intensity: 30-45 min/d, 3 d/wk, during 5 wk. Treatment contrast: 0 h.	FAP, walking speed, cadence, step length, stride length:leg length ratio Measured at baseline and 5 wk	The few significantly better functional results for some of the tested parameters in the CKC group suggest that this type of exercise is more effective than the OKC program in rehabilitation of these patients.
Sims et al 2009	6	45 (23/22)	Age: 67.95±14.76 yr Type: ?? Time since onset: 13.2±4.95 mos Inclusion: >6 mos post stroke, walk ≥20 m independently; no PHQ-9 <5, depression with psychotic features, other psychiatric disorders or uncontrolled heart diseases	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: Train in small groups with core PRT program entailed moderate intensity, i.e. 3 sets of 8-10 reps, resistance 80% of 1RM, using machine weights for major upper and lower limb muscle. Resistance increased when patient was able to complete 3 sets of 10 reps. C: Usual care. Intensity: ??, 2 d/wk, during 10 wk. Treatment contrast: ??	CES-D, AQoL, SF-12, SIS, SWLS, SSS, LOT-R, generalised dispositinal optimism, Self-esteem scale, RLOC Measured at baseline and 10 wk and 6 mos (follow-up)	The intervention appeared to be feasible within a community-based setting. To optimized stroke recovery and improve the quality of life of stroke survivors, heath professionals should continue to focus on helping survivors' mental health recovery as well their physical rehabilitation.
Cooke et al 2010	7	109 (36/35/38)	Age: 71.17±10.6 yr Type: first/rec isch/hem Time since onset: 33.86±16.50 d Inclusion: MI leg≥28	Comparison: Functional strength + conventional physiotherapy (FST+CPT) vs. CPT+CPT vs. CPT FST+CPT: FST focus on repetitive, progressive resistive exercise during goal-directed functional activity. Attention to exercise/activity being performed, with verbal feedback. Progression by increase repetition and resistance. In addition to routine CPT (see below). CPT+CPT: Experimental CPT emphasizing control/quality of movement, prominence to sensory stimulation and preparation of joint and muscle alignment prior to activating muscle or a functional task. Strongly therapist hands-on, by passive movements, active assisted exercises, and/or hands-on intervention to facilitate muscle activity or functional ability. Some active exercise and repetitive practice of functional tasks included but without systematic progression. In addition to routine CPT. CPT: Routine CPT, including soft tissue mobilization, facilitation of muscle activity, facilitation of coordinated multijoint movement, tactile and proprioceptive input, resistive exercise, functional training. Intensity: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: FST+CPT vs. CPT+CPT: 0 h. FST+CPT/ CPT+CPT vs. CPT: 24 h.	Walking speed, ability to walk at 0.8 m/s or more, symmetry step time, symmetry step length, modified RMI, knee flexion peak torque, knee extension peak torque, EuroQuol healthstate, EuroQuol self-perceived health Measured at baseline and 6 wk	Results indicate advantages for extra intensity physical therapy, both CPT and FST, which reached statistical significance at outcome for walking speed, ability to walk at 0.8 m/s or more, and torque about the knee during flexion for the group receiving extra CPT.
Tihanyi et al 2010	5	26 (13/13)	Age: 58.0±4.9 yr Type: isch/hem Time since onset: 28.1±8.5 d	Comparison: Whole body vibration vs. control (C) Whole body vibration: Then stand on whole body vibration apparatus (Nemes Bosco-system), both knees flexed 40^o, grasp handlebar, shift body mass over the affected leg, and 20 Hz whole body vibration was turned on for six, 1-min	Knee extensor strength Measured at baseline and 4 wk	Selection of the effective vibration frequency depends upon the physical condition of neuromuscular system. Low vibration frequency intervention can

			Inclusion: keep balance during quite standing >2 min	bouts separated by 1 min of rest. During the rest period patients sat on a chair placed next to the vibration platform. Two persons standing next to patient giving instructions. Before starting treatment, 2 familiarizing sessions. Usual, daily, conventional therapy. C: Conventional therapy. Intensity: 3 d/wk, during 4 wk. Treatment contrast: 144 min.		increase the strength in weak muscles due to neuromuscular impairment and restricted physical activity.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age ± SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Inaba et al. 1973	RCT	77 (28 / 23/ 26), unable to walk, completed the study (44% drop-outs)	mean: 56 y	type: all, but SAH excluded post acute: < 3 mo after stroke	Yes	Intervention: progressive resistance exercises in addition to functional training and selective stretching vs functional training and selective stretching E: progressive resistance exercises: mass extension of involved lower limb in supine position on Elgin-table (5 repetitions at one-half max and 10 at max weight. C: functional training and selective stretching Intensity: 5x/wk during 4-8 wk	Leg extension strength and ADL measured at 1 and 2 mo after start intervention	Patients who received progressive resistance exercises showed made a significant improvement in ADL and the greatest improvement took place in the first month.	4 failure at the questions: 5,6,7,8,9,11
Glasser et al. 1986	RCT	20 (10 / 10)	mean: y + y, range 40-75y	type: MCA-infract postacute: mean >3 and < 6mo after stroke	No	Intervention: isokinetic training (Kinetron) vs conventional exercises E isokinetic training with Kinetron with legs; C: conventional therapeutic exercise program and gait training Intensity: 2x/wk during 5 wk	FAP and TMW	Both groups showed equal progress after the 5-wk training period. No significant difference between groups in rate of ambulation between the groups	4 failure at the questions: 3,5,6,7,8,9
Lindsley et al. 1994	RCT	19 (10 / 9)	mean: 59 y, range 38-72 y	type: subacute: mean after stroke	No	Intervention: additional strength training (Kinetron) and PT vs PT E : C: Intensity: 90 min; 5x/wk during 2 wk	Self-selected and max walking speed, step length and interlimb phasing	Walking velocity and step length tended to improve more with Kinetron training than with traditional training alone, the difference between the groups was not statistically significant.	3 failure at the questions: 3,4,5,6,9,10, 11
Teixeira-Salmela et al. 1999	RCT	13 (6 / 7), with weakness and/or spasticity in LE	mean: 67 y + 9y	type: chronic: mean 8y + 11y after stroke	Yes	Intervention: aerobic exercises and muscle strengthening vs no therapy E: aerobic exercises and muscle strengthening for LE C: no intervention Intensity: 3 d/wk; 60-90 min during 10 wk	(comfortable) walking speed, muscle strength (Cybex II), spasticity	The combined program of muscle strengthening and physical conditioning resulted in gains in all measures of impairment and disability. These gains were not associated with measurable changes of spasticity in either quadriceps or ankle plantar flexors.	3 failure at the questions: 3,4,5,6,7,8,9
Bourbonnais et al. 2002	RCT	25 (12 / 13)	mean: 46 y + 14 y	type: first CVA chronic: mean 36 mo after stroke	Yes	Intervention: force-feedback program LE vs force-feedback program UE E: force-feedback program LE C: force-feedback program UE Intensity: 3x p/w during 6 wk	FMA, 2 min walk, walking speed, TUG	The treatment of the lower limb based on force feedback produces an improvement of gait velocity	6 failure at the questions: 5,6,7,9

RCTs investigating family-mediated exercises (paragraaf F.1.16)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Wall et al 1987	4	20 (5/5/5/5)	Age: 45-70 yr Type: ?? Time since onset: 18 mos – 20 yr Inclusion: discharge from rehabilitation, walk with or without cane but had reduced support phase time affected lower limb; no serious or unstable medical condition, major central sensory disorders, homonymous hemianopia, incontinence	Comparison: Exercises with different supervision A: At PT facility 10 exercises, designed hierarchically in terms of complexity. Each exercise 5 min: 2x 1.75 min 10 reps, 45 sec rest. 5 min rest after 5th and 8th exercise. At 1 mos interval most basic exercise was dropped and additional more demanding exercise was added. PT provided feedback and corrected patient. B: Identical exercises but at subject's home with supervision and correction from spouse or companion. Instructional videotapes shown to patients and companions when they visit laboratory for assessment. Booklet describing exercises. C: PT facility once a week, other time exercise at home with supervision and correction from spouse or companion. D: No therapy. Intensity: A, B, C: 1 h, 2 d/wk, during 6 mos. Treatment contrast: A vs. B. vs. C: 0 h. A, B, C vs. D: 52 h.	Walking speed, single support time, single support asymmetry ratio Measured at baseline, 1, 2, 3, 4, 5 and 6 mos and 7, 8, 9 mos (follow-up)	When each group was compared to pretest data, only walking speed was found to increase significantly, but even this improvement, seen only in the treatment groups, was inconsistent and not maintained.
Kalra et al 2004	8	300 (151/149)	Age: median 76, IQR 70-80 Type: isch Time since onset: stroke rehab unit Inclusion: Patients: pre-existent independent ADL, medically and neurologically stable, expected to return home with residual disability Caregivers: mRS 0-2, willing and able to provide support after discharge	Comparison: Caregiver training (E) vs. control (C) E: Caregivers received 1) instruction by appropriate professionals on common stroke related problems and their prevention, management of pressure areas, prevention of bed sores, continence, nutrition, positioning, gait facilitation, advice on benefits and local services, and 2) hands-on training in lifting and handling techniques, facilitation of mobility and transfers, continence, assistance with personal ADL and communication. Training started when patients' rehabilitation needs had stabilized and discharge was contemplated. In addition to conventional care (see below). C: Conventional care, consisting of 1) information on stroke and consequences, prevention, management options; 2) involvement in goal setting for rehabilitation and discharge planning; 3) encouragement to attend nursing and therapy activities to learn about patients' abilities and informal instruction on facilitation transfers, mobility, ADL; and 4) advice on community services, benefits, allowances. Intensity: 3-5 times, 30-45 min, follow-through session at home. Treatment contrast: 2 h.	Mortality, institutionalism, mRS, BI, FAI, HADS, EuroQoL, costs Caregiver burden scale, FAI, HADS, EuroQoL Measured at baseline, 3 and 12 mos	Training caregivers during patients' rehabilitation reduced costs and caregiver burden while improving psychosocial outcomes in caregivers and patients at one year.
Galvin et al 2011	8	40 (20/20)	Age: 63.15±13.3 yr Type: first isch/hem Time since onset: 18.9±2.9 d Inclusion: OPS 3.2-5.2; family member willing to participate, nominated by person with stroke as person he/she would most like to assist him, medically stable, physically able to assist in delivery of exercises	Comparison: Family-mediated exercises (FAME) vs. control (C) FAME: Program conducted at bedside with assistance of nominated family member, emphasis on achieving stability and improving gait velocity and lower limb strength. Treatment goals set weekly. Family member trained with skills necessary to carry out additional exercises. Exercise diary. In addition to routine PT as inpatient or outpatient. C: Routine PT as inpatient or outpatient. Intensity: 35 min/d, 7 d/wk, during 8 wk. (received: 227±34 min/wk) Treatment contrast: 1960 min.	mFMA leg, MAS*, BBS, walking speed; BI, NEADL, RNLI, CSI Measured at baseline and 8 wk and 2 mos (follow-up)	This evidence-based FAME intervention can serve to optimize patient recovery and family involvement after acute stroke at the same time as being mindful of available resources.

RCTs investigating cardiorespiratory training (paragraaf F.1.17)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Potempa et al 1995	4	42 (19/23)	Age: range 43-72 yr Type: ?? Time since onset: >6 mos Inclusion: no brain stem lesion, disorders that would preclude maximal exercise testing	Comparison: Aerobic exercise training (E) vs. control (C) E: Adapted cycle ergometer, with intensity gradually increasing from workload representing 30-50% of maximal effort to highest level attainable during wk 1-4, highest load maintained for further 6 wk. C: Passive exercise for ROM to body joints in systematic procedure. Intensity: 30 min/d, 3 d/wk, during 10 wk. Treatment contrast: 0 h.	FMA, weight, HR rest/ maximal exercise, systolic blood pressure, diastolic blood pressure, VO_2, VCO_2, VE, workload, exercise time, RER Measured at baseline and 10 wk	Hemiparetic stroke patients may improve their aerobic capacity and submaximal exercise systolic blood pressure response with training.
Katz-Leurer et al 2003, 2007	6, 5	92 (46/46) 64 (32/32)	Age: 61±11 yr Type: first isch Time since onset: <30 d Inclusion: <30 d post stroke, no pathological change ECG; resting blood pressure systolic ≤200 mmHG and diastolic ≤100; no arrhythmia, heart failure, β-blockers	Comparison: Aerobic training (E) vs. control (C) E: Train on leg cycle ergometer. Wk 1-2 wk multiple short 2 min intervals with 1 min rest periods for up to 10 min/d, then add ≥1 min to ≥1 interval working periods each day until he/she could work continuously for 20 min. Wk 3-8: cycling at 60-70% of HRR. In addition to traditional rehabilitation. C: Traditional rehabilitation, including PT, OT and speech therapy; group activity for general exercise (5 d/wk). Intensity: wk 1-2: 10-20 min/d, 5 d/wk. Wk 3-8: 30 min/d, 3 d/wk. Treatment contrast: 11.5 h.	HR at rest, peak workload, walking distance, walking speed, stair climbing, FIM, FAI Measured at baseline and 8 wk and 6 mos (FAI)	Early aerobic training resulted in positive effects on peak workload and walking parameters in stroke patients. No modification effect was found between HRV parameters and exercise on those parameters. Early, moderately intense aerobic training has no direct impact on independence in daily and social activities as measured by FAI total score six months after stroke.
Chu et al 2004	6	12 (7/5)	Age: 61.9±9.4 yr Type: first isch/hem Time since onset: 3±2 yr Inclusion: >1 yr post stroke, independent walking with or without assistive device, medically stable; no previous myocardial infarction, pedal cycle ergometer ≥60% age predicted HRmax	Comparison: Water-based exercises vs. control (C) Water-based exercises: Supervised water-based exercise group training with objective to improve cardiovascular fitness, in chest-level water at local community center swimming pool (temperature 26-28 ^{o}C), wearing flotation belt or lifejacket. Land-based stretching (10 min), light aerobic warm-up in water (5 min), moderate to high aerobic activities at target HR described for that week (30 min), light cool-down (5 min), gentle stretching in water (10 min). HR wk 1-2: 50-70%, wk 3-5: 75%, wk 6-8: 80% HRR.1 PT, 2 exercise physiologists. C: Supervised arm exercises to improve upper-extremity function. 6-station circuit while seating: gross upper-limb movement, fine motor movement, muscle strengthening of the shoulder/ elbow/ wrist/ fingers. Cool-down (5 min). Intensity: 1 h/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	VO_2max, maximal workload, walking speed comf, BBS, muscle strength Measured at baseline and 8 wk	A water-based exercise program undertaken as a group program may be an effective way to promote fitness in people with stroke.
Eich et al 2004	8	50 (25/25)	Age: 62.4±4.8 yr Type: first isch Time since onset: 6.10±2.2 wk Inclusion: walk ≥12 m with intermittent help or stand-by while walking, BI 50-80, cardiovascular stable	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Graded treadmill training, harness secured and minimally supported (≤15%) according to patients' needs at defined training heart rate (HRmax–HRrest)*0.6HRrest (30 min). If necessary help with setting paretic limb or assisting weight-shifting and hip extension. Warm-up and cool-down period of 1-2 min, optional two short pauses. PT following Bobath approach, including tone-inhibiting and gait preparatory maneuvers, walking practice on the floor and on the stairs. Necessary orthoses and walking aids were provided (30 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. C: PT (60 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. Intensity: 60 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	10MWT maximum, 6MTW, RMA, walking quality Measured at baseline and 6 wk and 6 mos (follow-up)	Aerobic treadmill plus Bobath walking training in moderately affected stroke patients was better than Bobath walking training alone with respect to the improvement of walking velocity and capacity.

Kamps et al 2005	4	31 (16/15)	Age: 63.1±8.1 yr Type: isch Time since onset: 12±9.5 mos Inclusion: Handicap of walking with ability to walk with supervision/aids >10 m, live at home; no sanitary constitution, pain, ability to use normal cycle ergometer	Comparison: MOTOmed vs. control (C) MOTOmed: MOTOmed at home, with display which gives feedback to the exerciser. Warm-up (2-3 min), active padelling (2x/d, >10 min) with 50-70 reps/min, BORG 13, cool down (2-3 min). Adjust intensity of training according to improvement in physical fitness, by increasing time. Phoned every 14 days to receive feedback and solve problems. In addition to conventional PT and OT. C: Conventional PT and OT. Intensity: 2x/d, >10 min, during 4 mos. Treatment contrast: 601 min.	10MWT comf, 10MWT max, Tinetti, BBS, TUG, 2MWT, 6MWT Measured at baseline and 4 mos	Using the MOTOmed Movement Trainer is a helpful addition to conventional thearpy and supports an active participation in the rehabilitation process of stroke patients.
Macko et al 2005	5	61 (32/29)	Age: 63±10 yr Type: isch Time since onset: >6 mos Inclusion: no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia; ≥3 consecutive minutes treadmill walking at ≥0.22 m/s	Comparison: Treadmill training (TT) vs. control (C) TT: Treadmill training, start with 40-50% HRR for 10-20 min, progressing with 5 min and 5% HRR every 2 weeks as tolerated, to 60-70% HRR for 40 min, by increasing velocity by 0.05 m/s and incline by 1%. C: 13 supervised stretching movements (35 min) and low-intensity treadmill walking at 30-40% HRR (5 min). Intensity: ≈40 min/d, 3 d/wk, during 6 mos. Treatment contrast: ≈0 h.	30ft walk comf and max, 6MWT, RMI, WIQ, VO_2peak Measured at baseline, 3 and 6 mos	TT improves both functional mobility and cardiovascular fitness in patients with chronic stroke and is more effective than reference rehabilitation common to conventional care.
Ivey et al 2007	4	46 (26/20)	Age: 63±9 yr Type: ?? Time since onset: >6 mos Inclusion: asymmetry of gait with reduced stance, or reduced stance and increased swing in affected limb, with preserved capacity for ambulation with assistive device; no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Treadmill training with handrail, harness support and heart rate monitoring. Target aerobic intensity, start with 40-50% HRR for 10-20 min, progressing to 60-70% HRR for 40 min. C: Conventional PT, 13 targeted active and passive supervised movements of upper and lower body. Intensity: ≈40 min/d, 3 d/wk, during 6 mos. Treatment contrast: ≈0 h.	VO_2peak, body weight, body fat, fat free mass, glucose values Measured at baseline and 6 mos	These preliminary findings suggest that progressive aerobic exercise can reduce insulin resistance and prevent diabetes in hemiparetic stroke survivors.
Luft et al 2008	5	71 (37/34)	Age: 63.2±8.7 yr Type: first isch Time since onset: 62.5 (range 36.0-88.9) mos Inclusion: no heart failure, unstable angina, peripheral arterial occlusive disease, diabetes, aphasia; ; ≥3 consecutive minutes treadmill walking at ≥0.09 m/s	Comparison: Treadmill training vs. control (C) TT: Treadmill training with handrail, harness support and, start with 40-50% HRR for 10-20 min, progressing with 5 min and 5% HRR every 2 weeks as tolerated, to 60-70% HRR for 40 min, by increasing velocity by 0.05 m/s and incline by 1%. C: 13 supervised traditional stretching movements actively if possible or passively with a therapists' assistance. Including quadriceps, calf, hip and hamstring stretch, low back rotation and stretch, chest stretch, bridging, shoulder shrugs, abduction, and flexion, heel slides and short arc of quadriceps. Intensity: ≈40 min/d, 3 d/wk, during 6 mos. Treatment contrast: ≈0 h.	10MWT max, 6MWT, VO_2peak, fMRI Measured at baseline and 6 mos	TT improves walking, fitness and recruits cerebellum-midbrain circuits, likely reflecting neural network plasticity. This neural recruitment is associated with better walking. These findings demonstrate the effectiveness of TT rehabilitation in promoting gait recovery of stroke survivors with long-term mobility impairment and provide evidence of neurplastic mechanisms that could lead to further refinements in these paradigms to improve functional outcomes.
Ivey et al 2010	4	53 (29/24)	Age: 62±8 yr Type: isch Time since onset: >6 mos Inclusion: >6 mos post stroke, completed conventional PT, mild-moderate hemiparetic gait,	Comparison: Training (E) vs. control (C) E: Treadmill training with handrail and harness support, with target aerobic intensity 60-70% HRR. Start with 40-50% HRR for 10-20 min and gradually progressing to target level. If incapable of continuous exercise, then discontinuous training. HR and blood pressure monitored. C: Performance of 13 targeted active and passive supervised stretching movements of upper and lower body.	Resting leg blood flow, reactive hyperemic leg blood flow, peak aerobic fitness Measured at baseline and 6 mos	Peripheral hemodynamic function improves with regular aerobic exercise training after disabling stroke.

			preserved capacity ambulation with assistive device, no history vascular surgery/ vascular disorders lower extremities/ symptomatic peripheral arterial occlusive disease	Intensity: 30-40 min/d, 3 d/wk, during 6 mos. Treatment contrast: 0 h.		
Ivey et al 2011	4	38 (1919)	Age: 61±8 yr Type: isch/hem Time since onset: >6 mos Inclusion: >6 mos post stroke, completed conventional PT, mild-moderate hemiparetic gait, preserved capacity ambulation with assistive device; no insufficient transtemporal windows for insonation of the MCA bilaterallly	Comparison: Training (E) vs. control (C) E: Treadmill training with handrail and harness support, with target aerobic intensity 60-70% HRR. Start with 40-50% HRR for 10-20 min and gradually progressing to target level. If incapable of continuous exercise, then discontinuous training. HR and blood pressure monitored. C: Performance of 13 targeted active and passive supervised stretching movements of upper and lower body. Intensity: 30-40 min/d, 3 d/wk, during 6 mos. Treatment contrast: 0 h.	Cerebral vasomotor reactivity, blood flow velocity Measured at baseline and 6 mos	Exercise induced cerebral vasomotor reactivity improvements in stroke survivors.
Lee et al 2008, 2010	8	48 (12/12/12/12)	Age: 67.2±10.6 yr Type: isch/hem Time since onset: 52.4±2.2 mos Inclusion: >3 mos post stroke, >45 yr, community-based living environment, gait velocity 0.15-1.4 m/s; no significant musculotendinous or bony restrictions, complete hemiplegia leg, contraindication moderate exercise by ACSM guidelines	Comparison: Aerobic + progressive resistance training (PRT) vs. sham aerobic + PRT vs. aerobic vs. sham PRT vs. sham aerobic + sham PRT Aerobic + PRT: Leg cycling on semi-recumbent motorized isokinetic cycle ergometer with calf supports with pedaling cadence 40 rev/min, with HR wk 1-2 at 50% of VO_2peak, increased to 70% VO_2peak wk 4. PRT of lower limb extensors, knee extensors and flexors, ankle plantarflexors using pneumatic resistance equipment. Hip abductors and dorsiflexors using free weights and isometric training. 2x 8 repetitions unilaterally, start 50% baseline 1RM progressed to 80% 1RM by wk 2. Sham aerobic + PRT: Sham aerobic exercise of motorized passive leg cycling. Followed by sham resistance training of leg extensors and knee flexors and extensors with minimum resistance to counter weight of machine against gravity, ankle plantarflexors, dorsiflexors and hip abductors trained without resistance Increased after each session (3%). Aerobic + sham PRT: Aerobic training and sham PRT as above. Sham aerobic + sham PRT: Sham aerobic training and sham PRT as above. Intensity: (sham) Aerobic 30 min, (sham) PRT 30 min, 30 sessions, 3 d/wk, during 10-12 wk. Treatment contrast: 0 h.	6MWT, 10MWT comf, 10MWT max, stair climbing power, peak power output, peak HR, peak oxygen uptake, treadmill walking physical cost index, treadmill walking oxygen cost, 1RM affected leg, 1RM unaffected leg, power affected leg, power unaffected leg, endurance affected leg, endurance unaffected leg Measured at baseline and 12 wk	Single-modality exercises targeted at existing impairments do not optimally address the functional deficits of walking but do ameliorate the underlying impairments.
Lennon et al 2008	7	48 (24/24)	Age: 59.0±10.3 yr Type: first/rec isch Time since onset: 237.3±110.7 wk Inclusion: >1 yr post stroke; no O_2 dependence, angina, unstable cardiac conditions, uncontrolled diabetes, major medical conditions, claudication, febrile illness, beta blockers	Comparison: Cardiac rehabilitation programme (E) vs. control (C) E: Cycle ergometry exercise with upper or lower limb (MOTOmed), with biofeedback alarms set at 50-60% maximal HR. Resistance and speed adjusted daily. Two life skills classes addressing stress management, relaxation and life balance. C: Usual care. Intensity: 30 min/d, 2 d/wk, during 10 wk. Treatment contrast: 10 h.	Cardiac risk (waist girth, total cholesterol, cardiac risk score, resting systolic blood pressure, resting diastolic blood pressure), fitness and function (BMI, resting HR, FEV_1, VO_2, peak wattage, RPE, HADS, FAI) Measured at baseline and 10 wk	Preliminary findings suggest non-acute ischemic stroke patients can improve their cardiovascular fitness and reduce their cardiac risk score with a cardiac rehabilitation programme. The intervention was associated with improvement in self-reported depression.
Quaney et al 2009	5	38 (19/10)	Age: 64.1±12.3 yr Type: first isch Time since onset:4.62 3.21 yr	Comparison: Aerobic exercises (E) vs. control (C) E: Progressive resistive exercises at target level equal to 70% maxHR for 45 min on a stationary bicycle, including 5 min warming-up and cooling-down. Wk 1 10-20 min at 40-50% maxHR, systematically progressed to 70% in wk 2.	VO_2max, WCST, Stroop task, Trail-making B-A, SRTT, PGFM, FMA, BBS, TUG	Aerobic exercises improved mobility and selected cognitive domains related to motor learning, which enhances sensorimotor control after stroke.

			Inclusion:>6 mos post stroke, residual hemiparetic deficit arm or leg; not regularly performing >20 min of cardiovascular exercise 3 d/wk; no alcohol consumption, cardiac history, other neurological diseases, hospitalization <3 mos or medical conditions prevent adherence to protocol	C: Upper and lower extremity stretching exercises at home, with PT contacting participants each week to answer questions about exercises. Intensity: 45 min/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	Measured at baseline and 8 wk and 16 wk (follow-up)	
Dobke et al 2010	5	31 (16/15)	Age: 63.1±8.1 yr Type: isch Time since onset: 12.0±9.5 mos Inclusion: hemiparesis, walking problems, walking with/without aid (>10 m), living at home, able to reach submaximal threshold, pain preventing training with MOTOmed®	Comparison: MOTOmed® vs. control (C) MOTOmed®: Training at home with MOTOmed®, starting treatment period with 1 hour visit of sportsinstructor. Folowing training at home: start with 2-3 min passive warm-up, ≥10 min active cycling, 2-3 min cool down. 50-70 RMP, Borg 13, try to cycle using legs symmetrically. Every 14 days telephone call. Conventional PT and OT. C: Conventional PT and OT. Intensity: 2x/d, 10 min/session, 7 d/wk, during 4 mos. Treatment contrast: 1680 min.	10MWT comf, 10MWT max, 2MWT, 6MWT, SF-36 Measured at baseline and at 4 mos	Additional treatment with the MOTOmed® movement therapy device can be considered as a beneficial addition to regular therapy. It allows patients to counteract consequences of lack of movement and contribute as well as positively influence the personal therapy process.
Moore et al 2010	5	20 (??/??)	Age: 50±15 yr Type: first isch/hem Time since onset: 13±8 mos Inclusion: 6 mos post stroke, walk >10 m overground without physical assistance, comf speed ≤0.9 m/s, primary stated goal to improve walking ability, enroll approx 1 mos before termination of PT services; no lower extremity contractures, cardiovascular instability	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: High-intensity stepping practice on motorized treadmill while wearing a harness with up to 40% BWS for subjects with a <0.2 m/s overground walking speed, reduced in 10% increments. Walk at highest tolerable speed with increase velocity in 0.5 km/h increments until HR was 80-85% or Borg 17. Hold on handrail for balance, PT did not provide manual assistance. Focus on increasing intensity and amount of stepping practice. C: No intervention. Intensity: 2-5 d/wk, during 4 wk. Treatment contrast: ??	Walking speed comf, walking speed max, 12MWT, O_2cost (gait efficiency), peak treadmill speed, VO_2peak, BBS, TUG Measured at baseline and 4 wk	Intensive locomotor training results in improved daily stepping gin individuals poststroke who have been discharged from PT because of a perceived plateau in motor function. These improvements may be related to the amount and intensity of stepping practice.
Kuys et al 2011	8	30 (15/15)	Age: 63±14 yr Type: first Time since onset: 52±32 d Inclusion: at least able to walk with stand-by help (item MAS* ≥2), walking speed ≤1.2 m/s; no cardiovascular problems or neurological or musculoskeletal conditions affecting walking	Comparison: Treadmill training (TT) vs. control (C) TT: Walking on treadmill (30 min excl rest) with intensity 40-60% HRR or Borg 11-14. Commenced at 40% HRR, progressing each week aiming for a 5-10% increase until 60% HRR was reached. Encouraged to use handrail, PT provided assistance if required. In addition to usual PT intervention using a task-oriented approach targeting impairments and activity limitations (60 min). C: Usual PT. Intensity: TT: 30 min/d, 3 d/wk, during 6 wk. Treatment contrast: 9 h.	10MWT comf and max, 6MWT Measured at baseline and 6 wk and 18 wk (follow-up)	Higher-intensity treadmill walking during rehabilitation after stroke is feasible and not detrimental to walking pattern and quality in those newly able to walk.
Toledano-Zarhi 2011	6	28 (14/14)	Age: 65±10 yr Type: isch Time since onset: 11±5 d Inclusion: mRS≤2, 1-3 wk post stroke; no systolic	Comparison: Aerobic rehabilitation program (E) vs. control (C) E: Supervised exercise-training, including training on a treadmill, hand-bike machine and stationary bike (2 d/wk) with progress in 8 stages, pulse rate target of 50-70% of HRmax. Group practice for inducing strength, flexibility and coordination performances (1 d/wk) In addition to provision of a home-exercise	6MWT, FSST, stairs ascending, stairs descending, HR rest, HR work, blood pressure systolic/diastolic rest/work, exercise duration,	An early supervised aerobic training programme after minor ischemic stroke is feasible and well tolerated and, in a per-protocol analysis, was associated with improved walking endurance.

			blood pressure ≥200 mmHg, diastolic blood pressure ≥100 mmHg, unstable angina pectoris, arrhythmia, congestive heart failure, ST depression ≥2 mm on resting ECG, 3rd degree atrioventricular block with no pacemaker, severe peripheral vascular disease, severe lung disease, orthopedic or neurological disability,dementia or major depression, aged >80 yr	booklet (see below). C: Provision of home-exercise booklet, including instructions for muscle strength and flexibility exercises, continue normal community routine. Intensity: Exercise 35-55 min/d, 2 d/wk, during 6 wk. Group practice: 45-55 min/d, 1 d/wk, during 6 wk. Treatment contrast: 750 min.	MET's Measured at baseline and 6 wk	

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age + SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Richards et al. 1993	RCT	27 (10/8/9) 27 of 215 patients submitted	mean: 69.1 y	iCVA sub-acute: mean 10 d + 1.9 d after stroke	Yes	Intervention: Intensive Treadmill gait training vs Routine conventional, not intense therapy E: early, intensive therapy on a treadmill C: two control groups: C1: early, intensive and conventional therapy and C2: routine conventional, not intense therapy Intensity: E: 2 session/day (time: 1,74+ 0,15 hrs/d), C1: 2 sessions/day (time: 1,79 + 0,10 hrs/d), without locomotor activities and C2: 1 session/day (time: 0,72 + 0,10 hrs/d). During 5 wk for all groups.	FMA, BI, BBS and FMW measured at 6 wk	Early muscle and early gait retraining facilitated gait recovery; no differences between conventional groups	5 failure at questions: 3,5,6,8,9
Potempa et al. 1995	RCT	42 (19 / 23)	mean: ? y + y, range 43-72 y	type: all except brain stem lesions chronic: > 6 mo after stroke	No	Intervention: cycle ergometer vs passive exercises E cycle ergometer; during first 4 wk of the program the training load was gradually increased from 30%-50% of max effort to highest level attainable for last 6 wk of training. C: passive exercise for ROM to body joints in a systematic procedure Intensity: 3x/wk; 30 min; during 10 wk	RHR (bpm), MHR (bpm), Metabolic parameters (VO2, VCO2, VE, RER), SBP, Exercise time and Workload (rpm) measured at2 and after start intervention	Hemiparetic stroke patients may improve their aerobic capacity and submaximal exercise blood pressure response with training. Sensimotor improvement is related to the improvement in aerobic capacity.	4 failure at the questions: 3,5,6,7,8,9
Duncan et al. 1998	RCT	20 (10 / 10)	mean: 67 y + 8 y	type: all post acute: mean 61 d. after stroke	Yes	Intervention: 'home-based' exercise program vs usual care E: 'home-based' exercise program: PNF and elastic band exercises, balance exercises and walking C: usual care as prescribed by their physicians Intensity: 90 min; 3x/wk during 8 wk	FMA, BI, LI-ADL, TMW, 6 min walk, BBS and JTHF	A 'home-based' exercise program is feasible and effective to improve strength, balance, endurance and bimanual activities.	7 failure at the questions: 5,6,7

Dean et al. 2000	RCT	12 (6 / 6) able to walk 10m. independently with or without assistive device 9 (5 / 4) completed the study (25% drop-outs)	mean: 64.3 y + 7.2 y	type: all chronic: mean 1.8 y + 0.8 y. after stroke	Yes	Intervention: evaluate the immediate and retained effects of a training program on the performance of locomotor-related tasks in chronic stroke E: practice at a series of workstations (strengthen the muscles of affected leg) as well as participating in walking races and relays with other members of the group. C: same workstation training, but training was designed to improve function of the affected upper limb and was considered 'sham 'lower limb training Intensity: 3d/wk for 1 hrs during 4 wk	TMW, 6 minute walk, TUG, step test and sit-to-stand measured at 4 wk and 2 mo after the training (follow-up)	The experimental group demonstrated significant immediate and retained (2-month follow-up) improvement compared with control group in walking speed and endurance, force production through the affected leg during sit-to-stand and the number of repetitions of the step test.	5 failure at the questions: 5,6,7,8,9
Rimmer et al. 2000	RCT	35 (18 / 17)	mean: 53 y + 8 y	type: all chronic: > 6 mo after stroke	Yes	Intervention: exercise program vs no therapy E: exercise program based on improving cardiovascular endurance (i.e. treadmill), muscle strength (i.e. stepper) and flexibility C: no intervention Intensity: 60 min; 3d/wk during 12 wk	Workload, peak VO2, muscle strength (UE + LE) and S&R	A supervised exercise training program for stroke survivors was highly effective in improving overall fitness.	5 failure at the questions: 3,5,6,7,9

RCTs investigating mixed training (paragraaf F.1.18)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Duncan et al 2003	8	100 (50/50)	Age: 68.5±9.0 yr Type: isch/hem Time since onset: 77.5±28.7 yr Inclusion: 30-150 d post stroke, ambulate 25 ft independently, FMA 27-90, OPS 2.0-5.2, palpable wrist extension; no serious cardiac conditions, oxygen dependence, weight-bearing pain, organ system disease	Comparison: Exercise (E) vs. control (C) E: Supervised progressive exercise program targeting strength, balance, endurance, upper extremity function, performed at home. C: Usual care. Education about stroke prevention and measurements of blood pressure and oxygen saturation (1x/2wk). Intensity: 36 sessions, 90 min/d, 3 d/wk, during 12 wk. Treatment contrast: ≈1620 min.	FMA arm, FMA leg, WMFT, grip strength, isometric ankle dorsiflexion andknee extension, 10MWT, BBS, FR, HRmax, VO_2peak, MET, execise duration Measured at baseline and 3 mos	This structured, progressive program of therapeutic exercise in persons who had completed acute rehabilitation services produced gains in endurance, balance, and mobility beyond those attributable to spontaneous recovery and usual care.
Salbach et al 2004	8	91 (44/47)	Age: 71±12 yr Type: first/rec isch/hem Time since onset: 239±83 d Inclusion: residual walking deficit, walk 10 m independently using aid or orthotic with or without supervision, residence in community, ≤1 yr post stroke	Comparison: Mobility intervention vs. control Mobility intervention: 10 walking-related tasks designed to strengthen lower extremities and enhance walking balance, speed and distance in a progressive manner: walking on treadmill, standing up, walking to, and sitting down on a chair, kicking a soccer ball against the wall, walking along a balance beam, performing step-ups, walking an obstacle course, walking while carrying an object, walking at maximal speed, walking backwards, walking up and down stairs. Challenged to maximize performance, rest when necessary. C: Functional upper extremity tasks done while sitting, recommended to practice these tasks at home. Intensity: ?? min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	6MWT, 5MWT, TUG, BBS Measured at baseline and 6 wk	Study findings support the efficacy of a task-oriented intervention in enhancing walking distance and speed in the first year post stroke, particularly in people with moderate walking deficits.
Studenski et al 2005 [secondary analysis Duncan 2003]	6	93 (44/49)	Age: 68.5±9.0 yr Type: isch/hem Time since onset: 77.5±28.7 d Inclusion: 3-38 d post stroke, no dependent ambulated 25 ft, no FMA 27-90, no OPS 2.0-5.2, no palpable wrist extension	Comparison: Home-based exercise program (E) vs. control (C) E: Progressive home-based exercise program, targeting upper and lower limb strength using elastic bands and body weight, balance, endurance using exercise bicycle, encouraged use of affected upper extremity supervised by PT or OT. After completion written guidelines for continued exercises. C: Rehabilitation services prescribed by personal physician. Provided with materials addressing health practices for preventing recurrent stroke, feedback on physical assessments. Intensity: E: 3 d/wk, during 12 wk. C: half received formal PT and OT. Treatment contrast: ??	Lawton IADL, BI, community ambulation, FIM cognitive, FIM motor, SF-36 subdomains, SIS subdomains Measured at baseline and 3 mos and 6 mos (follow-up)	This rehabilitation exercise program led to more rapid improvements in aspects of physical, social, and role function than usual care in persons with subacute stroke. Adherence interventions to promote continued exercise after treatment might be needed to continue benefit.
Lai et al 2006 [secondary analysis Duncan 2003]	6	93 (44/49)	Age: 68.5±9.0 yr Type: isch/hem Time since onset: 77.5±28.7 yr Inclusion: 30-150 d post stroke, ambulate 25 ft independently, FMA 27-90, OPS 2.0-5.2, palpable wrist extension; no serious cardiac conditions, oxygen dependence, weight-bearing pain, organ system disease	Comparison: Exercise (E) vs. control (C) E: Supervised progressive exercise program targeting strength, balance, endurance, upper extremity function, performed at home. C: Usual care. Education about stroke prevention and measurements of blood pressure and oxygen saturation (1x/2wk). Intensity: 36 sessions, 90 min/d, 3 d/wk, during 12 wk. Treatment contrast: ≈1620 min.	GDS, SF-36, SIS, antidepressant use Measured at baseline and 3 mos and 6 mos (follow-up)	Exercise may help reduce post stroke depressive symptoms.

Pang et al 2005, 2006	7	63 (32/31)	Age: 65.8±9.1 yr Type: isch/hem Time since onset: 5.2±5.0 yr Inclusion:>1 yr post stroke, ≥50 yr, walk >10m independently, living at home; no history of serious cardiac disease, uncontrolled blood pressure, pain while walking, neurological conditions	Comparison: Fitness and mobility exercises (E) vs. control (C) E: Three stations: 1) Cardiorespiratory fitness and mobility: brisk walking, sit-to-stand (10 min increment of 5 min every wk up to 30 min, start 40-50% HRR with increment of 10% HRR every 4 wk up to 70-80%); 2) mobility and balance: walking in different directions, tandem walking, obstacle course, sudden stops and turns, different surfaces, standing on different underground, stand with one foot in front of the other, kick ball; 3) partial squats, toe rises. Intensity and duration increased as tolerated. Wear hip protectors during each session. C: Seated upper extremity program in 3 stations: 1) shoulder muscle strength: resistance band; 2) elbow/wrist muscle strength and ROM: dumbbell/wrust cuff weigth, passive or self-assisted ROM, weight bearing; 3) hand activities: hand muscle strength, playing cards, picking up objects, electrical stimulation. Intensity: 1 h/d, 3 d/wk, during 19 wk. Treatment contrast: 0 h.	VO_2, 6MWT, knee extension strength, BBS, PASIPD Measured at baseline and 19 wk	The program is feasible and beneficial for improving some of the secondary complications resulting from physical inactivity in older adults living with stroke. This study provided some evidence that the 19-week comprehensive exercise program could have a positive impact on bone parameters at the tibia for individuals with chronic stroke.
Olney et al 2006	7	74 (38/36)	Age: 63.5±12.0 yr Type: isch/hem Time since onset: 4.1±4.4 yr Inclusion: walk 15 min with rests, tolerate activity for 45 min with rests; no coronary artery disease limiting involvement in exercise program, contraindications to exercise testing as specified by ACSM	Comparison: Supervised training (E) vs. unsupervised training (C) E: Class of 3-4 participants, including 1) warm up, 5-10 min; 2) aerobic exercise in graded walking or cycling program; 3) strength training of lower limb with Theraband, weights and functional exercises; 4) cool-down. Target range HR 50-70%, increase walking capacity from 50-70%, duration 10-20 min. Weekly adjustments by supervisor. C: As experimental group, but with written and verbal instructions on advancing exercises. Intensity: 1.5 h/d, 3 d/wk, during 10 wk. Treatment contrast: 0 h.	6MWT, HAP, SF-36, strength, PCI Measured at baseline and 10 wk and 1 yr (follow-up)	Supervised exercise programs and unsupervised programs after initial supervised instruction were both associated with physical benefits that were retained for 1 year, although supervised programs showed trends to greater improvement in self-reported gains.
Mead et al 2007	8	66 (32/34)	Age: 72.0±10.4 yr Type: first/rec isch/hem Time since onset: median 171 (IQR 55-287) d Inclusion: independently ambulatory; no medical contraindications to exercise training	Comparison: Exercise training (E) vs. control (C) E: Endurance and resistance training. Warm-up (15-20 min). 1) Endurance: circuit of cycle ergometry, raising and lowering 1.4-kg, 55-cm exercise ball, shuttle walking, standing chest press, stair climbing and descending (starting in wk 4), march in place between each circuit station. Duration increased from 9 min to 21 min by wk 12. Cycling increased by pedaling resistance, cadence or both with Borg 13-16. Graded cool-down and stretches. 2) Resistance training: seated upper back and triceps with elastic resistance training bands, progress repetitions from 4 using lowest-resistance band to 10 using highest-resistance band by wk 12. Pole-lifting while standing, progressing from 4 repetitions with 0.22-kg pole to 15 repetitions with 3.6-kg pole by wk 12; sit-to-stand exercise progressing from 4 to 10 repetitions by wk 12, increasing difficulty by manipulating length of pauses, angle of the knee and upper body levers. Cool-down and flexibility exercises (10-15 min). Groups up to 7 patients. C: Relaxation classes, including seated deep breathing and progressive muscular relaxation, increasing duration from 20 min to 49 min. Intensity: 1h15, 3 d/wk, during 12 wk. Treatment contrast: 0 h ??	FIM, NEADL, RMI, FR, SF-36 domains, HADS, leg extensor power affected leg, leg extensor power unaffected leg, walking speed comf, walking economy (oxygen uptake), TUG, sit-to-stand Measured at baseline and 3 mos and 7 mos (follow-up)	Exercise training for ambulatory stroke patients was feasible and led to significantly greater benefits in aspects of physical function and perceived effect of physical health on daily life.
Lee et al 2008, 2010	8	48 (12/12/12/12)	Age: 67.2±10.6 yr Type: isch/hem Time since onset: 52.4 2.2 mos Inclusion: >3 mos post stroke, >45 yr, community-based living environment, gait velocity 0.15-1.4 m/s; no significant musculotendinous or bony	Comparison: Aerobic + progressive resistance training (PRT) vs. sham aerobic + PRT vs. aerobic vs. sham PRT vs. sham aerobic + sham PRT Aerobic + PRT: Leg cycling on semi-recumbent motorized isokinetic cycle ergometer with calf supports with pedaling cadence 40 rev/min, with HR wk 1-2 at 50% of VO_2peak, increased to 70% VO2peak wk 4. PRT of lower limb extensors, knee extensors and flexors, ankle plantarflexors using pneumatic resistance equipment. Hip abductors and dorsiflexors using free weights and isometric training. 2x 8 repetitions unilaterally, start 50% basline 1RM progressed to 80% 1RM by wk 2. Sham aerobic + PRT: Sham aerobic exercise of motorized passive leg cycling.	6MWT, walking speed comf, walking speed max, stair climbing power, peak power output, peak HR, peak oxygen uptake, treadmill walking physical cost index, treadmill walking oxygen cost, 1RM affected leg, 1RM unaffected leg, power affected leg, power unaffected leg,	Single-modality exercises targeted at existing impairments do not optimally address the functional deficits of walking but do ameliorate the underlying impairments.

			restrictions, complete hemiplegia leg, contraindication moderate exercise by ACSM guidelines	Followed by sham resistance training of leg extensors and knee flexors and extensors with minimum resistance to counter weight of machine against gravity, ankle plantarflexors, dorsiflexors and hip abductors trained without resistance Increased after each session (3%). Aerobic + sham PRT: Aerobic training and sham PRT as above. Sham aerobic + sham PRT: Sham aerobic training and sham PRT as above. Intensity: (sham) Aerobic 30 min, (sham) PRT 30 min, 30 sessions, 3 d/wk, during 10-12 wk. Treatment contrast: 0 h.	endurance affected leg, endurance unaffected leg Measured at baseline and 12 wk	
Letombe et al 2010	4	18 (9/9)	Age: 59.1±9.4 yr Type: isch/hem Time since onset: 21±3 d Inclusion: no hemisensory neglect, unstable brain lesions	Comparison: Adapted physical activity programme (E) vs. control (C) E: Cardiorespiratory exercise, muscle strengthening, gait exercise and work focused on execute functions. Aerobic exercise using a semi-recumbent cycle ergometer, 70-80% maximum power (W). Treadmill and stepper to promote independent gait. Using isokinetic exercise machine for symmetric balancing stances and leg motor control, 6x 10 repetitions of 50-60% maximal force. Incremented according to improvement. Games and group activities for motor control, executive functions and balance. In addition to standardized multidisciplinary rehabilitation (see below). C: Standardized multidisciplinary rehabilitation, combining PT, OT, speech therapy and neuropsychological therapy (3 h/d, 5 d/wk), based on improving personal autonomy in ADL, with work focused on use of the legs: gait and stance exercises, treatment orthopedic disorders, balance work, use of support stockings and braces, freedom of ROM. Use wheelchair and performing transfers. For the arms strapping, prehension work and coordination combined with balance work in sitting and standing positions. Intensity: 40-60 min/d, 4 d/wk, during 4 wk. Treatment contrast: 800 min.	Maximal aerobic power, BI, Katz Measured at baseline and 28 d	Early post-stroke physical training appears to be needed to limit the negative effects of functional hypoactivity.
Outermans et al 2010	6	44 (23/21)	Age: 56.8±8.6 yr Type: first/rec Time since onset: 22.5±8.2 d Inclusion: 2-8 wk post stroke, walk 10 m FAC ≥3, no cardiovascular instability, no impairments lower extremities influencing walking ability	Comparison: High-intensity group exercises (E) vs. low-intensity group exercises (C) E: High-intensity group exercises incorporating 10 workstations (see Dean et al 2000) of 2.5 min followed by 1-minute transfer, focusing on improving postural control and gait-related activities. Cardiorespiratory workload 40-50% HRR, progression by increasing HRR towards 70-80% and increase number of repetitions. Afterwards walking relays and raced (10 min). In addition to usual PT (30 min/d, 5 d/wk). C: Low-intensity group exercises incorporating 10 workstations of 2.5 min followed by 1-minute transfer, focus on improving motor control of hemiparetic leg and balance, no strengthening or cardiorespiratory training. Afterwards games (10 min). In addition to usual PT (30 min/d, 5 d/wk). Intensity: 45 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	10MWT max, 6MWT, BBS, FR Measured at admission and 4 wk or before in case of early discharge	A high-intensity task-oriented training programme designed to improve hemiplegic gait and physical fitness was feasible in the present study and the effectiveness exceeds a low intensity physiotherapy-programme in terms of gait speed and walking capacity in patients with subacute stroke.

RCTs investigating water-based exercises (paragraaf F.1.19)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Chu et al 2004	6	12 (7/5)	Age: 61.9±9.4 yr Type: first isch/hem Time since onset: 3±2 yr Inclusion: >1 yr post stroke, independent walking with or without assistive device, medically stable, no previous myocardial infarction, pedal cycle ergometer ≥60% age predicted HRmax	Comparison: Water-based exercises vs. control (C) Water-based exercises: Supervised water-based exercise group training with objective to improve cardiovascular fitness, in chest-level water at local community center swimming pool (temperature 26-28 ^{o}C), wearing flotation belt or lifejacket. Land-based stretching (10 min), light aerobic warm-up in water (5 min), moderate to high aerobic activities at target HR described for that week (30 min), light cool-down (5 min), gentle stretching in water (10 min). HR wk 1-2: 50-70%, wk 3-5: 75%, wk 6-8: 80% HRR.1 PT, 2 exercise physiologists. C: Supervised arm exercises to improve upper-extremity function. 6-station circuit while seating: gross upper-limb movement, fine motor movement, muscle strengthening of the shoulder/ elbow/ wrist/ fingers. Cool-down (5 min). Intensity: 1 h/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	VO_2max, maximal workload, walking speed comf, BBS, muscle strength Measured at baseline and 8 wk	A water-based exercise program undertaken as a group program may be an effective way to promote fitness in people with stroke.
Aidar et al 2007	5	28 (15/13)	Age: 50.3±9.1 yr Type: isch Time since onset: >1 yr Inclusion: >1 yr post stroke, hemiparesis	Comparison: Water-based exercises vs. control (C) Water-based exercises: Warm-up not in swimming pool. Water-based exercises consisted of various walking exercises, with and without aids in swimming pool of 25x12.5 m with a depth of 1.5 m, no heated water. C: No therapy. Intensity: 45-60 min/d, 2 d/wk, during 12 wk. Treatment contrast: 1260 min.	SF-36 Measured at baseline and 12 wk	Doing physical exercises in water tends to improve motor behavior, with a greater degree of independence, significant improvements in functional capacity and other aspects linked to physical attitude.
Noh et al 2008	5	25 (13/12)	Age: 61.9±10.1 yr Type: first isch/hem Time since onset: 2.8±3.8 yr Inclusion: >6 mos post stroke, walk independently with or without assistive device, medically stable, no previous myocardial infarction, no uncontrolled hypertension, no arrhythmia and unstable cardiovascular status	Comparison: Aquatic therapy vs. control (C) Aquatic therapy: Supervised therapy (patient:PT ratio 2:1) in therapeutic pool (34 ^{o}C) to improve balance function associated with postural control. Light warm-up in water (10 min), Halliwick method (20 min) Ai Chi method (20 min), light cool-down (10 min). Support provided by therapist's hands and legs was gradually decreased. C: Supervised gym exercise program, including warm-up (10 min), lower-extremity strengthening, upper-extremity strengthening, gait training. Graded increments. Intensity: 1 h/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	BBS, rising from chair, weight-shift, modified MAS*, muscle strength Measured at baseline and 12 wk	Postural balance and knee flexor strength were improved after aquatic therapy based on the Halliwick and Ai Chi methods in stroke survivors.

RCTs investigating somatosensory training of the paretic leg (paragraaf F.1.20)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Morioka et al 2003	6	26 (12/14)	Age: 62.6±13.3 yr Type: first/rec isch/hem Time since onset: 65.4±18.6 d Inclusion: hemiplegia, standing maintenance was becoming independent; no higher brain dysfunction, dementia	Comparison: Perceptual learning (E) vs. control (C) E: Perceptual learning exercise to discriminate hardness of sponge rubber placed under sole of the foot while standing. Three 30-cm square rubbers (5, 10, 15 mm) with hardness of resp. 2425 nM, 1875 nM, 1500 Nm in random order. Verbal feedback. In addition to PT and OT (see below). C: PT and OT, including ordinary postural control exercises. Intensity: 10 d, during 2 wk. Treatment contrast: ??	Postural sway (eyes open and closed) Measured at baseline and 2 wk	The plantar perception exercise used as a method in this study is considered to be effective as a supplemental exercise for standing balance.
Lynch et al 2007	6	21 (10/11)	Age: 61.0±15.8 yr Type: first isch/hem Time since onset: 48.7±31.1 d Inclusion: sensory dysfunction lower limb, stand and walk 10 m with no more than 1 person assisting; no pre-existing sensory deficits, walking aid other than single-point stick prior to stroke	Comparison: Sensory retraining (E) vs. control (C) E: Education regarding sensation and sensory retraining; practice in detection and localization of touch at 7 points on soles of feet; hardness, texture and temperature discrimination by placing feet on variety of floor surfaces while sitting and standing with vision obscures; proprioception training big toe and/or ankle. Graded stimulation, comparison nonaffected side, quantitative feedback on outcome and performance, summary feedback. In addition to standard care. C: Close eyes and assisted to stand same periods of time as E. Eyes closed in supine, performing guided relaxation techniques. In addition to standard care. Intensity: 30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	Light touch, DPT, BBS, 10MWT, ILAS Measured at baseline and 2 wk and 2 wk (follow-up)	Results of this pilot study are unable to support or refute the routine use of sensory retraining of the lower limb for people during inpatient rehabilitation after stroke.
Yavuzer et al 2007	8	30 (15/15)	Age: 61.9±10.01 yr Type: first isch/hem Time since onset: 3.5±2.1 mos Inclusion: Brunnstrom stage 1-3, stand and take ≥1 step with or without assistance; no medical contraindication to walking or electric stimulation	Comparison: Sensory-amplitude electric stimulation (SES) vs. control (C) SES: SES of common peroneal nerve and belly tibialis anterior muscle. Asymmetric biphasic rectangular stimulation, frequency 35 Hz, pulse width 240 μs, ≈10mA so the patient perceived a mild tingling sensation but below an observable or palpable muscle contraction. Duty cycle of 10 seconds on and 10 seconds off. In addition to conventional rehabilitation, consisting of NDT, PT, OT and speech therapy. C: Placebo SES, machine was turned on but without stimulation. In addition to conventional rehabilitation (see above). Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	Brunnstrom stage leg, walking velocity, step length, % stance phase on paretic side, sagittal plane kinematics (ROM) Measured at baseline and 4 wk	In our patients with stroke, SES of the paretic leg was not superior to placebo in terms of lower-extremity motor recovery and gait kinematics.
Torriani et al 2008	4	18 (6/6/6)	Age: 58.67±15.19 yr Type: ?? Time since onset: >6 mos Inclusion: >6 mos post stroke, stand without help; no peripheral neuropathy, vestibular or visual deficit	Comparison: Sensory stimulation (S) vs. motor stimulation (M) vs. sensory and motor stimulation (S+M) S: Sensory stimulation plantar region foot, with marbles, plastic balls, foam roller and wood, beans and brushes. M: Deep manual massage in the leg associated to the active mobilization of the ankle dorsiflexor and plantar-flexor muscles of the hemiparetic foot. S+M: Sensorial stimulations and deep massage (see above). Intensity: 1x15 min. Treatment contrast: 0 h.	Sensibility, PASS Measured at baseline and after intervention	Sensorial stimulation or motor stimulation (used associated or separately) promotes improvement in hemiparetic's balance and sensibility after stroke.
Wu et al 2010	7	23 (12/11)	Age: 59.9±11.4 yr Type: first isch/hem Time since onset: 10.0±7.3 mos Inclusion: move upper limb independently	Comparison: Outpatient rehabilitation + thermal stimulation arm (E) vs. outpatient rehabilitation + thermal stimulation leg (C) E: PT and OT. Additional thermal stimulation arm, with two thermal stimulators and two therapeutic pads: hot pad 46-47°C, cold-pad 7-8°C. Hot pad on paretic hand 10 times for 15 sec, interleaved with 30 sec pauses. Patients had to withdraw or move hand from pad when discomfort occurred or after 15 sec of	MAS, STREAM leg, BI Measured at baseline, 8 wk and 1 mos (follow-up)	Additional arm thermal stimulation could provide further improvement in motor function of arm than those in control group.

				stimulation. During pause perform voluntary paretic wrist and elbow extensions. Then 10 times 30 sec cold pad stimulations. 2 alternate cycles of heat and cold stimulation. C: PT and OT. Additional thermal stimulation leg. Intensity: PT 1 h, 3 d/wk; OT 1 h ,3 d/wk; thermal stimulation 30 min/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.		
Chen et al 2011	7	33 (17/16)	Age: 58.0±11.5 yr Type: first isch/hem Time since onset: 11.0 (range 9.5-12.0) d Inclusion: <4 wk post stroke, Brunnstrom stage ≤3, FAC* ≤1 (walk independently); no diabetes or sensory impairment	Comparison: Thermal stimulation (TS) vs. control (C) TS: Thermal stimulation intervention aiming to facilitate recovery of balance and motor function of the lower limb. Hot pack (75°C) wrapped in two towels on nonparetic leg (calf or foot), then on paretic leg. Encouraged to actively move leg as much as possible away from stimulus with a movement pattern guided by therapist when discomfort developed, or after 30 s, followed by 30 s rest. Three cycles per session, each of 8 repetitions with hot pack, 8 repetitions cold pack (0°C). Lie on back (antigravity) or side (gravity). In addition to PT and OT (5 d/wk, 6 wk). C: PT and OT. Intensity: 48 min/d, 5 d/wk, during 6 wk. Treatment contrast: 1440 min.	FMA leg, MRC leg, MMAS*, PASS-TC, BBS, FAC*, independent walking Measured at baseline, 4 and 6 wk.	Thermal stimulation accompanied by either manual facilitation or encouragement for active participation of the paretic lower limb may be an effective promising supplementary treatment for the early-phase rehabilitation of moderate to severe stroke that warrants additional study.

RCTs investigating electrostimulation for the paretic leg (paragraaf 1.21)

RCTs investigating NMS for the paretic leg

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Newsam et al 2004	5	20 (10/10)	Age: 51.8±15.2 yr Type: isch/hem Time since onset: 38.4±40.0 d Inclusion: knee extension MRC ≥1; no severe spasticity quadriceps femoris, peripheral nerve injury or disease	Comparison: Functional electrical stimulation (FES) vs. control (C) FES: Standard PT focused on improving transfer ability to a stand-by assistance level and ambulation to limited community or household status. Incorporating functional treatment, directed at impairments such as weakness, ROM, impaired motor control, decreased balance, emphasis on improving functional status. FES applied (5 d/wk) during gait training of weight shifting activities only, with 2 self-adhesive electrodes placed on motor points of vastus lateralis and vastus medialis oblique. Symmetric biphasic square wave pulses (35 pulses/s; phase duration 220 µs, activated by investigator during stance phase. Ramps during weight-shifting ≈2 sec, during gait ≈0.5 sec. C: Standard PT but without electrical stimulation. Intensity: 1 h/d, 6 d/wk, during 3 wk. Treatment contrast: 0 h.	MVIT knee extension, interpolated twitch Measured at baseline, 1, 2 and 3 wk	A brief and dynamic electric stimulation facilitation program significantly improved motor unit recruitment in persons after CVA.
Wright et al 2004	2	26 (??/??)	Age: ?? Type: ?? Time since onset: <6 mos Inclusion: <6 mos post stroke, failure to achieve heel strike and corrected by FES, inability to achieve effective push-off at terminal stance; no previous AFO <4 wk, required other AFO than selected for trial	Comparison: Ankle-foot orthosis (AFO) vs. Electrical stimulation (ES) AFO: Wear Orthopmerical Supera-Lite AFO. ES: Wear Odstock Dropped Foot Stimulator. Intensity: ?? Treatment contrast: 0 h.	10MWT, PCI, 3MWT, MAS, RMI Measured at baseline and every 6 wk up to 24 wk	No significant differences between the groups were observed by ANCOVA on any of these measurements.
Chen et al 2005	6	24 (12/12)	Age: 57 (range 41-69) yr Type: ?? Time since onset: 12-35 mos Inclusion: MAS 2-3; no diabetes mellitus, peripheral neuropathy	Comparison: Electrical stimulation (ES) vs. control (C) ES: Electrical stimulation with disposable electrodes, active electrode on junction of gastrocnemius muscle and Achilles tendon, reference electrode on distal end of Achilles tendon. Bipolar symmetrical rectangular waves, frequency 20Hz, pulse duration 0.2 ms, intensity adjusted to a maximum without inducing muscle contraction. C: Placebo ES, with intensity kept at zero. Intensity: 20 min/d, 6 d/wk, during 1 mos. Treatment contrast: 0 h.	MAS, Tibial Fmax/Mmax ratio, H-reflex latency, H-reflex recovery curve, 10MWT Measured at baseline and 1 mos	We demonstrated a way to suppress spasticity at a metameric site and to increase walking speed effectively by applying surface ES on the muscle-tendon junction of spastic gastrocnemius muscles.
Yan et al 2005	6	41 (13/15/13)	Age: 68.2±7.7 yr Type: first isch/hem Time since onset: 8.7±5.8 d Inclusion: no receptive dysphasia or cognitive impairment (AMT <7)	Comparison: Functional electrical stimulation (FES) vs. placebo (P) vs. control (C) FES: Standard PT (60 min) based on NDT approach, and OT (60 min) focused on ADL. Two dual-channel stimulators with surface electrodes on quadriceps, hamstring, tibialis anterior, medial gastrocnemius. 30Hz, 20-30 mA, activation sequence that mimicked normal gait. P: Standard PT and OT. Electrical stimulation device with disconnected circuit. C: Standard PT and OT. Intensity: FES: 30 min/d, 5 d/wk, during 3 wk. Placebo: 60 min/d, 5 d/wk, during 3 wk. Treatment contrast: FES vs. P: 7.5 h. FES/ P vs. C: 15 h.	CSS, MIVC ankle dorsiflexor and planter-flexors, TUG Measured at baseline, wk 1, 2, 3 and 8 wk (follow-up)	Fifteen sessions of FES, applied to subjects with acute stroke plus standard rehabilitation, improved their motor and walking ability to the degree that more subjects were able to return to home.
Tong et al 2006	6	50	Age: 61.8±10.8 yr	Comparison: Electromechanical gait trainer + functional electrical stimulation (GT-	EMS, BBS, FAC, MI leg, 5MWT	In this sample with subacute stroke,

		(15/15/20)	Type: first isch/hem Time since onset: 2.3±1.0 wk Inclusion: <6 wk post stroke, ability to stand upright supported or unsupported for 1 min, FAC <3; no potentially fatal cardiac arrhythmias, pacemaker	FES) vs. GT GT-FES: GT with BWS, optional rest break 1-3 min after first 10 min, stance-swing phase ratio 60-40%, target velocity 0.20-0.60m/s. Training variables included step length, walking speed, BWS, use of handrail. Assistance with knee extension and verbal cueing. Additional FES on quadriceps and peroneal nerve paretic leg, with self-adhesive electrodes, waveform and pulse width with fixed values. In addition to PT (40 min/d) and multidisciplinary treatments (1.5 h/d). GT: GT as GT-FES but without FES. In addition to PT (40 min/d) and multidisciplinary treatments (1.5 h/d). Intensity: 20 min/d, 7 d/wk, during 4 wk. Treatment contrast: 0 h.	max, FIM Measured at baseline and 4 wk	participants who trained on the electromechanical gait trainer with BWS, with or without FES, had a faster gait, better mobility, and improvement in functional ambulation than participants who underwent conventional gait training.
Yavuzer et al 2006	6	25 (12/13)	Age: 56.3±7.5 yr Type: first isch/hem Time since onset: 2.4±1.7 mos Inclusion: Brunnstrom stage 1-3, stand and take ≥1 step with or without assistance; no medical contraindication to walking or electric stimulation	Comparison: Electrical stimulation (ES) vs. control (C) ES: ES to tibialis anterior with electrodes close to insertion points. Surge-alternating current, frequency 80 Hz to stimulate muscle contraction, stimulation time 10 seconds (including 2 seconds ramp up, 1 second ramp down), off time 50 seconds. Not volitionally contract muscles during ES. In addition to conventional stroke rehabilitation consisting of NDT, PT, OT, speech therapy. C: Conventional stroke rehabilitation (see above). Intensity: ES 10 min/d, 5 d/wk, during 4 wk. Treatment contrast: 200 min.	Brunnstrom stage leg, walking velocity, step length, % stance phase on paretic side, sagittal plane kinematics (ROM) Measured at baseline and 4 wk	ES of the tibialis anterior muscle combined with a conventional stroke rehabilitation program was not superior to a conventional stroke rehabilitation program alone, in terms of lower-extremity motor recovery and gait kinematics.
Bakhtiary et al 2008	8	40 (20/20)	Age: 55 (range 42-65) yr Type: ?? Time since onset: ?? Inclusion: ankle plantarflexor spasticity	Comparison: Combination (Bobath + electrical stimulation (ES)) vs. control (C) ES: Start with infrared on lower extremity (10 min) at distance of 50 cm to warm up limbs. Bobath inhibitory techniques (15 min) of passive movement of ankle joint dorsiflexion, knee joint extension, abduction and external rotation of hip joint. In addition neuromuscular electrical stimulation of m. tibialis anterior muscle (9 minutes) of supramaximal muscle stimulation (100 Hz, pulse duration 0.1 ms), 4 seconds on, 6 seconds off. C: Infrared and Bobath as above. Intensity: ES: 9 min/d, 20 sessions. Treatment contrast: 180 min.	MAS, ankle joint dorsiflexion ROM, dorsiflexor strength, soleus muscle H-reflex Measured at baseline and post-intervention	Therapy combining Bobath inhibitory technique and electrical stimulation may help to reduce spasticity effectively in stroke patients.
Ferrante et al 2008	6	20 (10/10)	Age: 51±13 yr Type: isch/hem Time since onset: 56.1±22.8 d Inclusion: sit wheelchair for 45 min, MAS <2, good knee extension up to 150°, hip flexion up to 80°	Comparison: Functional electrical stimulation (FES) vs. control (C) FES: Sit in chair in front of Thera-Live ergometer with current-controlled 8-channel stimulator of quadriceps, hamstrings, gluteus maximus and tibialis anterior. 5 minutes passive cycling, 10 minutes FES, 5 minutes passive cycling, 10 minutes FES, 10 minutes passive cycling. Constant value of 40 rounds per minute, not participate voluntary to the movement. In addition to standard rehabilitation, including stretching, muscular conditioning with active or passive mobility, exercises to recover the trunk control, standing position, walking training. C: Standard rehabilitation (see above). Intensity: FES: 35 min/d, 5 d/wk, during 4 wk. Treatment contrast: 700 min.	TCT, MI leg, UMCT, 50m walk, STS, MIVT knee extension Measured at baseline and 4 wk	Rehabilitation including FES cycling was more effective in promoting muscle strength and motor recovery of the lower extremity than therapist-assisted standard rehabilitation alone.
Janssen et al 2008	6	12 (6/6)	Age: 54.2±10.7 yr Type: isch/hem Time since onset: 12.3±5.4 mos Inclusion: hemiparesis lower extremity; no severe cognitive, communicative, perceptual or sensory problems, unstable cardiorespiratory problems, inability to tolerate ES and/or contraindication to it	Comparison: Functional electrical stimulation (FES) vs. control (C) FES: Semirecumbent Ergys2 bicycle ergometer with computer-controlled ES of quadriceps, gluteal and hamstring muscles. Current amplitude depending on cadence, with target cadence higher than preferred cadence, with amplitude set as high as tolerated, resulting in muscle contractions. Frequency 60 Hz symmetrical biphasic sine pulse, pulse duration 450 µs. Each session of at least 3 bouts, per bout 5-10 minutes, followed by 5-minute rest. Resistance systematically increased every 2 minutes, with initial level based on graded exercise test. C: As FES, but with current set to just sensible stimulation not evoking muscle contractions. Intensity: 25-30 min/d, 2 d/wk, during 6 wk. Treatment contrast: 0 h.	6MWT, BBS, RMI, VO_2peak, POmax, strength knee extension Measured at baseline and 6 wk	This study showed that a short cycling training program on a semirecumbent cycle ergometer can markedly improve cycling performance, aerobic capacity, and functional performance in people with chronic stroke. The use of ES had no additional effects in this specific group of subjects with chronic stroke.

Ng et al 2008	6	54 (16/17/21)	Age: 62.0±10.0 yr Type: first isch/hem Time since onset: 2.3±1.1 wk Inclusion: ability to stand upright (supported or unsupported) for 1 minute, FAC <3; no skin allergy, cardiac pacemaker, aphasia or cognitive deficit with inability to follow commands, severe hip/knee/ankle contracture or orthopedic problem influencing PROM	Comparison: Gait trainer (GT) + Functional electrical stimulation (FES) vs. GT vs. control (C) GT: Electromechanical gait trainer, body weight partially supported by a harness which was decreased by 5 kg, gait cycle ratio 60-40% between stance and swing phase, gait speed increase 0.1 m/s if possible. Therapist gave assistance of knee extension, verbal cueing head and trunk movements. Optional rest beak of 1-3 minutes. GT + FES: GT as above, with FES simultaneously of quadriceps and peroneal nerve. Rectangular pulse, pulse width 400 µs with rising edge and falling edge ramp set as 0.3 seconds, intensity adjusted. C: Conventional therapy, including stretching exercise based on PNF and Bobath concepts, cardiovascular exercises, strengthening exercise, ADL training, overground walking with or without walking aid or orthosis and with manual assistance from therapist depending on subject's abilities. Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	EMS, BBS, FAC, MI leg, gait speed, FIM, BI Measured at baseline and 4 wk and 6 mos (follow-up)	For the early stage after stroke, this study indicated a higher effectiveness in poststroke gait training that used an electromechanical gait trainer compared with conventional overground gait training. The training effect was sustained through to the 6-month follow-up after the intervention.
Kojović et al 2009	5	13 (7/6)	Age: 61.0±13.1 yr Type: first Time since onset: 22.6±7.6 d Inclusion: ambulate with single cane or hand support; no metal implants, severe cognitive or communication impairment	Comparison: Functional electrical stimulation (FES) vs. control (C) FES: While walking, sensor-driven four-channel electrical stimulation of quadriceps, hamstrings, soleus and tibialis anterior. Frequency 50 Hz, pulse duration 400 µs, trapezoidal slopes with 5 pulses rising time and 3 pulses fall time, intensity 12-38 mA to result in muscle contractions within comfort boundaries. Walking physically assisted by therapist or use of tripod cane and encouraged on how to improve walking pattern. In addition to standard rehabilitation program. C: Standard rehabilitation. Intensity: 45 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA leg, BI, walking speed, PCI Measured at baseline and 4 wk	The results indicate significant differences in all outcome scores between the groups.
Cheng et al 2010	6	15 (8/7)	Age: 52.87±8.74 yr Type: first isch/hem Time since onset: 33.6±37.9 mos Inclusion: walk ≥6 m with spastic foot with or without assistive device; no sensory loss or oversensitivity to electrical stimulation	Comparison: Electrical stimulation (ES) vs. control (C) ES: Active ankle dorsiflexion movements challenged by a rocker board with force plate while standing, with visual feedback of performance to perform weight shifting toward center and posterior directions. ES with surface electrodes on motor points m. tibialis anterior, frequency 40 Hz, intensity to elicit maximal contraction without inducing discomfort, on-off time 10 seconds. Distribute body weight on both legs as evenly as possible. Suspension system provided safety, did not support bodyweight (30 min). Followed by ambulation training focusing on ankle control, with verbal cues to actively dosiflex ankle throughout swing phase and heel strike (15 min). C: General exercises including ROM, strengthening lower extremities and mat exercises (30 min). Followed by ambulation training focusing on ankle control, with verbal cues to actively dosiflex ankle throughout swing phase and heel strike (15 min). Intensity: 45 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Dorsiflexor muscle strength, dynamic plantarflexor spasticity, ankle ROM at heel strike, balance performance, gait velocity, gait spatial asymmetry ratio, gait temporal asymmetry ration, EFAP Measured at baseline and 4 wk	Our results suggest that repeated ES with volitional ankle movements can decrease dynamic ankle spasticity in subjects with stroke. Furthermore, such improvement parallels better gait symmetry and functional gait performance.
Ambrosini et al 2011	8	35 (17/18)	Age: 59±10 yr Type: first isch/hem Time since onset: 48±43 d Inclusion: MAS <2; no allergy to electrodes or inability to tolerate stimulation	Comparison: Functional electrical stimulation (FES) vs. control (C) FES: Sit in chair in front of motorized cycle-ergometer (MOTOmed) with current-controlled 8-channel stimulator with surface electrodes on quadriceps, hamstrings, gluteus maximum, tibialis anterior of both legs. Rectangular biphasic pulse with pulse width of 300µs, frequency of 20 Hz, intensity on each muscle at a tolerated value producing visibly good muscle contractions with stimulation timing synchronized to cycling movement. 5-minute warm-up of passive cycling, 15-minute training of FES cycling, 5-minute cool-down of passive cycling. Not contribute voluntarily to the pedaling, speed 20 rounds per minute. In addition to standard rehabilitation (3 h/d). C: As FES group but with sham stimulation with intensity set at zero. In addition to standard rehabilitation (3 h/d). Intensity: 25 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	MI leg, gait speed (50m walk test), TCT, UMCT, pedaling test Measured at baseline, 4 wk and 3-5 mos (follow-up)	The study demonstrated that 20 sessions of FES cycling training significantly improved lower extremity motor functions and accelerated the recovery of overground locomotion in postacute hemiparetic patients. Improvements were maintained at follow-up.

RCTs investigating EMG-NMS for the paretic leg

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Heckmann et al 1997	4	28 (14/14)	Age: 50.1±14 yr Type: first isch/hem Time since onset: 56.1±24 d Inclusion: right-handed, large supratentorial lesion; no previous stroke, dementia, bilateral lesions	Comparison: EMG-NMS vs. control (C) EMG-NMS: EMG-NMS of paretic hand and upper arm extensors, ankle extensors and knee flexors. Intensity to achieve a maximum effect of movement but not of force. EMG-activity required to trigger stimulation 80% of maximum voluntary surface EMG activity. 0.3 ms biphasic sinus-waved pulses, 80 Hz, constant current 20-60 mA for 1 s. Each group of muscles was stimulated 15 times per session. Supervised by advanced medical students. In addition to conventional therapy (see below). C: Conventional physiotherapy based on principles of Bobath (45 min/d, 5 d/wk), supplemented by OT predominantly covering ADL (>3h/wk plus≤2 h group therapy). Intensity: 15 contractions per muscle group/session, 5 d/wk, during 4 wk. Treatment contrast: ??	Spasticity, pendulum test, strength ankle extensors, BI Measured at baseline and 5 wk	The study group's results in evaluated spasticity scores, mobility parameters, and BI were superior to those of the control group, but the difference was not significant.
Mesci et al 2009	6	40 (20/20)	Age: 62.65±7.52 yr Type: first isch/hem Time since onset: 9.45±4.80 mos Inclusion: MAS <4, ROM ankle at least neutral position, normal deep sensation	Comparison: Electrical stimulation (ES) vs. control (C) ES: ES of hemiplegic foot dosiflexor muscles with EMG-trigger, first toe and then ankle dorsiflexors would be fully contracted without discomfort or pain. Symmetrical biphasic wave, frequency 50 Hz, 400 µs width. Current was increased to keep contractions at the same level. For every contraction, a trigger needed to be pressed. In addition to conventional exercise program, including positioning, ROM, active assistive exercises, progressive resistive exercises, endurance training, standing up and balance training, self-care skills, mobility proficiency and basic and advanced ADL training. C: Conventional exercise program (see above). Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 200 min.	PROM ankle dorsiflexion, MAS, FMA leg, FIM, RMA, FAC Measured at baseline and 4 wk	Use of ES in hemiplegic foot dorsiflexion can contribute to the clinical improvement of patients when used in combination with rehabilitation programs.

RCTs investigating TENS for the paretic leg

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Tekeoğlu et al 1998	4	60 (30/30)	Age: 55.9±7.0 yr Type: ?? Time since onset: 40.8±11.4 d Inclusion: discrete loss of motor function but able to stand and walk if assisted	Comparison: Transcutaneous electric nerve stimulation (TENS) vs. placebo (C) TENS: TENS with two surface electrodes on extensor muscles of elbow, other two electrodes on peroneal nerve posterior to head of fibula. Square pulses 0.2 ms, 100 Hz. Intensity at bearable pain threshold. In addition to Todd-Davies exercise programme. C: Sham stimulation. In addition to Todd-Davies exercise programme. Intensity: TENS/sham 30 min/d, 5 d/wk, during 8 wk. Treatment contrast: 0 h.	MAS, BI Measured at baseline and 8 wk	TENS appears to be an effective adjunct in the regaining of motor functions and improving ADL in hemplegic patients, but the accidental imbalance in severity of disability at entry makes interpretation uncertain.
Ng et al 2007	6	88 (22/22/22/22)	Age: 58.4±7.1 yr Type: first isch/hem Time since onset: 5.0±3.0 yr Inclusion: walk 10m unassisted with or without walking aid, CSS ≥10 ankle plantarflexors; no receptive dysphasia or cognitive impairment (AMT <7)	Comparison: Transcutaneous electrical nerve stimulation (TENS) vs. placebo TENS + task-related training (TRT) vs. TENS + TRT vs. control (C) TENS: At home TENS stimulation with electrodes placed over 4 acupuncture points in the affected leg. Frequency 100 Hz, 0.2ms square pulses, 2-3 times sensory threshold. Placebo TENS + TRT: At home identical-looking TENS device with electrical circuit disconnected inside. Followed by TRT including 4 weight bearing and stepping exercises using wooden blocks of 2.5 or 5 cm height: 1) load affected leg; 2) step up with affected leg; 3) step down with unaffected leg; 4) heel lifts from dorsiflexed position in standing and functional training; 5) stand up from chair, walk, return to chair; 6) walk with rhythmic auditory cues (metronome). 8 sessions in laboratory ensured that patients could follow home program and progress was made to higher block when exercise could be performed 20 times without compensation, and repetitions completed within 10 minutes. Walking progressed by increasing speed. Logbooks were kept. TENS + TRT: TENS and TRT (see above). C: No treatment. Intensity: TENS: 60 min/d, 5 d/wk, during 4 wk. TRT: 60 min/d, 5 d/wk, during 4 wk. Treatment contrast: TENS vs. placebo TENS + TRT: -20 h. TENS vs. C: 20 h. TENS + TRT vs. C: 40 h. TENS + TRT vs. placebo TENS: 0 h.	CSS, MIVC dorsiflexion and plantarflexion, gait velocity Measured at baseline and 2, 4 and 8 wk (follow-up)	In patients with chronic stroke, 20 sessions of a combined TENS + TRT home-based program decreased plantarflexor spasticity, improved dorsiflexor and plantarflexor strength, and increased gait velocity significantly more than TENS alone, placebo TENS + TRT, or no treatment. Such improvements can even be maintained 4 weeks after treatment ended.
Yavuzer et al 2007	8	30 (15/15)	Age: 61.9±10.01 yr Type: first isch/hem Time since onset: 3.5±2.1 mos Inclusion: Brunnstrom stage 1-3, stand and take ≥1 step with or without assistance; no medical contraindication to walking or electric stimulation	Comparison: Sensory-amplitude electric stimulation (SES) vs. control (C) SES: SES of common peroneal nerve and belly tibialis anterior muscle. Asymmetric biphasic rectangular stimulation, frequency 35 Hz, pulse width 240 µs, ≈10mA so the patient perceived a mild tingling sensation but below an observable or palpable muscle contraction. Duty cycle of 10 seconds on and 10 seconds off. In addition to conventional rehabilitation, consisting of NDT, PT, OT and speech therapy. C: Placebo SES, machine was turned on but without stimulation. In addition to conventional rehabilitation (see above). Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	Brunnstrom stage leg, walking velocity, step length, % stance phase on paretic side, sagittal plane kinematics (ROM) Measured at baseline and 4 wk	In our patients with stroke, SES of the paretic leg was not superior to placebo in terms of lower-extremity motor recovery and gait kinematics.
Ng et al 2009, Hui-Chan et al 2009	7	109 (27/25/28/29)	Age: 56.6±7.9 yr Type: ?? Time since onset: 4.7±3.4 yr Inclusion: >1 yr post stroke, walk 10m unassisted with or without walking aid, CSS ≥10 ankle plantarflexors, no unstable cardiopulmonary	Comparison: Transcutaneous electrical nerve stimulation + task-related training (TENS+TRT) vs. Placebo TENS + TRT (PLBO+TRT) vs. TENS vs. control (C) TENS+TRT: Home rehabilitation programme, consisting of TENS stimulator with electrodes over four acupuncture points on the affected leg, 100 Hz (60 min). Training of loading affected leg, stepping up with affected leg, stepping down with unaffected leg, heel lifts from dorsiflexed position while standing, standing up from chair – walk – return to chair, walk with rhythmic auditory cues generated by a metronome (60 min). PLBO+TRT: Home rehabilitation programme, consisting of placebo TENS from TENS device with electrical circuit disconnected inside (60 min).	CSS, MIVC dorsiflexion, MICV plantarflexion, walking speed comf, 6MWT, TUG Measured at baseline, 2 and 4 wk and 8 wk (follow-up)	Home-based rehabilitation programmes improved the lower limb motor functions in patients who had sustained strokes more than 1 year previously. A combination of TENS with TRT decreased plantarflexor spasticity, improved ankle dorsiflexor and plantarflexor strength, and increased gait velocity significantly more than either TENS alone, PLBO+TRT, or no treatment. Most of these improvements were

			disease, no uncontrolled diabetes mellitus	TENS: See above. C: No treatment. Intensity: TENS+TRT/ PLBO+TRT: 120 min/d, 5 d/wk, during 4 wk. TENS: 60 min/d, 5 d/wk, during 4 wk. C: 0 h. Treatment contrast: TENS+TRT/ PLBO+TRT vs. TENS: 20 h. TENS+TRT/ PLBO+TRT vs. C: 40 h. TENS vs. C: 20 h.		maintained 4 weeks after treatment.
Yan et al 2009	5	62 (21/21/20)	Age: 68.4±9.6 yr Type: first/rec isch/hem Time since onset: 9.2±4.4 d Inclusion: hipflexors MRC ≤3; no receptive dysphasia or cognitive impairment	Comparison: Transcutaneous electrical nerve stimulation (TENS) vs. placebo TENS vs. control (C) TENS: Stimulator with electrodes attached on acupuncture points on the affected lower extremity (St 36, Lv 3, GB 34, BI 60). Frequency 100 Hz, 0.2 ms pulses, constant mode within tolerance level. In addition to standard rehabilitation, including PT (1h) and OT (1h). Placebo TENS: Same electrodes, location and device as TENS, with circuit disconnected. In addition to standard rehabilitation. C: Standard rehabilitation. Intensity: 60 min/d, 5 d/wk, during 3 wk. Treatment contrast: TENS vs. placebo TENS: 0 h. TENS/ placebo TENS vs. C: 15 h.	CSS, MIVC ankle dorsiflexion and plantarflexion, EMG co-contraction, TUG Measured at baseline and 3 and 8 wk (follow-up)	Three weeks of TENS to lower leg acupuncture points, given 5 times a week within 10 days post-stroke, significantly decreased ankle plantarflexor spasticity, and increased dorsiflexor strength concomitant with a decrease in antagonist co-contraction.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Merletti et al. 1978	RCT	49 (24/25) limited or absent spasticity of plantar flexors	mean: 56.1y + 13.6y, range 14-80y	type : ? post-acute : mean 4.5 mo + 3.3 mo after stroke, range 1-15 mo	Yes	Intervention: Additional FES and PT vs PT Intensity: FES: 20 minutes/day for 6d/wk traditional PT (Kabat + Bobath techniques) for 1 hrs/d FES-characteristics: pulse duration 300 µs and pulses frequency was 30Hz; stimulation time was 1.5 s. ON and 3 s. OFF Electrodes: stimulation of peroneal nerve applied during walking or while sitting;	Ankle dorsiflexion torque (Nm) measured twice a week during 4 wk treatment	FES induced recovery of muscle force in hemiparetic subjects.	4 failure at the questions: 3,5,6,7,8,9
Cozean et al. 1988	RCT	36 11% drop-outs, 32 (8/8/8/8) completed the study, with spastic, equines problems	mean: 55.3y (SD:?)	type: iCVA and hCVA chronic: mean 16 of 36 patients > 1y after stroke	Yes	Intervention: 4 randomly divided groups receive either control (=standard PT),FES, BF or combined FES/BF Intensity: All therapies: 3x/wk 30 minutes, during 6 wk; BF/FES-group: 15 minutes BF and 15 minutes FES FES-characteristics: ? Electrodes: (FES): stimulation of anterior tibialis during swing phase and gastrocnemius during stance phase	Gait analysis: measurements of mean knee angle, ankle angle, cycle time and stride length measured bi-wk + 4wk after ending treatment	Combined therapy with BF and FES resulted in improvements in gait.	6 failure at the questions: 3,5,6,9
Macdonell et al. 1994	RCT	38 (20/18) with ankle dorsiflexion weakness: MRC < 4	mean: 67y + 9y, range 42-80y	type: all sub-acute mean 26d, range 11-45d	Yes	Intervention: Additional FES and PT vs PT Intensity: FES: 5d/wk, max. 30-40 min/d, combined with exercise or functional activities 3 d/wk for 20 min. for 4 weeks and C: self-exercise program 5 d/wk and exercise or functional activities 3 d/wk for 20 min.(4wk) FES-characteristics: pulse duration 300 µs and pulses frequency was 30-50Hz; stimulation cycle was 10s. ON and 30s. OFF Electrodes: stimulation applied at peroneal nerve	BI, FMA-lower extremity and FAC measured at 4 and 8 wk	Although this study found no conclusive evidence of benefit of FES plus physical therapy over physical therapy alone, the increased rate of improvement in FES-treated patients is potentially significant and suggests that longer periods of treatment and follow-up may be required to demonstrate a therapeutic effect.	5 failure at the questions: 3,5,6,8,9

Bogataj et al. 1995	RCT	20 (10/10) could stand independently or with the aid of a therapist	mean : 56.3y + 10.3y range 38-75y	type : ? post-acute : mean 110d + 64d after stroke	Yes	Intervention: MFES vs conventional therapy; one group started with MFES for 3 wk and continued conventional therapy and the other group had the reverse sequence of therapies Intensity: one therapy session per day (0.5-1hrs), 5x/wk during 6 wk FES-characteristics: stimulation sequence of the whole cycle: range 1-5 s.; repeated stimulation pattern of a 3s. stimulation train and 1 s. pause; pulse duration of 200 μs and frequency of 30Hz, max stimulation was limited to 50mA Electrodes: stimulation to peroneal nerve, soleus, hamstrings, quadriceps femoris, gluteus maximus and optionally triceps brachii;	Gait speed, stride length, gait cadence and FMA measured at 3 and 6 wk	The superiority of the MFES method as compared with conventional therapy was mainly attributed to the enhanced motor learning accomplished of MFES. These results, however, are preliminary, and further research is needed.	6 failure at the questions: 5,6,7,9
Burridge et al. 1997	RCT	33 0.3% drop-outs, 32 (16/16) completed the trial, drop foot and able to walk 10m 33 of 51 submitted study	mean: 57y +11.5 y	type: ? chronic: mean 4.5y after stroke (SD:?)	Yes	Intervention: Additional FES and PT vs PT Intensity: FES: min/d: ? , during 12-13 wk PT: 10 sessions of 1 hrs during first month of trial FES-characteristics: asymmetrical, biphasic pulses of 300 μs duration at a frequency of 40Hz; stimulation parameters (ramp, timing duration and output levels) individually adjusted. Electrodes: the stimulator is the ODFS; stimulation applied at peroneal nerve	TMW and PCI measured at 4-5 wk and at 12-13 wk	Walking was statistically significantly improved when the ODFS was worn but no “carry-over” was measured. PT alone, in this group of subjects with established stroke did not improve walking	6 failure at the questions: 4,5,6,7

RCTs investigating EMG-biofeedback for the paretic leg (paragraaf F.1.22)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Jonsdottir et al 2010	7	20 (10/10)	Age: 61.6±13.1 yr Type: first Time since onset: 5.9±10.5 yr Inclusion: ≥6 mos post stroke, walk 10 m without aid, minimum muscle contraction triceps surae, no visual or auditory deficits	Comparison: Electromyography biofeedback (EMG-BFB) vs. control (C) EMG-BFB: Acoustic signal driven by surface EMG of gastrocnemius lateralis during gait, with goal to increase power production of ankle during push-off phase, and increase velocity. Session 1-5: constant BFB and verbal instruction; 6-15: variable practice paradigm with intermittent EMG-BFB; 16-20: variable practice, BFB mostly withdrawn. C: Usual rehabilitation care, including NDT and neurofacilitation techniques, task-specific training, task-oriented training. ≥15 min devoted to gait training. Intensity: 20 sessions, 45 min/d, 3 d/wk. Treatment contrast: 0 h.	Walking speed comf, ankle power peak, stride length, knee flexion peak Measured at baseline and post treatment and 6 wk (follow-up)	A task-oriented BFB treatment was effective in increasing peak ankle power, gait velocity, and stride length in a population with hemiparesis.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Basmajian et al. 1975	RCT	20 (10/10) with drop foot following stroke	mean: 50.7 y., range 30-63y.	type: ? chronic: mean 33.6 mo after stroke, range 4-120 mo.	No	Intervention: additional EMG/BF and PT vs PT E: additional EMG/BF training plus gait training C: gait training EMG/BF-characteristics: audio- and visual feedback with patient seated in chair and knees in varying positions. Intensity: 3d/wk; 40 min/session during 5 wk (15 sessions)	Ankle AROM, ankle strength, gait quality measured after 5 wk treatment	Addition of BF significantly increased ROM and strength of ankle dorsiflexion	3 failure at the questions: 3,4,5,6,7,9, 10
Hurd et al. 1980	RCT	24 (12 / 12)	mean: 57.6 y + 18.7y	type: ?? postacute: mean 77d. + 56d. after stroke	Yes	Intervention: actual EMG/BF vs simulated EMG/BF E: received actual EMG/BF; visual and audio feedback to produce contractions of m. anterior tibialis C: simulated (placebo) EMG/BF (same conditions) EMG/BF-characteristics: audio feedback was given in the form of a constant pitched tone. Visual feedback in the form of a voltmeter whose scale of deflection could be adjusted to correspond to the range of the patients responses. Intensity: 5d/wk; 20 min in 10-15 trials during 2 wk	AROM and muscle activity measured at 2 wk after start treatment	No significant differences was found between actual EMG/BF and simulated EG/BF in AROM, measured in degrees, and muscle activity, measured in microvolts.	6 failure at the questions: 3,5,6,9

Mandel et al. 1990	RCT	37 (13 / 13 / 11) with various classifications of lower limb deficits and who no longer receiving any treatment aimed at improving their gait	mean: 56.5 y. + 13.4 y., range 22-80y.	type: all chronic: mean 32 mo. + 24.3 mo. after stroke	No	Intervention: comparison of rhythmic positional BF or EMG/BF vs no-treatment. E: 2 experimental groups received standardized BF while sitting (knees at 70 degrees), long sitting (unsupported), standing and walking; difference between groups being the nature of BF (EMG or RP) in the second 6 wk -period: E1) EMG feedback during active ankle movements, E2) received RP feedback only at the precise points of heel-off and swing-through to reinforce the correct timing. C: no treatment during 12 wk EMG/BF-characteristics: auditory and visual feedback of EMG signals of calf and pretibial muscle activity. And RP feedback of ankle ROM, and during walking at precise points to correct timing events. Intensity: 2d/wk, ?? min, two periods of 6 wk each, total 24 sessions in 12 wk.	Active ROM (ankle) and gait speed measurements at 6 and 12 wk and at 3 mo follow-up	The subjects receiving rhythmic positional biofeedback significantly increased their walking speeds relative to other groups at 12 wk and after follow-up (3 mo), without any increase in subjectively reported energy cost.	3 failure at the questions: 3,4,5,6,8,9, 11
Binder et al. 1981	RCT	10 (5/ 5) able to walk with or without assistive device	mean: ?	type: ? chronic: > 16 mo after stroke mean: ?	No	Intervention: additional EMG/BF and standards PT vs standard PT E: additional EMG/BF incorporated into both mat and gait training exercises C: standard PT based on neuromuscular facilitation techniques (Rood, Kabat, Knott and Voss, Brunnstrom and Bobath). EMG/BF-characteristics: auditory and visual feedback into mat and gait, with electrodes at quadriceps, hamstrings, anterior tibialis and gastrocnemius. Intensity: 3 d/wk 30-40 min for 4 wk (12 sessions) and for 1 patient additional 12 sessions in next 4 wk	AROM ankle dorsiflexion, ankle and knee angle, unilateral weight bearing , 50m. walk measured at 4 and 8 wk.	EMG/BF may be an effective adjunct to therapeutic exercise for chronic hemiplegic patients in decreasing their ambulation time. Also the results suggested the existence of a rehabilitation potential in chronic hemiplegic patients.	5 failure at the questions: 3,4,5,6,9
Winchester et al. 1983	RCT	40 (20 / 20) with active extension of paretic knee	mean: 58.5 y. +11.5 y.	type: iCVA and hCVA post-acute: mean 52d. + 39d. after stroke	Yes	Intervention: additional combination of PFST+ES and PT vs PT E: PFST while patient was sitting on the knee exercise unit with knee in 90 degrees (30 min) and cyclical quadriceps femoris muscle stimulation (2 hrs) C: PT based on neuromuscular facilitation techniques, progressive resistive exercises and weight-bearing BF-characteristics: auditory and visual feedback when changing joint angle while voluntary knee extension Intensity: 5 d/wk during 4 wk; C: 30 min/d and additional PFST: 30 min/d and ES: 2 hrs/d	AROM, PROM, knee-torque, position sense and nominal spasticity scale measured at 4 wk and AROM and torque were measured weekly	PFST is effective when used to augment a facilitation program for improving knee extension control in hemiparetic patients. No change was noted in the ability to extend the knees using isolated quadriceps femoris muscle control.	4 failure at the questions: 3,5,6,7,8,9
John 1986	RCT	12 (6 / 6) with weakness of paretic LE 60 patients were screened and 12 were selected (=20%)	mean: 48.3 y range 17-63y.	type: all post-acute: mean 75d. after stroke, range 12 - 280 d.	Yes	Intervention: additional EMG/BF and PT vs PT in two phases. Groups received randomly allocated E1 + E2. E1: PT, sensory stimuli to paretic leg E2: EMG/BF applied to muscles of LE and PT; seeE1 C: each patient acted as his/her own control EMG/BF-characteristics: auditory feedback (sound from machine) when voluntary contraction of healthy muscle. Facilitatory techniques employed by therapist to stimulate muscle activity at paretic site Intensity: 12-15 sessions in 3 wk (total 24-30 in 6 wk)	Ashburn Scale (15 m. walk, climbing 7 stairs, active knee extension, knee angle) measured at 3 and 6 wk	A 6 wk course of PT improves muscular function and ROM in patients with weakness due to a upper motor neurone lesions, but that these effects are not enhanced by EMG/BF	2 failure at the questions: 3,4,5,6,8,9, 10, 11

Mulder et al. 1986	RCT	12 (6 / 6) without re-acquiring the dorsiflexion function of ankle after stroke	mean: ? range 34-68y.	type: ?? phase : ?? mean: ?? after stroke	No	Intervention: EMG feedback vs NDT. E: received visual information concerning the electrical activity of the muscles under training to stimulate dorsiflexion of the paretic foot C: conventional PT based on NDT: regulation postural tone, reciprocal innervations of agonist and antagonist muscles and coordination regulation EMG/BF-characteristics: visual feedback (EMG-signal of m. peroneus or m. tibialis anterior) in 3 conditions: 1) sitting with knees flexed; 2) sitting with knees extended and 3) standing Intensity: 3d/wk; 40 min for 5 wk (15 sessions)	Ankle AROM and gait velocity measured after at 5 wk (velocity) and AROM measured 6 times in 5 wk (prior to session 1,4,7,10, 13 and following 15	No significant differences between the two methods	3 failure at the questions: 3,4,5,6,7,8,9
Cozean et al. 1988	RCT	36 11% drop-outs, 32 (8/8/8/8) completed the study, with spastic, equines problems	mean: 55.3y (SD:?)	type: iCVA and hCVA chronic: mean 16 of 36 patients > 1y after stroke	Yes	Intervention: 4 randomly divided groups received: 1) control (=standard PT); 2) FES; 3) BF; 4) FES/BF EMG/BF-characteristics: EMG-signals of anterior tibialis and calf muscles (voluntary dorsiflexion and relaxation gastrocnemius) in sitting and BF training of gait pattern. Intensity: all therapies: 3d/wk 30 minutes, during 6 wk; BF/FES-group: 15 minutes BF and 15 minutes FES	Gait analysis: measurements of mean knee angle, ankle angle, cycle time and stride length measured 2-wk and 4wk after ending treatment	BF alone appeared to be somewhat more effective than FES, but a statistically significant difference was not seen. Combined therapy with BF and FES resulted in improvements in gait.	6 failure at the questions: 3,5,6,9
Colborne et al. 1993	RCT, cross-over design	8 able to walk independent with or without waking device	mean: ?	type: ? chronic: mean 17 mo after stroke	Yes	Intervention: 3-period cross-over design with 3 treatments: 1) EMG (soleus), 2) joint angle feedback (electro-goniometer) and 3) PT based on NDT + MRP EMG/BF-characteristics: auditory and visual BF from affected-side soleus muscle during walking Intensity: 2d/wk 30 min for 4 wk (8 sessions)	ROM, stride length, stride time and velocity measured every period (4 wk) and 1 mo. after ending cross-over trial	Both feedback methods improved gait	3 failure at the questions: 3,4,5,6,7,8,9
Intiso et al. 1994	RCT	16 (8 / 8) with drop foot 14 (8 / 6) completed the study (11% drop outs)	mean: 57.4 y. +15.4 y. range 40-85y	type: first stroke chronic: mean 9.8 mo + 9.3 mo after stroke	Yes	Intervention: additional EMG/BF and PT vs PT E: phase 1: learning about the technique and in phase 2: acoustic feedback with portable EMG/BF during walking C: treatment according to Bobath-method plus standard exercises for dorsiflexion of the foot EMG/BF-characteristics: BF at anterior tibialis muscle, 20 isotonic contractions lasting 5 sec followed by 30 sec rest with flexed knee (30 degrees) Intensity: 5d/wk 60 min for 2 mo (40 sessions)	BI, CNS, AS, Adams scale, gait quality and kinematic parameters of gait measured at baseline and after the therapy program	EMG/BF increased muscle strength and improved recovery of functional locomotion in patients with hemiparesis and drop foot after cerebral ischemia	6 failure at the questions: 3,5,6,9
Bradley et al. 1998	RCT	21 (12 / 9) 23 admitted, 21 started and 19 completed the study (17% drop-outs)	mean: 58.5 y. +11.5 y.	type: first stroke post-acute: mean 36d +? after stroke	Yes	Intervention: comparison of EMG/BF and PT vs placebo EMG/BF and PT to improve gait after stroke E: encourage active control at the hip, knee and ankle, improving weight transference to affected side by EMG/BF C: same techniques as E, but EMG/BF turned off and faced away EMG/BF-characteristics: facilitate or inhibit abnormal muscle tone via auditory and visual signals transmitted from electrodes placed over the appropriate muscles Intensity: 3 d/wk during 6 wk (18 treatments)	MBS, MAS, sensation test, TMW, RMI and NEAI measured after 6 wk and 3 mo (follow-up)	No significant difference in the rate of improvement after stroke between the two groups. Although EMG/BF was provide little evidence to support the clinical significance of using EMG/BF to improve gait in the acute phase after stroke	4 failure at the questions: 3,4,5,6,9,11

RCTs investigating Bilateral Leg Training with Rhythmic Auditory Cueing (paragraaf F.2.1)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Johannsen et al 2010	8	24 (12/12)	Age: 63.6±12.5 yr Type: isch/hem Time since onset: 62.5±50.9 mos Inclusion: walking disability, ability to stand and transfer, RMAg 6-12	Comparison: Bilateral leg training with rhythmic auditory cueing (BLETRAC) vs. bilateral arm training with rhythmic auditory cueing (BATRAC) BLETRAC: Custom designed apparatus, on which patients actively performed periodic simultaneous bilateral antiphase limb movements that required hip and knee joint movements, with tracks' inclination of 6^o, paced by auditory metronome set to individual level at each session. Per session 3 blocks of 10 min, with 5 min rest. BATRAC: Same dose as BLETRAC, with bilateral alternating upper extremity movements with hands moving vertical grips forward and backward in reciprocal fashion. Intensity: 45 min/d, 2 d/wk, during 5 wk. Treatment contrast: 0 h.	FMA leg, FMA arm, 10MWT, step length, cycles repetitive foot task, cycles repetitive hand aiming task Measured at baseline and 6 wk	This exploratory trial demonstrates that transfer of the BATRAC approach to the legs is feasible. Transient improvements of limb motor function in chronic stroke participants were induced by targeted exercise (BATRAC for the upper extremity and BLETRAC for the lower extremity). It may be that further periods of training would increase and maintain effects.

RCTs investigating mirror therapy for the paretic leg (paragraaf F.2.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Sütbeyaz et al 2007	7	40 (20/20)	Age: 62.7±9.7 yr Type: first isch/hem Time since onset: 3.5±1.3 mos Inclusion: <12 mos post stroke, Brunnstrom stage leg 1-3	Comparison: Mirror therapy (MT) vs. control (C) MT: Non-paretic ankle dorsiflexion movements at self-selected speed while sitting in semi-seating position on a bed, with mirror board positioned between legs perpendicular to the subject's midline, observing reflection of nonparetic leg. Supervised without additional verbal feedback. In addition to conventional stroke rehabilitation program (2-5 h/d, 5 d/wk, 4 wk). C: Sham therapy, as MT but with nonreflecting side of the mirror used. In addition to conventional stroke rehabilitation program. Intensity: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	Brunnstrom stages, MAS, FAC, FIM motor Measured at baseline and 4 wk and 6 mos (follow-up)	Mirror therapy combined with a conventional stroke rehabilitation program enhances lower-extremity motor recovery and motor functioning in subacute stroke patients.

RCTs limb overloading lower extremity (paragraaf F.2.3)

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Pomeroy et al. 2001	RCT	24 (12 / 12), were able to walk 10 m	mean: ?	type: chronic: mean: > 6 mo after stroke	Yes	Intervention: weighted garments vs no weighted garments E: wearing weighted garments are worn on the paretic site only (at wrist, biceps, thigh, ankle, pelvis and shoulder girdle); they walked during 10 minutes within the room; at the end of this 10-minutes period the weight in each garment was reduced to a third and the subject was instructed to wear the garments on a daily basis. C: wearing no weighted garments Intensity: 6 wk on daily basis	BBS, gait (instrumented walkway): velocity and symmetry parameters measured before randomization (wk 1) and after the intervention (wk 7), both: not wearing garments)	There is no evidence that stroke patients who wore weighted garments showed no change in balance and gait.	7 failure at the questions: *5,6,9*

RCTs investigating systematic feedback on walking speed (paragraaf F.2.4)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Dobkin et al 2010	7	179 (88/91)	Age: 62.9±12.6 yr Type: first/rec isch/hem Time since onset: 27.3±78 d Inclusion: MRC ankle/ knee/ hip ≤4, ≥5 steps with no more than maximal assistance of 1 person	Comparison: Daily reinforcement of walking speed (DRS) vs. no reinforcement of walking speed (NRS) DRS: Conventional inpatient rehabilitation. Also performing a daily 10m walk as part of PT session. Timing after being told to walk as quickly as they felt safe, then given specific feedback and encouragement concerning speed. NRS: Conventional inpatient rehabilitation. Also performing a daily 10m walk as part of PT session. Not timed and received no information about walking speed. Intensity: ?? Treatment contrast: 0 h.	Walking speed (max), FAC, LOS Measured at baseline and up to 8 wk or discharge	An internet-based collaboration of 18 centers found that feedback about performance once a day produced gains in walking speed large enough to permit unlimited, slow community ambulation at discharge from inpatient rehabilitation.

RCTs investigating contracture prevention (tilt table or night splint) (paragraaf F.2.5)

First author, year of publication	**PEDro**	**N (E/C)**	**Patient characteristics**	**Intervention (e.g. type, duration, frequency)**	**Outcome measure (primary)**	**Conclusions (author)**
Robinson et al 2008	8	30 (16/14)	Age: 74±12 yr Type: first Time since onset: 12.6±5.4 d Inclusion: <3 wk post stroke, MAS* item 5 (walking) <3, affected ankle dorsiflexion within 10^o of intact ankle, no diabetic, no circulatory problems contraindicating application of splints	Comparison: Night splint (NS) vs. tilt table (TT) NS: Affected ankle splinted in plantargrade position by a prefabricated splint or padded fiberglass splint. Nursing staff or family applied splint with participant in supine and knee extended after they were assisted to bed. Removed prior to being assisted out of bed in the morning. In addition to inpatient rehabilitation aiming at early weight bearing and regaining mobility (5 d/wk), or outpatient rehabilitation following discharge (1-2 d/wk). No other intervention aimed purely at maintaining ankle dorsiflexion. TT: Standing on tilt table with affected ankle positioned at maximal dorsiflexion using appropriately-angled wedge. Unaffected leg placed on a stool, affected hip and knee maintained in extension using straps. In addition to in- and outpatient rehabilitation (see above). Intensity: NS: 7 d/wk, during 4 wk; TT: 30-40 min/d, 5 d/wk, during 4 wk. Treatment contrast: ??	PROM ankle dorsiflexion, MAS* item 4 (standing ability) Measured at baseline and 4 wk and 10 wk (follow-up)	When added to early rehabilitation, wearing a night splint on the affected ankle in stroke patients appears to be as effective as standing on a tilt table in preventing contracture at the ankle. However, since there was no control group, the prevention of contracture may have been due to other factors.

RCTs investigating passive joint mobilization (ankle) (paragraaf F.2.6)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Kluding et al 2008	5	17 (8/9)	Age: 55.8±11.9 yr Type: ?? Time since onset: 21.4±13.8 mos Inclusion: transfer from sit to stand, walk 10 m without human assistance, <8° passive ankle dorsiflexion hemiparetic side; no contraindications ankle joint mobilization	<u>Comparison</u>: Ankle joint mobilizations + functional practice (M/FP) vs. FP <u>M/FP</u>: Ankle joint mobilization on hemiplegic leg: proximal tibia-fibula anterior and posterior direction, distal tibia-fibula anterior and posterior direction, talocrural articulations in loose packed position. Mobilizations applied with grade I or II manual traction and gliding during first session, other sessions grade III (5 min). Functional training of sit-to-stand, walking, climbing stairs (15 min). Functional training (see below). <u>FP</u>: Functional training of sit-to-stand, walking, climbing stairs (15 min). Sitting and standing balance (10 min). Based on motor learning principles, with multiple repeated practice opportunities, use of variability and progression. Manual guidance minimized. Encouraged to maximize available ankle motion during functional tasks and to bear weight through their involved limb. <u>Intensity</u>: 30 min/d, 2 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.	PROM ankle dorsiflexion, AROM ankle, peak dorsiflexion sit-to-stand, peak dorsiflexion gait, peak weight bearing difference sit-to-stand, average weight bearing difference, sit-to-stand, RMI Measured at baseline and 4 wk	The increase in ankle motion did not improve joint kinematics and may have prevented improvement in weight-bearing symmetry.

RCTs investigating ROM exercises for the ankle with special equipment (paragraaf F.2.7)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Rydwik et al 2006	6	18 (9/9)	Age: 74.9±8.7 yr Type: first isch/hem Time since onset: 42.6±18.2 mos Inclusion: ≥1 yr post stroke, spasticity and/or decrease A ROM hemiparetic leg/ankle, able to walk	Comparison: Portable stretching device (E) vs. control (C) E: Portable device to maintain or increase ROM in the ankle by passive and active dorsal extension and plantar flexion, subject lying face up. Warming up (passive, 5 min), active and passive workout (15-20 min), cooling down (passive, 5 min). Hold 10 s maximum ROM positions, progression by increasing length of active and decrease passive work period. C: No therapy. Intensity: 30 min/d, 3 d/wk, during 6 wk. Treatment contrast: 9 h.	SF-36, SF-36 subdomains, FIM, Instrumental activity measure, Romberg, semitandem, tandem, TUG, 6MWT, 10MWT comf, 10MWT max, number of steps, ROM, 1RM Measured at baseline and 6 wk and 12 wk (follow-up)	The study showed no significant effect of an ankle-exercise intervention programme with Stimulo.

RCTs investigating ultrasound for the paretic leg (paragraaf F.2.8)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Ansari et al 2007	7	12 (6/6)	Age: 57.33±11.29 yr Type: ?? Time since onset: 15.25±11.64 mos Inclusion: >6 mos post stroke, ankle plantarflexor spasticity; no fixed ankle contracture, spasticity modifying drugs, stretching exercise regime	Comparison: Ultrasound (US) vs. control (C) US: Ultrasound to area of calf muscle groups with stroking technique, frequency 1 MHz, continuous mode, 1.5 W/cm2. C: Sham US. Intensity: 15 sessions, 10 min/d, every other day. Treatment contrast: 0 h.	Hmax/Mmax ratio, MAS, AROM, PROM Measured at baseline and post treatment	Results from the present study show that treatment with US can reduce Hmax/HMmax ratio as a measure of alpha motorneuron excitability and MAS in stroke patients with ankle plantar flexor spasticity.

RCTs investigating segmental muscle vibration (paragraaf F.2.9)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Paoloni et al 2010	8	44 (22/22)	Age: 59.5±13.3 yr Type: first isch Time since onset: 1.85±0.59 yr Inclusion: foot drop >6 mos, walk ≥10 m without assistive devices; no ankle spasticity MAS 3-4, conditions that may interfere with locomotion	Comparison: Segmental muscle vibration (SMV) vs. control (C) SMV: Low amplitude SMV on tibialis anterior and peroneus longus by acoustic wave vibratory device while lying supine. Frequency 120 Hz, amplitude 10 µm (subthreshold for tonic vibration reflex), trains of 6 sec divided by 1 sec pauses. Following PT, involving stretching, muscle strengthening, balance, overground walking. C: PT (see above). Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 360 min.	Time-distance characteristics, kinematic characteristics stance phase, kinematic characteristics swing phase Measured at baseline and 8 wk	SMV added to general physical therapy may improve gait performance in patients with foot drop secondary to chronic stroke.

RCTs investigating whole body vibration (paragraaf F.2.10)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Van Nes et al 2006	8	53 (27/26)	Age: 59.7±12.3 yr Type: first isch/hem Time since onset: 38.9±9.2 d Inclusion: <6 wk post stroke, BBS <40; no nonstroke-related sensory or motor impairment, medication interfering with postural control, contraindications for whole body vibration (WBV)	Comparison: Whole body vibration (WBV) vs. control (C) WBV: Train on commercially available device, with platform making fast oscillating movements around a sagittal axis in the middle. Stand with feet at equal and standardized distance from axis, vibration amplitude≈3 mm, frequency 30 Hz. Patients with FAC 3-5: adopt squat position and hold on support bar. Patients with FAC 0-2: supported at buttocks by height-adjustable bench with knees and hips in 45^{o} flexion while holding onto supportbar. Per session 4x45 sec stimulation interrupted by 1 min break. In addition to individualized treatment program consisting of at least individual PT (30 min/d, 5 d/wk), group PT (60 min/d, 5 d/wk), individual OT (30 min/d, 3 d/wk), speech and language therapy and psychologic treatment. C: Adopt same standing position as WBV, with program consisting of regular exercises for trunk, arm, and leg muscles interrupted by periods of relaxation, given individually or in small groups. In addition to individualized treatment program (see above). Intensity: 4x 45 s/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	BBS, BI, TCT, RMI, FAC, MI, somatosensory threshold Measured at baseline and 6 wk and 12 wk (follow-up)	Daily sessions of whole-body vibration during 6 weeks are not more effective in terms of recovery of balance and activities of daily living than the same amount of exercise therapy on music in the postacute phase of stroke.

RCTs investigating orthosis (AFO and KAFO) (paragraaf F.3.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Kosak 2000	4	56 (22/34)	Age: mean±SEM 71±1 yr Type: first isch/hem Time since onset: mean±SEM 40±3 d Inclusion: FIM walk ≤3, m. iliopsoas MRC ≤3	Comparison: Aggressive assisted walking (ABAW) vs. body-weight supported treadmill training (BWSTT) PBWSTT and PT vs traditional gait training (using knee-ankle combination bracing and hemi-bar if needed) and PT (45 min). ABAW: Aggressive bracing assisted walking (ABAW) on the floor using a KAFO or AFO and rigid hemi-bar. In addition to traditional PT (45 min). BWSTT: initially 30% BWS, progressively decreased till 0%; mean 12.5 treatment sessions. In addition to traditional PT (45 min). Intensity: max 45 min, 5 d/wk, during 6 wk.	2MWT Measured at 2-wk intervals during the study (2, 4, 6 wk)	PBWSTT and ABAW are equally effective gait training techniques except for asubset of patients with major hemispheric stroke who are difficult to mobilize using ABAW alone.
Wright et al 2004	2	26 (??/??)	Age: ?? Type: ?? Time since onset: <6 mos Inclusion: <6 mos post stroke, failure to achieve heel strike and corrected by FES, inability to achieve effective push-off at terminal stance; no previous AFO <4 wk, required other AFO than selected for trial	Comparison: Ankle-foot orthosis (AFO) vs. Elecrical stimulation (ES) AFO: Wear Orthopmerical Supera-Lite AFO. ES: Wear Odstock Dropped Foot Stimulator. Intensity: 24 wk. Treatment contrast: 0 h.	10MWT, PCI, 3MWT, MAS, RMI Measured at baseline and every 6 wk up to 24 wk	No significant differences between the groups were observed by ANCOVA on any of these measurements.
Erel et al 2011	6	28 (14/14)	Age: 42.5±14.89 yr Type: isch/hem Time since onset: 30.21±13.84 mos Inclusion: FAC 3-5, no AFO, >6 mos post stroke, MAS ≤3, passive dorsiflexion ≥90°	Comparison: Ankle-foot orthosis (E) vs. control (C) E: Dynamic ankle-foot orthosis. C: No intervention. Intensity: 6 mos. Treatment contrast: ??	FR, TUG, TUS, TDS, walking speed comf, physiological cost index Measured at baseline and 6 mos	Chronic hemiparetic patients may benefit from using dynamic ankle-foot orthosis.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**

Beckerman et al. 1996 (Arch Phys Med Rehabil)	RCT	60 (15/16/15/14), able to walk, with spastic equino-varus foot, 5 % drop-outs, 57 completed the study	median: 58y, range 21-72y	type: first (iCVA and hCVA) chronic: median 34 mo after stroke; range 5-185 mo	Yes	pp AFO in 5º dorsiflexion vs placebo (pp hinged) AFO, combined with thermo coagulation vs placebo thermo coagulation (2x2 factorial design) Four treatment groups: TH/AFO; PTH/AFO; TH/PAFO; PTH/PAFO during 3 months	SIP-ambulation and walking speed (distance of 5.5 m) measured at 6 and 15 weeks after randomisation	No support was found for the beneficial effects of either thermo coagulation of the tibial nerve or a polypropylene ankle-foot orthosis in 5 degrees of dorsiflexion on the walking ability of stroke patients	7 failure at questions: 5,6,9
Beckerman et al. 1996 (Clin Rehabil)	RCT, same study					Same 2x2 factorial design: different outcome	Spasticity, FMA, walking speed (distance 5.5 m)	No effect of the AFO could be demonstrated. When the efficacy of TH and the AFO are judged in terms of functional abilities, however, the effects seem of little value.	7 failure at questions: 5,6,9

RCTs investigating intensity of practice (paragraaf B.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Wall et al 1987	4	20 (5/5/5/5)	Age: 45-70 yr Type: ?? Time since onset: 18 mos – 20 yr Inclusion: discharge from rehabilitation, walk with or without cane but had reduced support phase time affected lower limb; no serious or unstable medical condition, major central sensory disorders, homonymous hemianopia, incontinence	Comparison: Exercises with different supervision A: At PT facility 10 exercises, designed hierarchically in terms of complexity. Each exercise 5 min: 2x 1.75 min 10 reps, 45 sec rest. 5 min rest after 5th and 8th exercise. At 1 mos interval most basic exercise was dropped and additional more demanding exercise was added. PT provided feedback and corrected patient. B: Identical exercises but at subject's home with supervision and correction from spouse or companion. Instructional videotapes shown to patients and companians when they visit laboratory for assessment. Booklet describing exercises. C: PT facility once a week, other time exercise at home with supervision and correction from spouse or companion. D: No therapy. Intensity: A, B, C: 1 h, 2 d/wk, during 6 mos. Treatment contrast: A vs. B. vs. C: 0 h. A, B, C vs. D: 52 h.	Walking speed, single support time, single support asymmetry ratio Measured at baseline, 1, 2, 3, 4, 5 and 6 mos and 7, 8, 9 mos (follow-up)	When each group was compared to pretest data, only walking speed was found to increase significantly, but even this improvement, seen only in the treatment groups, was inconsistent and not maintained.
Young et al 1991, 1992	8	107 (57/50)	Age: median 72 (range 60-88) yr Type: first/rec Time since onset: 4-12 wk Inclusion: >60 yr, discharge BI <20; no return to previous functional capabilities, main need for family relief	Comparison: Day hospital (DH) vs. home physical therapy (HPT) DH: After hospital discharge, day hospital with multidisciplinary rehabilitation, including individual and group OT and PT. HPT: After hospital discharge, home PT. Intensity: PT → DH: 2 d/wk, during 8 wk (total 7.5 h). HPT: <20 h, frequency and duration left to discretion of PT, during 8 wk (total 5 h). Treatment contrast: 2.5 h.	BI, MCA, FAI, NHP, GHQ (carer), community support Measured at baseline (hospital discharge) and 8 wk and 6 mos (follow-up)	The findings suggest that HPT is slightly more effective for stroke aftercare than DH attendance and is considerably more resource efficient.
Baskett et al 1999	8	100 (50/50)	Age: 71.7±9.1 yr Type: first/rec Time since onset: 37.5±36.4 d Inclusion: need for ongoing PT/OT, resident in private home or rest home	Comparison: Outpatient therapy vs. home therapy Outpatient: At discharge referred to day hospital program or dedicated PT and/or OT outpatient department at hospital. Multidisciplinary team assessment. Progress monitored weekly, program modified. PT/OT according to Bobath, Carr and Shepherd. Home: Visit at home after discharge by PT and OT for assessment, ongoing rehabilitation goals. Self-directed therapy program of home exercise and activities was devised with functional approach, goals set towards restoration, or improvement, of normal activities within home and extending boundaries of limitations. Personalized diary, updated ads required, with help caregiver. Exercise several times a day. Intensity: Outpatient: day hospital 5 h/d, 2-3 d/wk, during up to 3 mos; total 11.3±8.2 h. Home: 1 d/wk, up to 3 mos; total 8.75±6.1 h. Treatment contrast: 2.55 h.	10MWT, MAS*, FAT, NHPT, grip strength, BI, GHQ, HADS Measured at baseline and 3 mos	A supervised home-based program is as effective as outpatient or day hospital therapy.
Lippert-Grüner et al 1999	2	20 (??/??)	Age: ?? Type: isch/hem Time since onset: 4-6 wk Inclusion: central arm paresis	Comparison: Strength training (E) vs. control (C) E: Training with hand-finger dynamometer of isometric maximal muscle power training of handflexion and handextension, with frequency 5 sec contraction, 5 sec relaxation. In addition to normal rehabilitation. C: Normal rehabilitation. Intensity: 5 min/d, 10 d, during 2 wk. Treatment contrast: 50 min.	Muscle strength Measured at baseline and 2 wk	Additional isometric muscle power training in patients with centrally caused arm paresis can be made efficiently, adding a useful part to therapeutical spectrum.
Andersen et al 2002	6	138 (51/44/43)	Age: 69.8±9.9 yr Type: first/rec isch/hem	Comparison: Follow-up home-visit by physician (INT1-HVP) vs. physiotherapist instruction in patients home (INT2-PI) vs. control (C)	FQM, BI, FAI, IEADL	Follow-up services after stroke may be a way of improving functional outcome.

			Time since onset: 87.6±76 d Inclusion: acute stroke, discharge to own home, SSS <58 or MRC ≤4+; no disease likely to shorten life, previously included in study	INT1-HVP: Home visits of physician focused on early detection and treatment of complications, maintenance of functional ability, psychological and social adjustment to new life with stroke. Patients were allowed to contact project physician by phone. INT2-PI: Instruction and re-education by PT after discharge characterized by instruction and education; frequency determined by PT and adjusted to patients' needs. Evaluation of indoor and outdoor mobility and some basic ADLs, test strategies to solve problems. C: Standard aftercare including outpatient rehabilitation on ordination by hospital physician or GP, homecare to compensate for disability. Intensity: INT1-HVP: 3x 1 h (wk 2, 6, 12); INT2-PI: 2.9 h (wk 0-6). Treatment contrast: INT1-HVP vs. INT2-PI 6 min. INT1-HVP vs. C: 3 h. INT2-PI vs. C: 2.9 h.	Measured at baseline and 6 mos	
Byl et al 2003	4	18 (8/10)	Age: 69.0±5.1 yr Type: first/rec Time since onset: chronic Inclusion: walk >100 ft independent, elevate arm ≥60°, flex elbow 40°-65° against gravity, initiate partial opening/ closing of the hand	Comparison: Sensory training (ST) vs. control (C) ST: Sensory discriminative training, including 1) using stress-free hand strategies in all functional activities, e.g. use hand in functional position, let sensation of objects open hand, hold objects with least force possible and feel everything with different fingers, perform activities with eyes closed, thread fingers together and facilitate maintenance of carpal and obliqarm arches of the hand; 2) improve sensory discrimination, e.g. watch videotape demonstrating sensory activities, play games with eyes closed, read Braille books, place coarse and unusual surfaces on objects to help control excessive feedback, place hand into box filled with objects; 3) quiet the nervous system, e.g. facilitate normal motor movements following light sensory stimuli, keep arm close to trunk, wrap up in blanket and rock in a rocker, positioning, tape skin; 4) reinforce learning with mental rehearsal and mirror. Activities matched to abilities, required attention and repetition, feedback on performance, progressed in difficulty. At home wear garden glove unaffected hand 7 h/d, practice specific functional activities ≥15 min to ≥90 min/d. Videotape demonstrating how to perform variety of tasks emphasizing sensory discrimination and fine motor activities, each task ≥5 min. Keep log. C: Fine motor training. Intensity: Total 12 h, 1.5 h/d during 4 wk. Treatment contrast: 0 h.	Graphesthesia, kinesthesia, Byl-Cheney-Boczai Test for stereognosis, digital reaction time, PPT, MMT, ROM, WMFT, CFE, gait speed comf Measured at baseline, 4 wk and 8 wk	This study provides evidence documenting significant improvement in function in the late poststroke recovery period following 12 hours of supervised learning based sensory motor training.
Di Lauro et al 2003	7	60 (29/31)	Age: 69.3±8.0 yr Type: isch Time since onset: <24 h Inclusion: BI ≤3; no slight hemiparesis, severe concomitant cardiac/ respiratory disorders	Comparison: Intensive (E) vs. control (C) E: Morning session: mobilization according to Knott&Voss (45 min), proprioceptive recognition, rehabilitative nursing (15 min). Afternoon session: mobilization (15 min), tactile, kinesthetic and proprioceptive stimulation, visual stimulation, cognitive skill exercises, acoustic stimulation (45 min). C: Passive and active mobilization, bedsores prevention, correct positioning in bed (45 min/d). Intensity: 2x 1 h/d, during 2 wk. Treatment contrast: 750 min.	modified NIHSS, BI Measured at baseline and 14 d and 180 d (follow-up)	This study shows that there is no point in adopting an intensive rehabilitative treatment for an ischemic stroke in its acute phase: a more expensive and time-consuming effort does not in any way lead to a better outcome.
Duncan et al 2003	8	100 (50/50)	Age: 68.5±9.0 yr Type: isch/hem Time since onset: 77.5±28.7 yr Inclusion: 30-150 d post stroke, ambulate 25 ft independently, FMA 27-90, OPS 2.0-5.2, palpable wrist extension; no serious cardiac conditions, oxygen dependence, weight-bearing pain, organ system disease	Comparison: Exercise (E) vs. control (C) E: Supervised progressive exercise program targeting strength, balance, endurance, upper extremity function, performed at home. C: Usual care. Education about stroke prevention and measurements of blood pressure and oxygen saturation (1x/2wk). Intensity: 36 sessions, 90 min/d, 3 d/wk, during 12 wk. Treatment contrast: ≈1620 min.	FMA arm, FMA leg, WMFT, grip strength, isometric ankle dorsiflexion andknee extension, 10MWT, BBS, FR, HRmax, VO_{2peak}, MET, execise duration Measured at baseline and 3 mos	This structured, progressive program of therapeutic exercise in persons who had completed acute rehabilitation services produced gains in endurance, balance, and mobility beyond those attributable to spontaneous recovery and usual care.

Katz-Leurer et al 2003, 2007	5	92 (46/46) 64 (32/32)	Age: 61±11 yr Type: first isch Time since onset: <30 d Inclusion: <30 d post stroke, no pathological change ECG; resting blood pressure systolic ≤200 mmHG and diastolic ≤100; no arrhythmia, heart failure, β-blockers	<u>Comparison</u>: Aerobic training (E) vs. control (C) <u>E</u>: Train on leg cycle ergometer. Wk 1-2 wk multiple short 2 min intervals with 1 min rest periods for up to 10 min/d, then add ≥1 min to ≥1 interval working periods each day until he/she could work continuously for 20 min. Wk 3-8: cycling at 60-70% of HRR. In addition to traditional rehabilitation. <u>C</u>: Traditional rehabilitation, including PT, OT and speech therapy; group activity for general exercise (5 d/wk). <u>Intensity</u>: wk 1-2: 10-20 min/d, 5 d/wk. Wk 3-8: 30 min/d, 3 d/wk. <u>Treatment contrast</u>: 11.5 h.	HR at rest, peak workload, walking distance, walking speed, stair climbing, FIM, FAI Measured at baseline and 8 wk and 6 mos (FAI)	Early aerobic training resulted in positive effects on peak workload and walking parameters in stroke patients. No modification effect was found between HRV parameters and exercise on those parameters. Early, moderately intense aerobic training has no direct impact on independence in daily and social activities as measured by FAI total score six months after stroke.
Morioka et al 2003	6	26 (12/14)	Age: 62.6±13.3 yr Type: isch/hem first/rec Time since onset: 65.4±18.6 d Inclusion: hemiplegia, standing maintenance was becoming independent; no higher brain dysfunction, dementia	<u>Comparison</u>: Perceptual learning (E) vs. control (C) <u>E</u>: Perceptual learning exercise to discriminate hardness of sponge rubber placed under sole of the foot while standing. Three 30-cm square rubbers (5, 10, 15 mm) with hardness of resp. 2425 nM, 1875 nM, 1500 Nm in random order. Verbal feedback. In addition to PT and OT (see below). <u>C</u>: PT and OT, including ordinary postural control exercises. <u>Intensity</u>: 10 d, during 2 wk. <u>Treatment contrast</u>: ??	Postural sway (eyes open and closed) Measured at baseline and 2 wk	The plantar perception exercise used as a method in this study is considered to be effective as a supplemental exercise for standing balance.
Barreca et al 2004	6	48 (25/23)	Age: median 67 (IQR 56-72) yr Type: isch/hem Time since onset: 30 IQR 21-48) d Inclusion: CMSA postural control ≥3, unable to safe and independent rise from sitting to standing (CMSA stage 4 postural control item 3)	<u>Comparison</u>: Sit-to-stand (STS) vs. control (C) <u>STS</u>: STS practice sessions in groups of 6-7 participants. Standing from sitting from variety of different surfaces, attempted to complete 3 practice sets of 5 STS until class was over. In addition to regular therapy. <u>C</u>: Recreational therapy, remaining seated in wheelchair. <u>Intensity</u>: 45 min/d, 3 d/wk, during regaining independent STS or discharge. <u>Treatment contrast</u>: 714.15 min.	General health status satisfaction, QoL satisfaction, independent STS Measured at baseline and weekly till independent STS or discharge	This study supports the importance of repetitive practice in improving STS performance.
GAPS 2004	8	70 (35/35)	Age: 68±11 yr Type: first Time since onset: 22±14 d Inclusion: sitting balance, no uncontrolled diseases	<u>Comparison</u>: Augmented PT (E) vs. control (C) <u>E</u>: Additional physiotherapy input to double total daily PT, broadly based on Bobath approach. Specific objectives including independent dynamic sitting balance, standing balance, upper limb function, walking, other functional mobility tasks. <u>C</u>: Conventional PT, broadly based on Bobath approach (see above). <u>Intensity</u>: E: 60-80 min/d, 5 d/wk (received: 43 sessions 95% CI 35-51, 62 min/d, total 34 h). C: 30-40 min/d, 5 d/wk (received: 32 sessions 95% CI 24-40, 35 min/d, total 21 h). <u>Treatment contrast</u>: 135 min/wk.	Mobility milestones, RMI, BI, NEADL, EuroQoL Measured at baseline and 1, 4 wk, 3, 6 mos	A modest augmented physiotherapy programme resulted in patients having more direct physiotherapy time and being more active. The inability to show statistically significant changes in outcome measures could indicate either that this intervention is ineffective or that our study could not detect modest changes.
Kalra et al 2004	8	300 (151/149)	Age: median 76, IQR 70-80 Type: isch Time since onset: stroke rehab unit Inclusion: Patients: pre-existent independent ADL, medically and neurologically stable, expected to return home with residual disability Caregivers: mRS 0-2, willing and able to provide support after discharge	<u>Comparison</u>: Caregiver training (E) vs. control (C) <u>E</u>: Caregiveres received 1) instruction by appropriate professionals on common stroke related problems and their prevention, management of pressure areas, prevention of bed sores, continence, nutrition, positioning, gait facilitation, advice on benefits and local services, and 2) hands-on training in lifting and handling techniques, facilitation of mobility and transfers, continence, assistance with personal ADL and communication. Training started when patients' rehabilitation needs had stabilized and discharge was contemplated. In addition to conventional care (see below). <u>C</u>: Conventional care, consisting of 1) information on stroke and consequences, prevention, management options; 2) involvement in goal setting for rehabilitation and discharge planning; 3) encouragement to attend nursing and therapy activities to learn about patients' abilities and informal instruction on facilitation transfers, mobility, ADL; and 4) advice on community services, benefits, allowances.	Mortality, institutionalism, mRS, BI, FAI, HADS, EuroQoL, costs Caregiver burden scale, FAI, HADS, EuroQoL Measured at baseline, 3 and 12 mos	Training caregivers during patients' rehabilitation reduced costs and caregiver burden while improving psychosocial outcomes in caregivers and patients at one year.

				Intensity: 3-5 times, 30-45 min, follow-through session at home. Treatment contrast: 2 h.		
Lin et al 2004	6	19 (9/10)	Age: 61.4±11.2 yr Type: first/rec isch/hem Time since onset: 44.0±29.6 mos Inclusion: 1 yr post stroke, BI 5-14	Comparison: Home-based PT vs. control (C) Home-based PT: Low-intensity home based PT, mainly consisting of motor facilitation, postural control training, functional ambulation training with gait correction, ADL training. Daily exercise programs, primary caregiver counseling to foster treatment compliance. C: No intervention. Intensity: 50-60 min/d, 1 d/wk, during 10 wk. Treatment contrast: 550 min.	BI, STREAM Measured at baseline and 10 wk	Low-intensity home-based physical therapy specifically improves motor function in lower limbs in chronic stroke survivors. However, there are non-significant improvements in motor function in upper limbs, mobility and ADL performance.
Winstein et al 2004	6	64 (21/22/21)	Age: <35 yr n=0, 35-75 yr n=19, ≥75 n=1 Type: first/rec isch/hem/SAB Time since onset: 16.1±7.7 d Inclusion: ??	Comparison: Strength training (ST) vs. Functional task practice (FTP) vs. control (C) ST: Resistance to available arm motion to increase strength of shoulder, elbow, wrist and hand motions, using eccentric, concentric and isometric muscle contractions. Progressed to repetitions against resistance using free weights, Theraband or grip devices for fingers. In addition to standard dose PT and OT. FTP: Systematic and repetitive practice of tasks that could be performed within the level of available voluntary motion. Progressively arranged to account for proximal-to-distal recovery patterns of reaching and grasping actions. Principles of motor learning by provision of knowledge of results and progressed task difficulty. In addition to standard dose PT and OT. C: Muscle facilitation exercises emphasizing NDT, NMS primarily for shoulder subluxation, stretching exercises, ADL including self-care where upper limb was used as assist if appropriate, caregiver training. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: FTP vs. ST: 0 h. FTP/ST vs. C: 20 h.	FIM mobility, FIM self-care, FMA arm FMA ROM, FMA pain, FMA sensory, FTHUE, isometric torque, grasp and pinch force Measured at baseline, 4 wk and 6 and 9 mos (follow-up)	Task specificity and stroke severity are important factors for rehabilitation of arm use in acute stroke. Twenty hours of upper extremity-specific therapy over 4-6 weeks significantly affected functional outcomes. The immediate benefits of a functional task approach were similar to those of resistance-strength approach, however, the former was more beneficial in the long-term.
Chen et al 2005	6	29 (15/14)	Age: 58.5±12.9 yr Type: first isch/hem Time since onset: 14.3±6.8 d Inclusion: FMA arm stage <4, no diabetic history or sensory impairment attributable to peripheral vascular disease or neuropathy	Comparison: Thermal stimulation (TS) vs. control (C) TS: Thermal stimulation, with thermal agent placed on region of hand and wrist, with thermal couple placed between hand and agent. Heating agent ≠75 C ^{o}) placed on nonparetic hand and wrist, feel change of skin temperature and learn to move hand from agent when unpleasantness developed. Heating agent on paretic hand 10 times up to 15 seconds, interleaved with ≥30 seconds pause. Move paretic hand away if it felt uncomfortable, or accept 15 second stimulation. Identical procedure for 30 second cooling agent (<0 C^o). In addition to standard therapy. C: Standard therapy. Visit of PT to discuss progress in rehabilitation. Intensity: TS: 30 min/d, 5 d/wk, during 6 wk. CT: 15-20 min/d, ≥3 d/wk, during 6 wk. Treatment contrast: 540 min.	FMA arm, modified motor assessment scale, ROM wrist, gripstrength, Semmes-Weinstein monofilament Measured at baseline, weekly till 6 wk	TS on the paretic hand significantly enhances the recovery of several aspects of sensory and motor functions in hemiplegic stroke patients.
Davidson et al 2005	8	41 (21/20)	Age: 68.9±13.52 yr Type: ?? Time since onset: ?? Inclusion: medical stable	Comparison: Weekend training (E) vs. control (C) E: Additional exercises at the weekend provided by nursing staff who were trained by a PT. Repeatedly practicing activities during course of usual nursing duties: lying to sitting on side bed, sitting balance, sitting to standing, standing balance, stepping. No specific duration stipulated. In addition to usual care (5 d/wk). C: Usual care (5 d/wk). Intensity: 7 d/wk. Treatment contrast: 2 d/wk. (received: 12.73±13.77 per weekend day)	MAS*, BI, length of stay hospital, length of stay stroke unit Measured at baseline and discharge	The present study indicates that an increase in one-to-one input by nurses for people with stroke did not lead to a measurable difference in outcome in this small study.
Howe et al 2005	6	35 (17/18)	Age: 71.5±10.9 yr Type: first/rec isch/hem Time since onset: 26.5±15.7 d Inclusion: no conditions affecting balance, no 'pusher syndrome'	Comparison: Lateral weight transference exercises (E) vs. control (C) E: Exercises aimed at improving lateral weight transference in sitting and standing based on work of Davies. Including repetition of self-initiated goal-oriented activities in various postures, with manual guidance and verbal encouragement. In addition to usual care, including PT. C: Usual care, including PT. Intensity: 30 min/d, 3 d/wk, during 4 wk.	Lateral reach sitting, standing up, sitting down, static standing balance Measured at baseline and 4 wk, and 8 wk (follow-up)	A training programme aimed at improving lateral weight transference did not appear to enhance the rehabilitation of acute stroke patients. Improvements observed in postural control in standing and sitting may be attributable to usual care or natural recovery.

				<u>Treatment contrast</u>: 6 h.		
Kamps et al 2005	4	31 (16/15)	Age: 63.1±8.1 yr Type: isch Time since onset: 12±9.5 mos Inclusion: Handicap of walking with ability to walk with supervision/aids >10 m, live at home; no sanitary constitution, pain, ability to use normal cycle ergometer	<u>Comparison</u>: MOTOmed vs. control (C) <u>MOTOmed</u>: MOTOmed at home, with display which gives feedback to the exerciser. Warm-up (2-3 min), active padelling (2x/d, >10 min) with 50-70 reps/min, BORG 13, cool down (2-3 min). Adjust intensity of training according to improvement in physical fitness, by increasing time. Phoned every 14 days to receive feedback and solve problems. In addition to conventional PT and OT. <u>C</u>: Conventional PT and OT. <u>Intensity</u>: 2x/d, >10 min, during 4 mos. <u>Treatment contrast</u>: 601 min.	10MWT comf, 10MWT max, Tinetti, BBS, TUG, 2MWT, 6MWT Measured at baseline and 4 mos	Using the MOTOmed Movement Trainer is a helpful addition to conventional thearpy and supports an active participation in the rehabilitation process of stroke patients.
Platz et al 2005	8	60 (20/20/20)	Age: 60.6±10.5 yr Type: first isch Time since onset: 6.5±3.9 wk Inclusion: FMA UE 5-34, 3 wk to 6 mos post stroke, no contractures of arm joints	<u>Comparison</u>: Augmented exercise therapy as Bobath (AETT Bobath) vs. AETT BASIS training vs. control (C) <u>AETT Bobath</u>: Bobath approach with emphasis on control of muscle tone and recruitment of arm activity in functional situations with various positions. In addition to usual standard rehabilitation therapy (see below). <u>AETT BASIS</u>: Systematic repetitive technique training all degrees of freedom of the arm across full ROM, encouraging selective dynamic movements. Stages: 1) selective innervation for isolated motions without postural control; 2) selective innervation for isolated motions with postural control; 3) selective innervation for complex motions with postural control. In addition to usual standard rehabilitation therapy (see below). <u>C</u>: Standard rehabilitation therapy, addressing e.g. ADL, arm activities, stance, gait, speech and cognition. <u>Intensity</u>: 45 min/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 900 min.	FMA arm, FMA sensation, FMA joint, ARAT, MAS Measured at baseline and 4 wk	The augmented exercise therapy time as Arm BASIS training enhanced selective motor control. Type of training was more relevant for recovery of motor control than therapeutic time spent.
Yang et al 2005	6	25 (13/12)	Age: 63.38±7.7 yr Type: first Time since onset: 5.45±3.03 mos Inclusion: Brunnstrom stage 3-4, walk 11 m with or without walking aid or orthosis, stable medical, no comorbidity precluding gait training, no uncontrolled health condition contraindicating exercise, no gait-influencing diseases	<u>Comparison</u>: Backward training (E) vs. control (C) <u>E</u>: Backward walking according to Davies (1990): 1) take step backwards within parallel bars therapist provides assistance to move leg in correct pattern with reducing assistance, 2) subject takes over actively with only slight help, therapist facilitates walking backwards between parallel bars, 3) walk backward actively away from parallel bars, distance and speed of walking progressively increased. In addition to conventional stroke rehabilitation programme (see below). <u>C</u>: Conventional stroke rehabilitation programme, focused on strengthening, function and mobility activities, gait training, gait preparatory training takes approx 20-30% of each sessions time (40 min/d, 3 d/wk, 3 wk). <u>Intensity</u>: 30 min/d, 3 d/wk, during 3 wk. <u>Treatment contrast</u>: 4.5 h.	Walking speed comf, cadence, stride length, gait cycle (time), symmetry index Measured at baseline and 3 wk	This study demonstrated that asymmetric gait pattern in patients post stroke could be improved from receiving additional backward walking therapy.
Katz-Leurer et al 2006	6	24 (10/14)	Age: 59±8 yr Type: first isch Time since onset: <30 d Inclusion: unable to sit for 10 s, unable to stand without support for >1 min, >30 d after acute hospitalization, not unconscious and/or totally incontinent after event, no significant change in blood pressure, no arrhythmia, no heart failure, not receiving beta blockers	<u>Comparison</u>: Cycling (E) vs. control (C) <u>E</u>: Train on electrically powered leg cycle ergometer, at comfortable speed, intensity <40% HRR adjusted for age. Start with short workout periods of 2 min with 1 min rest for up to 10 min, increase to 30 minutes at end of wk 1 and continue following 2 wk. In addition to regular therapy, consisting of PT based on Bobath approach, OT, speech therapy and group activity for general exercise. <u>C</u>: Regular therapy (see above). <u>Intensity</u>: 10-30 min/d, 5 d/wk, during 3 wk. <u>Treatment contrast</u>: 300 min.	PASS total, PASS static, PASS dynamic, FMA LE, FIM total, FIM motor Measured at baseline and 3 wk and 6 wk (follow-up)	These preliminary findings suggest that stroke patients in the subacute stage can improve their motor and balance abilities after an early short duration of cycling training.

Lai et al 2006 [secondary analysis Duncan 2003]	6	93 (44/49)	Age: 68.5±9.0 yr Type: isch/hem Time since onset: 77.5±28.7 yr Inclusion: 30-150 d post stroke, ambulate 25 ft independently, FM 27-90, OPS 2.0-5.2, palpable wrist extension; no serious cardiac conditions, oxygen dependence, weight-bearing pain, organ system disease	Comparison: Exercise (E) vs. control (C) E: Supervised progressive exercise program targeting strength, balance, endurance, upper extremity function, performed at home. C: Usual care. Education about stroke prevention and measurements of blood pressure and oxygen saturation (1x/2wk). Intensity: 36 sessions, 90 min/d, 3 d/wk, during 12 wk. Treatment contrast: ≈1620 min.	GDS, SF-36, SIS, antidepressant use Measured at baseline and 3 mos and 6 mos (follow-up)	Exercise may help reduce post stroke depressive symptoms.
Ryan et al 2006	7	89 (35/32)	Age: 76.4±6.1 yr Type: ?? Time since onset: 45±47.3 d Inclusion: aged ≥65 yr, no concomitant disease	Comparison: Augmented service (E) vs. control (C) E: Augmented rehabilitation service by multidisciplinary team with≥6 face -to-face contacts per week. C: Routine rehabilitation by multidisciplinary team≤3 face -to-face contacts a week. Intensity: Up to 12 wk. Treatment contrast: ??	BI, TOM subscales, HADS, EQ-5D, EQ-VAS, FAI Measured at baseline and 3 mos	Following stroke older people who receive a more intensive community-based multidisciplinary rehabilitation service may experience short-term benefit in relation to social participation and some aspects of health-related quality of life.
Yang et al 2006	8	48 (24/24)	Age: 56.8±10.2 yr Type: first Time since onset: 62.7±27.4 mos Inclusion: ?1 yr post stroke, walk 10 m dependently without an assistive device, no uncontrolled health condition for which exercise was contraindicated	Comparison: Task-oriented resistance strength training vs. control (C) Task-oriented: Task-oriented progressive resistance strength training in circuit class format. Workstations designed to strengthen muscles in bilateral lower limbs in a functionally relevant way, each workstation 5 minutes, encouraged to work as hard as possible. Given verbal feedback and instructions aimed at improving performance. Progression by increasing number of repetitions and increasing complexity. C: No rehabilitation training. Number of participants per group: ?? Staff: 1 PT. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	Muscle strength, walking speed comf, cadence, stride length, 6MWT Measured at baseline and 4 wk	The task-oriented progressive resistance strength training programme could improve lower extremity muscle strength in individuals with chronic stroke and could carry over to improvement in functional abilities.
Aidar et al 2007	5	28 (15/13)	Age: 50.3±9.1 yr Type: isch Time since onset: >1 yr Inclusion: >1 yr post stroke, hemiparesis	Comparison: Water-based exercises vs. control (C) Water-based exercises: Warm-up not in swimming pool. Water-based exercises consisted of various walking exercises, with and without aids in swimming pool of 25x12.5 m with a depth of 1.5 m, no heated water. C: No therapy. Intensity: 45-60 min/d, 2 d/wk, during 12 wk. Treatment contrast: 1260 min.	SF-36 Measured at baseline and 12 wk	Doing physical exercises in water tends to improve motor behavior, with a greater degree of independence, significant improvements in functional capacity and other aspects linked to physical attitude.
Allison et al 2007	7	17 (7/10)	Age: 72.4±17.9 yr Type: ?? Time since onset: 20.6±20.5 d Inclusion: no unstable comorbidity	Comparison: Standing practice (E) vs. control (C) E: Standing practice, typically involving use of either standing frames, tilt tables or standing at tables to provide support when enabling standing to occur, encouraged to be active while standing, practicing reaching tasks, sit-to-stand movements. Rest periods as necessary. In addition to conventional physiotherapy, including strengthening, improving movement, mobility, and upper limb function (45 min/d, 5 d/wk). C: Conventional physiotherapy (see above). Intensity: 45 min/d, 5 d/wk, during 2 wk. Treatment contrast: 450 min.	RMA GF, TCT, BBS Measured at baseline, 1 and 2 wk and 12 wk (follow-up)	A larger study is required to establish the value of additional standing practice after stroke. This pilot demonstrates that the RMAg and BBS would be useful in such a study. Fatigue may be a significant barrier to ability to participate in more intensive porgrammes so screening participants for severe fatigue may be useful.
Jeong et al 2007	5	33 (16/17)	Age: 58.0±7.192 yr Type: isch/hem Time since onset: 5.437±4.530 yr Inclusion: >6 mos post stroke, MRC 2-4, no	Comparison: Rhythmic auditory stimulation (RAS) vs. control (C) RAS: RAS music-movement program at public health center, including 1) preparatory activities; 2) main activity, dynamic rhythmic motions involving whole body, starting with the upper and lower limbs and moving toward the upper body, main exercise incorporated repetitive movements such as sitting on a chair, standing up, walking, walking in a circle, shaking an egg shaker and playing	ROM, mood states, interpersonal relationships, QoL Measured at baseline and postintervention	Paticipants in the experimental group gained a wider range of motion and flexibility, had more positive moods, and reported increased frequency and quality of interpersonal relationships.

			previous participation in rehabilitation program, intact auditory function	percussion instruments; 3) wrap-up activities with feedback and instruction on how to continue RAS at home, share feelings and concerns; 4) telephone follow-up once a week, given RAS tape and instructions. C: Referral information about usual care available in surrounding community. Intensity: 2 h/wk, during 8 wk. Treatment contrast: ??		
Langhammer et al 2007, 2008, 2009	7	75 (35/40)	Age: 76±12.7 yr Type: first Time since onset: 22±13 d Inclusion: no SAH, bleeding, tumor, other serious illness, brainstem or cerebellar stroke	Comparison: Intensive exercise program (E) vs. regular exercise program (C) E: After hospital discharge, start with functional exercise program, with emphasis on intensity of endurance, strength and balance, during four periods in the first 12 months after discharge, with minimum of 20 h every third month. Encouraged to maintain a high activity level apart from training sessions. C: After hospital discharge, PT exercises in accordance with routines in community if required. Encouraged to maintain a high activity level apart from training sessions. Intensity: >20 h every 2 mos, 2x/d, 1 h/d, 2-3 d/wk (at home) or 7 d/wk (inpatient) Treatment contrast: ??	MAS*, BI, grip strength, NHP, 6MWT, BBS, TUG Measured at baseline, hospital discharge, 3, 6 and 12 mos	Motor function, activities of daily living functions and grip strength improved initially and were maintained during the first year after stroke in all patients irrespective of exercise regime.
Mead et al 2007	8	66 (32/34)	Age: 72.0±10.4 yr Type: first/rec isch/hem Time since onset: median 171 (IQR 55-287) d Inclusion: independently ambulatory, no medical contraindications to exercise training	Comparison: Exercise training (E) vs. control (C) E: Endurance and resistance training. Warm-up (15-20 min). 1) Endurance: circuit of cycle ergometry, raising and lowering 1.4-kg, 55-cm exercise ball, shuttle walking, standing chest press, stair climbing and descending (starting in wk 4), march in place between each circuit station. Duration increased from 9 min to 21 min by wk 12. Cycling increased by pedaling resistance, cadence or both with Borg 13-16. Graded cool-down and stretches. 2) Resistance training: seated upper back and triceps with elastic resistance training bands, progress repetitions from 4 using lowest-resistance band to 10 using highest-resistance band by wk 12. Pole-lifting while standing, progressing from 4 repetitions with 0.22-kg pole to 15 repetitions with 3.6-kg pole by wk 12; sit-to-stand exercise progressing from 4 to 10 repetitions by wk 12, increasing difficulty by manipulating length of pauses, angle of the knee and upper body levers. Cool-down and flexibility exercises (10-15 min). Groups up to 7 patients. C: Relaxation classes, including seated deep breathing and progressive muscular relaxation, increasing duration from 20 min to 49 min. Number of participants per group: ≤7. Staff: 1 advanced exercise instructor. Intensity: 1h15, 3 d/wk, during 12 wk. Treatment contrast: ??	FIM, NEADL, RMI, FR, SF-36 domains, HADS, leg extensor power affected leg, leg extensor power unaffected leg, walking speed comf, walking economy (oxygen uptake), TUG, STS Measured at baseline and 3 mos and 7 mos (follow-up)	Exercise training for ambulatory stroke patients was feasible and led to significantly greater benefits in aspects of physical function and perceived effect of physical health on daily life.
Yang et al 2007	7	25 (13/12)	Age: 59.46±11.83 yr Type: ?? Time since onset: 4.08±3.13 yr Inclusion: ≥1 yr post stroke, gait velocity >58 cm/s, walk 10 m independently without an assistive device, functional use involved upper extremity, no uncontrolled health condition for which exercise is contraindicated	Comparison: Ball exercise training vs. control (C) Ball exercise training: Training based on dual-task concept, walking while manipulating either 1 or 2 balls. Variable practice for walking condition involved walking forward, backward, circular route, S-shaped route. C: No rehabilitation training. Intensity: 20 min/d, 3 d/wk, during 4 wk. Treatment contrast: 4 h.	Walking speed comf, cadence, stride time, stride length, temporal symmetry index [tested at two conditions: 1. preferred waling, 2. walking while carrying a tray with glasses] Measured at baseline and 4 wk	The dual-task-based exercise program is feasible and beneficial for improving walking ability in subjects with chronic stroke.
Bernhardt et al 2008*	8	71 (38/33)	Age: 74.6±14.6 yr Type: first/rec isch/hem Time since onset: <24 h Inclusion: satisfied physiologic limits (systolic blood pressure 120-220 mm Hg, oxygen saturation	Comparison: Very early mobilization (VEM) vs. control (C) VEM: Mobilization as soon as practical, goal <24 h after onset. Additional mobilization with aim of assisting patients to be upright and out of bed (sitting or standing) at least twice a day. Physiologic monitoring of blood pressure, heart rate, oxygen saturation, temperature before each mobilization in the first 3 days post stroke. Delivered by nurse and PT first 14 days or until discharge. In addition to standard care (6 d/wk).	Death (3 mos), serious adverse events (3 mos), falls (14 d, 3 mos), detoriation <7 d, Borg, time to first mobilization, mRS Measured at baseline and 7,14 d, 3, 6, 12 mos	VEM of patients within 24 hours of acute stroke appears safe and feasible.

			>92% with or without supplemention, heart rate 40-100 bmp, temperature <38.5°), hospital admission <24 h, no detoriation <1 h of admission, no severe heart failure or lower limb fracture preventing mobilization	C: Standard care (6 d/wk). Mobilization later than VEM, once a day. Intensity: VEM: early and 2x/d, during 2 wk (167, range 62-305 min). C: 1x/d, during 2 wk (69, range 31-115 min). Treatment contrast: 98 min.		
Britton et al 2008	4	18 (9/9)	Age: 68.4±13.3 yr Type: ?? Time since onset: 50.8±35.2 d Inclusion: STS with 'stand by' supervision without using hands, STS ≤3 in 10 s (MAS*), impaired upper limb function, not medically unfit	Comparison: Sit-to-stand (STS) vs. control (C) STS: Whole task practice of STS without using arms of support, with emphasis on technique: foto placement, speed, increase weight-bearing affeted leg. Instruction and verbal feedback by PT assistant, balance performance monitor performed visual feedback. Aim to maximize number of STS. In case of fatigue strengthening exercises specific to muscle groups and range of movement used in STS. In addition to routine PT and OT. C: Routine PT and OT. Intensity: 30 min/d, during 1 wk. Treatment contrast: 2.5 h.	Time to stand, % weight through affected foot at thighs-off, number of attempts needed for three successful STS, number STS in 1 min Measured at baseline and 1 wk	Task-specific practice given for 30 minutes a day appears promising for patients learning to sit-to-stand.
Flansbjer et al 2008	7	24 (15/9)	Age: 61±5 yr Type: isch/hem Time since onset: 18.9±7.9 mos Inclusion: 40-70 yr, >6 mos post stroke, isolated extension and flexion knee, >15° reduction strength paretic limb, walk without supervision ≥200 m with or without walking aid, no dysfunction impact knee muscle strength/ gait performance/ perceived participation	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: Progressive resistance training using leg extension/ curl rehab exercise machine. Warm-up stationary cycling (5 min), 5 repetitions without resistance and 5 reps at 25% of maximum load. 6-8 reps in 2 sets at low speed (30-40 s/set) with 80% of maximum load, with 2 min rest between sets. Load adjusted every to 2 wk to remain 80%. First train extensors nonparetic lower limb, followed by paretic lower limb. After 10 min rest, same procedure for flexors. Passively static stretch. PRT effective 6 min. Perform usual daily activities and training but no PRT. C: Continue usual daily activities and other forms of training, but no PRT. Intensity: 90 min/d, 2 d/wk, during 10 wk. Treatment contrast: 1800 min.	Dynamic knee muscle strength, isokinetic knee muscle strength, TUG, walking speed max, 6MWT, SIS participation Measured at baseline and 10 wk	Progressive resistance training is an effective intervention to improve muscle strength in chronic stroke.
Huijgen 2008	5	12 (9/3)	Age: 69±8 yr Type: ?? Time since onset: 3.0±12.6 yr Inclusion: NHPT >25 s, ≥1 peg NHPT <180 s, internet connection, living at home, no major visual problems, no problems contra-indicating autonomous exercise at home	Comparison: Home activity care desk (HCAD) vs. control (C) HCAD: Usual care (1 mos), followed by 4 training sessions with HCAD and 1 mos training at home. Hospital-based server and portable unit with seven sensorized tools. Exercises such as reaching, grasping, lateral pinch, pinch grip, holding, manipulation, finger dexterity. Two webcams for videoconferencing and recording. PT used infos for weekly videoconference with patient. C: Usual care and generic exercises prescribed by physician. Intensity: 30 min/d, 5 d/wk, during 1 mos. Treatment contrast: ??	ARAT, NHPT, VAS user satisfaction Measured at baseline, 1 mos (usual care) and 2 mos (HCAD)	A telerehabilitation intervention using HCAD may increase the efficiency of care.
Lennon et al 2008	7	48 (24/24)	Age: 59.0±10.3 yr Type: first/rec isch Time since onset: 237.3±110.7 wk Inclusion: >1 yr post stroke; no O2 dependence, angina, unstable cardiac conditions, uncontrolled diabetes, major medical conditions, claudication, febrile illness, beta	Comparison: Cardiac rehabilitation programme (E) vs. control (C) E: Cycle ergometry exercise with upper or lower limb (MOTOmed), with biofeedback alarms set at 50-60% maximal HR. Resistance and speed adjusted daily. Two life skills classes addressing stress management, relaxation and life balance. C: Usual care. Intensity: 30 min/d, 2 d/wk, during 10 wk. Treatment contrast: 10 h.	Cardiac risk (waist girth, total cholesterol, cardiac risk score, resting systolic blood pressure, resting diastolic blood pressure), fitness and function (BMI, resting HR, FEV_1, VO_2, peak wattage, RPE, HADS, FAI) Measured at baseline and 10 wk	Preliminary findings suggest non-acute ischemic stroke patients can improve their cardiovascular fitness and reduce their cardiac risk score with a cardiac rehabilitation programme. The intervention was associated with improvement in self-reported depression.

			blockers			
Page et al 2008	5	7 (4/3)	Age: 61.29±12.3 yr Type: isch Time since onset: 44.43±24.48 mos Inclusion: >18 yr, >12 mos post stroke, PROM legs within normal limits, grade 3 hamstrings and triceps surae/ quadriceps, grade 2 gluteus maximus/ hamstrings, walk 10 m with no more assistance than 'close supervision' ; no MAS >4, VAS >4, heterotropic ossification, fracture or history of fracture in lower limb, injections of anti-spastic drugs <3 mos, oxygen dependence, severe weight-bearing pain, life expectancy <1 yr, acute medical non-stable comorbidities	Comparison: Reciprocal leg extension exercise (E) vs. control (C) E: Perform coupled reciprocal knee extension while seated on NuStepTRS4000 Recumbent Cross Trainer (NuStep). Warm-up with legs only (6 min), run-time with increasing resistance (level 1-10) and time (10-30 min), warm-down (5 min). C: Home exercise programme written on sheet with pictures, including ankle circumduction, dorsiflexion, plantarflexion, knee extension and flexion, hip adduction and abduction. Intensity: E: 40 min/d, 3 d/wk, during 8 wk. C: 30 min/d, 3 d/wk, during 8 wk. Treatment contrast: 240 min.	FMA leg, BBS Measured at baseline and 8 wk	Impairment reductions and balance gains may be achieved using a resistance-based, reciprocal upper and lower limb locomotor training protocol.
Donaldson et al 2009	7	30 (10/10/10)	Age: 72.8±11.9 yr Type: isch Time since onset: 21.7±16.8 d Inclusion: ARAT >4, unable to complete NHPT in 50 seconds	Comparison: Conventional + functional strength (CPT+FST) vs. conventional + conventional (CPT+CPT) vs. conventional (CPT) CPT+FST: Standardized treatment schedule (see below). In addition functional strength training with prominence to: directing subject's attention to exercise/activity being performed, appropriate verbal feedback on performance, repetition, goal-directed functional activity (hands-off). Based on normal upper limb function, with focus on improving power shoulder/elbow muscles to enable appropriate placing the hand and then using it to manipulate objects. Initial level of resistance maximum load still permitting 5 repetitions through available range of muscle length. Progression using repetition, altering size and weight of items, and using heavier weights. Divided in: muscle group-specific, upper limb gross movement patterns, hand reaching/retrieval activity, hand grip activities, hand manipulation involving entire everyday activities. CPT+CPT: Standardized treatment schedule (see below), double time. CPT: Standardized treatment schedule, i.e. soft tissue mobilization, facilitation of muscle activity/movement, positioning, education patient/carer. Therapist hands-on, to provide sensory input to optimize joint alignment in preparation of voluntary movement. Intensity: Plus therapy: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: CPT+FST/CPT+CPT vs. CPT: 24 h. CPT+FST vs. CPT+CPT: 0 h.	ARAT, NHPT, upper limb strength, isometric force Measured at baseline, 6 and 12 wk (follow-up)	This exploratory phase II trial found a trend for enhanced motor recovery for the CPT+FST group for all measures except hand grip force. The improvements found achieved set clinical importance for ATAT, NHPT, and isometric elbow flexion force.
Harris et al 2009	8	103 (53/50)	Age:69.4±11.7 yr Type: isch/hem Time since onset: 20.5±7.1 d Inclusion: Scapular elevation and wrist extension MRC 1, FMA arm 10-57	Comparison: Graded repetitive arm supplementary program (GRASP) vs. control (C) GRASP: Homework-based exercise program to improve paretic upper limb performance, encourage use of paretic upper limb in ADL. Three exercise books and kits, depending on severity. Book contained written and pictorial instructions, kit contained inexpensive equipment. Grading by varying repetition, including strengthening of arm and hand, ROM, gross and fine motor skills, repetitive goal and task oriented activities. Monitoring once a week. Keep logbook. Asked to continue program till follow-up. C: Education book with four modules, containing information on stroke recovery and general health. Homework assignment for each module. Contact once a	CAHAI, ARAT, MAL, SF-12 Measured at baseline, 4 wk and 3 mos (follow-up)	A self-administered homework exercise program provides a cost-, time- and treatment-effective delivery model for improving upper limb recovery in subacute stroke.

				week to review information and homework assignment. Intensity: GRASP: 1 h/d, 6 d/wk, during 4 wk. Treatment contrast: ??		
Peurala et al 2009	5	30 (20/10)	Age: 65.7±9.2 yr Type: first/rec* isch/hem Time since onset: 8.6±2.3 d Inclusion: FAC ≤3, voluntary movement affected leg, BI 25-75, no unstable cardiovascular disease	Comparison: Overground walk (WALK) vs. control (C) WALK: Walk overground for 20 min in 1 h with 1-2 PTs using individual walking aid, progressed by increasing speed and decreasing amount of manual guidance and reliance on walking aids. In addition to gait-oriented PT (55 min/d). C: Often transferred to health centre, where they received 1-2 PT sessions daily, but not with same intensity. Intensity: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: ??	FAC, 10MWT max, MMAS*, RMA gross movements, RMA lower limb function plus trunk control, 6MWT, RMI Measured at baseline and 3 wk and 6 mos (follow-up)	Exercise therapy with walking training improved gait function irrespective of the method used, but the time and effort required to achieve the results favor the gait trainer exercise. Early intensive gait training resulted in better walking ability than did conventional treatment.
Platz et al 2009	8	144 (49/48/47)	Age:58.1 12.0 yr± Type: first isch Time since onset: 4.7±3.0 wk Inclusion: MI arm <100 and >25	Comparison: Splint (C) vs. conventional motor therapy (CONV) vs. modular impairment-oriented training (IOT) C: Inflatable splint arm therapy, consisting of 5 different hand/arm pressure splits of various sizes, with positioning in an antispastic position. CONV: Best conventional therapy based on whatever the therapist regarded the best possible physical therapy regimen. Not restricted in terms of type of therapeutic approach, but devices such as robots or functional electrical stimulation could not be used. IOT: Standardized impairment-oriented training 1) for severe affected Arm BASIS training that address the lack of selective movements, by repetitive training of isolated motions across full ROM in that segment. During first phase, therapist takes over weight of the arm and assist movement, followed by relearning combination of dynamic and postural control for isolated motion, finally multijoint movements and coordination; 2) for mild affected Arm Ability training that trains speed, aiming, dexterity, tracking and steadiness, with variation of task difficulty and individually standardized. Knowledge of results intermittently shown by diagrams on PC screen. Intensity: 45 min/d, 5 d/wk, during 3-4 wk. Treatment contrast: 0 h.	FMA UE, TEMPA, FMA passive joint motion and pain, MAS Measured at baseline, 3-4 wk and 4 wk (follow-up)	Specificity of active training seemed more important for motor recovery than intensity (therapy time). The comprehensive modular IOT approach promoted motor recovery in patients with either severe or mild arm paresis.
Verheyden et al 2009	7	33 (17/16)	Age: 55±11 yr Type: first isch/hem Time since onset: 53±24 d Inclusion: hemiparesis, no disorders affecting motor performance, no maximum trunk performance score	Comparison: Trunk exercises (E) vs. control (C) E: Selective movements of upper and lower part of the trunk in supine and sitting, gradually introduced and number of repetitions determined on performance. In addition to conventional multidisciplinary stroke rehabilitation (see below). C: Conventional multidisciplinary stroke rehabilitation, consisting mainly of PT, OT, cursing care. If needed neuropsychological and speech therapy. Main emphasis on NDT and motor relearning strategies. Intensity: 30 min/d, 4 d/wk, during 5 wk. Treatment contrast: 10 h.	TIS, TIS static sitting balance, TIS dynamic sitting balance, TIS coordination Measured at baseline and 5 wk	Our results suggest that, in addition to conventional therapy, trunk exercises aimed at improving sitting balance and selective trunk movements have a beneficial effect on the selective performance of lateral flexion of the trunk after stroke.
Askim et al 2010	7	62 (30/32)	Age: 75.4±7.9 yr Type: isch/hem Time since onset: 14.4±7.4 d Inclusion: pre-existent mRS <3, BBS <45, SSS >14, MMSE >20; no serious cardiac diseases, other functional impairments	Comparison: Intensive motor training (IMT) vs. control (C) IMT: Early supported discharge, with additional sessions of motor training, including reaching tasks in sitting and standing position, sit-to-stand, step tasks, walking tasks. Individually adapted and varied. Repeat as many repetitions of each task as tolerated. Home exercises consisting of 4 tasks individually chosen, 10 repts and each exercise 2x/d, 6 d/wk. In addition to standard conventional therapy. C: Conventional therapy. Intensity: 30-50 min, 3 d/wk, during 4 wk. Treatment contrast: 480 min.	BBS, MAS*, BI, step test, SIS mobility, SIS recovery, 5MWT max Measured at baseline and 4 wk and 12 and 26 wk (follow-up)	In this randomized, controlled trial, a community-based intensive motor training program, doubling the amount of physical therapy during the first 4 weeks after discharge, did not show significant improvement of balance or any other functional outcomes.
Cooke et al 2010	7	109 (36/35/38)	Age: 71.17±10.6 yr Type: first/rec isch/hem Time since onset: 33.86±16.50 d Inclusion: MI leg ≥28	Comparison: Functional strength + conventional physiotherapy (FST+CPT) vs. CPT+CPT vs. CPT FST+CPT: FST focus on repetitive, progressive resistive exercise during goal-directed functional activity. Attention to exercise/activity being performed, with verbal feedback. Progression by increase repetition and resistance. In addition to	Walking speed, ability to walk at 0.8 m/s or more, symmetry step time, symmetry step length, modified RMI, knee flexion peak torque, knee extension peak	Results indicate advantages for extra intensity physical therapy, both CPT and FST, which reached statistical significance at outcome for walking speed, ability to walk at 0.8 m/s or more, and torque about

				routine CPT (see below). <u>CPT+CPT</u>: Experimental CPT emphasizing control/quality of movement, prominence to sensory stimulation and preparation of joint and muscle alignment prior to activating muscle or a functional task. Strongly therapist hands-on, by passive movements, active assisted exercises, and/or hands-on intervention to facilitate muscle activity or functional ability. Some active exercise and repetitive practice of functional tasks included but without systematic progression. In addition to routine CPT. <u>CPT</u>: Routine CPT, including soft tissue mobilization, facilitation of muscle activity, facilitation of coordinated multijoint movement, tactile and proprioceptive input, resistive exercise, functional training. <u>Intensity</u>: 1 h/d, 4 d/wk, during 6 wk. <u>Treatment contrast</u>: FST+CPT vs. CPT+CPT: 0 h. FST+CPT/ CPT+CPT vs. CPT: 24 h.	torque, EuroQuol healthstate, EuroQuol self-perceived health Measured at baseline and 6 wk	the knee during flexion for the group receiving extra CPT.
Harrington et al 2010	8	243 (119/124)	Age: 70±20 yr Type: ?? Time since onset: median 10.3 (range 5.4-17.7) yr Inclusion: ≥50 yr, returned living in community ≥3 mos, felt able to participate in group activities	<u>Comparison:</u> Intervention group (E) vs. control (C) <u>E:</u> 9 patients plus carers or family members. Facilitated by volunteers and qualifie exercise instructors, supported by PT. 1) 1 h exercises to improve balance, endurance, strength, flexibility, function and well-being; start with warm-up, then circuit, home exercise manuals; 2) interactive education, interspersed with goal-setting sessions, social sessions and unstructured sessions set aside for troup to decide particular issues they wanted to discuss. Family members encouraged to attend scheme and help in exercise class; one dedicated session for family members. <u>C:</u> Standard care and information sheet detailing local groups and contact numbers. <u>Intensity:</u> 2 h/d, 2 d/wk, during 8 wk. <u>Treatment contrast:</u> 32 h.	SIPSO, FAI,RMI, costs, QHOQoL-Bref, HADS, CSI, FR, TUG Measured at baseline and 9 wk and 6 mos (follow-up)	The community scheme for stroke survivors was a low-cost intervention successful in improving physical integration, maintained at one year, when compared to standard care.
Holmgren et al 2010 A, B	8	34 (15/19)	Age: 77.7±7.6 yr Type: first/rec Time since onset: 139.7±37.7 d Inclusion: 3-6 mos post stroke, fall risk, walk 10 m with or without walking aid, not able to walk outdoors independently, no severe vision or hearing impairment	<u>Comparison</u>: High-intensive exercise program (E) vs. control (C) <u>E</u>: Individualized group training (6 sessions over 3 d/wk), focus on physical activity and functional performance. First session (45 min) focus on strength and balance, followed by 30 min rest. Next session (45 min) of activities related to real-life situations. Strength ≥2 sets with 8-12 maximum repetitions, balance close to balance maximum, rest not more than necessary, If Borg RPE <15 then exercises were increased. Educational group discussions about fall risk and security aspects (1 h session/wk). Individualized home-based exercise program consisting of maximum of three different exercises to perform between wk 5 and 3 mos (3 d/wk). <u>C</u>: Educational group discussion about hidden dysfunctions after stroke and how to cope, including communication difficulties, fatigue, depressive symptoms, mood swings, personality changes, dysphagia. No special focus on risks of falling (1 h session/wk). <u>Intensity</u>: during 5 wk. <u>Treatment contrast</u>: 30 h.	SF-36, GDS-15 Measured at baseline and 5 wk BBS, BI, FES-I, FAI Measured at baseline and 5 wk and 3 and 6 mos (follow-up)	Based on these data, it is concluded that high-intensive functional exercises implemented in real-life situations should also include education on hidden dysfunctions after stroke instead of solely focus on falls and safety aspects to have a favorable impact on HRQoL. This study suggests that our program consisting of HIFE implemented in real-life situations together with educadtional discussions may improve performance of everyday life acdtivities and improve falls efficacy in stroke subjects with risk of falls.
Langhorne et al 2010	8	EM: 32 (16/16) AM: 32 (16/16)	Age: median 64 (IQR 60-72) yr Type: first/rec isch/hem Time since onset: median 27.0 (IQR 24.5-29.8) h Inclusion: <24 h of admission, no full recovery, no severe comorbidities requiring close medical monitoring	<u>Comparison</u>: Early active mobilization (EM) vs. Automated monitoring (AM) vs. control (C) <u>EM</u>: Aimed to get patients up to sit, stand and walk within 24 h of stroke and continue this 4 times a day. In addition to standard care. <u>AM</u>: Protocol-driven approach to continuous monitoring, using ambulatory monitoring, routine monitoring continued for 3 days and could be extended to 7 days if physiological variables were unstable. In addition to standard care. <u>C</u>: Standard care, of multidisciplinary stroke unit, aiming to getting patients up to sit, stand and walk from day of admission, intermittent monitoring (every 4 h), mobilization by PT (30-60 min/d) and nurses. <u>Intensity</u>: ?? <u>Treatment contrast</u>: ??	Time to first mobilization, best level of mobilization activity achieved, physiological abnormalities, early medical complications and adverse events, patient activity, neurological detoriation, NIHSS, RMI, Borg, BI, mRS Measured at baseline and 5 d and 3 mos	We have demonstrated the feasibility of implementing EM and AM for physiological complications in a randomized controlled trial.
Letombe et al	4	18 (9/9)	Age: 59.1±9.4 yr	<u>Comparison</u>: Adapted physical activity programme (E) vs. control (C)	Maximal aerobic power, BI, Katz	Early post-stroke physical training appears

2010			Type: isch/hem Time since onset: 21±3 d Inclusion: no hemisensory neglect, unstable brain lesions	E: Cardiorespiratory exercise, muscle strengthening, gait exercise and work focused on execute functions. Aerobic exercise using a semi-recumbent cycle ergometer, 70-80% maximum power (W). Treadmill and stepper to promote independent gait. Using isokinetic exercise machine for symmetric balancing stances and leg motor control, 6x 10 repetitions of 50-60% maximal force. Incremented according to improvement. Games and group activities for motor control, executive functions and balance. In addition to standardized multidisciplinary rehabilitation (see below). C: Standardized multidisciplinary rehabilitation, combining PT, OT, speech therapy and neuropsychological therapy (3 h/d, 5 d/wk), based on improving personal autonomy in ADL, with work focused on use of the legs: gait and stance exercises, treatment orthopedic disorders, balance work, use of support stockings and braces, freedom of ROM. Use wheelchair and performing transfers. For the arms strapping, prehension work and coordination combined with balance work in sitting and standing positions. Intensity: 40-60 min/d, 4 d/wk, during 4 wk. Treatment contrast: 800 min.	Measured at baseline and 28 d	to be needed to limit the negative effects of functional hypoactivity.
Tihanyi et al 2010	5	26 (13/13)	Age: 58.0±4.9 yr Type: isch/hem Time since onset: 28.1±8.5 d Inclusion: keep balance during quite standing >2 min	Comparison: Whole body vibration vs. control (C) Whole body vibration: Then stand on whole body vibration apparatus (Nemes Bosco-system), both knees flexed 40^o, grasp handlebar, shift body mass over the affected leg, and 20 Hz whole body vibration was turned on for six, 1-min bouts separated by 1 min of rest. During the rest period patients sat on a chair placed next to the vibration platform. Two persons standing next to patient giving instructions. Before starting treatment, 2 familiarizing sessions. Usual, daily, conventional therapy. C: Conventional therapy. Intensity: 3 d/wk, during 4 wk. Treatment contrast: 144 min.	Knee extensor strength Measured at baseline and 4 wk	Selection of the effective vibration frequency depends upon the physical condition of neuromuscular system. Low vibration frequency intervention can increase the strength in weak muscles due to neuromuscular impairment and restricted physical activity.
Tung et al 2010	6	32 (16/16)	Age: 51.0±12.1 yr Type: first Time since onset: 26.9±16.0 mos Inclusion: BBS <50 independent, sit-to-stand, no deep sensory deficits or hemineglect	Comparison: Sit-to-stand (E) vs. control (C) E: Sit-to-stand training, using an armless chair with backrest, with increasing difficulty a) regular floor, knee flexion 105^o, b) regular floor, knee flexion 90^o, c) regular floor, knee flexion 75^o, d) spongy floor, knee flexion 105^o, e) spongy floor, knee flexion 90^o, f) spongy floor, knee flexion 75^o. In addition to general PT programme (see below). Progression to next task if average time normal elderly was reached. C: General PT programme, including balance training, gait training, strengthening exercise lower extremities, ADL training (3 d/wk, 4 wk). Intensity: 15 min/d, 3 d/wk, during 4 wk. Treatment contrast: 3 h.	Static balance: weight distribution; Dynamic balance: maximal excursion, directional control, BBS, duration sit-to-stand; Strength: hip extensors, knee extensors, plantar flexors Measured at baseline and 4 wk	Additional sit-to-stand training is encouraged due to effects on dynamic balance and extensor muscles strength in subjects with stroke.
Chen et al 2011	7	33 (17/16)	Age: 58.0±11.5 yr Type: first isch/hem Time since onset: 11.0 (range 9.5-12.0) d Inclusion: <4 wk post stroke, Brunnstrom stage ≤3, FAC* ≤1 (walk independently), no diabetes or sensory impairment	Comparison: Thermal stimulation (TS) vs. control (C) TS: Thermal stimulation intervention aiming to facilitate recovery of balance and motor function of the lower limb. Hot pack (75^{o}C) wrapped in two towels on nonparetic leg (calf or foot), then on paretic leg. Encouraged to actively move leg as much as possible away from stimulus with a movement pattern guided by therapist when discomfort developed, or after 30 s, followed by 30 s rest. Three cycles per session, each of 8 repetitions with hot pack, 8 repetitions cold pack (0^{o}C). Lie on back (antigravity) or side (gravity). In addition to PT and OT (5 d/wk, 6 wk). C: PT and OT. Intensity: 48 min/d, 5 d/wk, during 6 wk. Treatment contrast: 1440 min.	FMA leg MRC leg, MMAS*, PASS-TC, BBS, FAC*, independent walking Measured at baseline, 4 and 6 wk.	Thermal stimulation accompanied by either manual facilitation or encouragement for active participation of the paretic lower limb may be an effective promising supplementary treatment for the early-phase rehabilitation of moderate to severe stroke that warrants additional study.
Erel et al 2011	6	28 (14/14)	Age: 42.5±14.89 yr Type: isch/hem Time since onset: 30.21±13.84 mos Inclusion: FAC 3-5, no	Comparison: Ankle-foot orthosis (E) vs. control (C) E: Dynamic ankle-foot orthosis. C: No intervention. Intensity: 6 mos. Treatment contrast: ??	FR, TUG, TUS, TDS, walking speed comf, physiological cost index Measured at baseline and 6 mos	Chronic hemiparetic patients may benefit from using dynamic ankle-foot orthosis.

			AFO, >6 mos post stroke, MAS ≤3, passive dorsiflexion ≥90°			
Galvin et al 2011	8	40 (20/20)	Age: 63.15±13.3 yr Type: first isch/hem Time since onset: 18.9±2.9 d Inclusion: OPS 3.2-5.2; family member willing to participate, nominated by person with stroke as person he/she would most like to assist him, medically stable, physically able to assist in delivery of exercises	Comparison: Family-mediated exercises (FAME) vs. control (C) FAME: Program conducted at bedside with assistance of nominated family member, emphasis on achieving stability and improving gait velocity and lower limb strength. Treatment goals set weekly. Family member trained with skills necessary to carry out additional exercises. Exercise diary. In addition to routine PT as inpatient or outpatient. C: Routine PT as inpatient or outpatient. Intensity: 35 min/d, 7 d/wk, during 8 wk. (received: 227±34 min/wk) Treatment contrast: 1960 min.	mFMA leg, MAS*, BBS, walking speed; BI, NEADL, RNLI, CSI Measured at baseline and 8 wk and 2 mos (follow-up)	This evidence-based FAME intervention can serve to optimize patient recovery and family involvement after acute stroke at the same time as being mindful of available resources.
Hesse et al 2011	8	50 (25/25)	Age: 62.4±11.3 yr Type: first isch/hem Time since onset: 16.4±6.0 wk Inclusion: discharged home with next 10 d, participated comprehensive inpatient rehabilitation program, lived with relatives, walk independently within home, BI 55-80, no diseases impairing mobility	Comparison: Intermittent high-intensity PT (E) vs. control (C) E: Intermittent high-intensity home-based PT in blocks over 12 mos, consisting of eclectic treatment approach of Bobath and motor relearning programme, aim to improve motor functions relevant for ADL. Between treatment blocks instructed in self-therapy programme including stretching, strengthening, motor tasks (>30 min, 5 d/wk), keeping a diary and telephone contact PT every 2 wk. C: Continuous low-intensity regular home-based PT in private unit of physiotherapist with eclectic approach (see above). Intensity: E: 96 sessions, 3x 2 mos, 30-45 min, 4 d/wk, with two months no therapy, during 12 mos. C: 104 sessions, 30-45 min/d, 2 d/wk, during 12 mos. Treatment contrast: 320 min.	RMI, RMA leg and trunk, RMA arm, 10MWT max, stair climbing, TUG, MAS, RADL I and II Measured at baseline and 2, 4, 6, 8, 10, 12 mos and 15 mos (follow-up)	The intermittent high-intensity and continuous low-intensity therapy protocols were equally effective, the sheer intensity seems more important than the time-mode of application.
Hunter et al 2011	8	76 (18/19/20/19)	Age: 73.3±7.3 yr Type: isch/hem Time since onset: 35.6±23.6 d Inclusion: 8-84 d post stroke, MI arm <61, no diseases affecting upper-limb movement	Comparison: Mobilization and tactile stimulation (MTS) 30 min vs. MTS 60 min vs. MTS 120 min vs. control (C) MTS 30: Tactile and proprioceptive stimulation through actions such as guided sensory exploration, massage, passive joint/soft-tissue mobilization technique, active-assisted movements, active movements. In addition to routine conventional PT (see below). MTS 60: In addition to routine conventional PT (see below). MTS 120: In addition to routine conventional PT (see below). C: Routine conventional PT, i.e. soft tissue mobilization, facilitation of muscle activity/movement, positioning, education patient/carer. Therapist hands-on, to provide sensory input to optimize joint alignment in preparation of voluntary movement. Intensity: MTS 30: 30 min/d, 5 d/wk, during 14 working days. MTS 60: 60 min/d, 5 d/wk, during 14 working days. MTS 120: 120 min/d, 5 d/wk, during 14 working days. Treatment contrast: MTS 30 vs. C: 420 min. MTS 30 vs. MTS 60: 420 min. MTS 30 vs. MTS 120: 1260 min. MTS 60 vs. MTS 120: 840 min. MTS 60 vs. C: 840 min. MTS 120 vs. C: 1680 min.	MI arm, ARAT Measured at baseline and 14 working days	The authors were not able to deliver a maximum dose of 120 minutes of daily therapy each day. The mean daily dose of MTS feasible for subseqarmnt evaluation is between 37 and 66 minutes.
Kuys et al 2011	8	30 (15/15)	Age: 63±14 yr Type: first Time since onset: 52±32 d Inclusion: at least able to walk with stand-by help (Motor assessment scale walking item ≥2), walking speed ≤1.2 m/s, no cardiovascular problems or	Comparison: Treadmill training (TT) vs. control (C) TT: Walking on treadmill (30 min excl rest) with intensity 40-60% HRR or Borg 11-14. Commenced at 40% HRR, progressing each week aiming for a 5-10% increase until 60% HRR was reached. Encouraged to use handrail, PT provided assistance if required. In addition to usual PT intervention using a task-oriented approach targeting impairments and activity limitations (60 min). C: Usual PT. Intensity: TT: 30 min/d, 3 d/wk, during 6 wk. Treatment contrast: 9 h.	10MWT comf and max, 6MWT Measured at baseline and 6 wk and 18 wk (follow-up)	Higher-intensity treadmill walking during rehabilitation after stroke is feasible and not detrimental to walking pattern and quality in those newly able to walk.

			neurological or musculoskeletal conditions affecting walking			
Merkert et al 2011	4	66 (33/33)	Age: 74.5±8.3 yr Type: ?? Time since onset: 92.4±284.6 d Inclusion: decreased stability of trunk or lower limb, no pacemaker or defibrillators, body weight <150 kg	Comparison: Whole body vibration and balance training (E) vs. control (C) E: Vibroshpere training on round vibrating platform consisting of two repetitions of three exercise: supine bridging, seated, standing. In addition to conventional comprehensive geriatric rehabilitation with each training interval 15-90 sec, frequency vibration 35 Hz. C: Conventional comprehensive geriatric rehabilitation. Intensity: 15 sessions Treatment contrast: ??	BBS, functional test of the lower back, BI, TG, TUG Measured at baseline and after 15 sessions	Ultimately, the highly significant improvements in functional status found in this study indicate that combined vibration and balance training using Vibrosphere may be a useful addition to current rehabilitation of stroke patients.
Park et al 2011	6	25 (13/12)	Age: 59.38±8.46 yr Type: isch/hem Time since onset: 28.08±12.59 mos Inclusion: 6 mos – 5 yr post stroke, walking speed <0.7 m/s, no auditory or visual deficits, no conditions that may interfere with study	Comparison: Community training (E) vs. control (C) E: Community-based ambulation training, consisting of four phases in various community situations, increasing distance covered and environmental demands. In addition to functional training based on Bobath, consisting of standing up from sitting, guided movement of trunk and lower limb to simulate normal walking, forward and backward stepping, stair climbing (1 h/d, 5 d/wk). C: Functional training (see above), no specific walking training. Intensity: 1 h/d 3 d/wk, during 4 wk. Treatment contrast: 12 h.	10MWT max, 6MWT, community walk test, walking ability questionnaire, ABC Measured at baseline and 4 wk	The findings demonstrate that community-based ambulation training can be helpful in improving walking ability of patients with poststroke hemparesis and may be used as a practical adjunct to routine rehabilitation therapy.
Toledano-Zarhi 2011	6	28 (14/14)	Age: 65±10 yr Type: isch Time since onset: 11±5 d Inclusion: mRS≤2, 1-3 wk post stroke; no systolic blood pressure ≥200 mmHg, diastolic blood pressure ≥100 mmHG, unstable angina pectoris, arrhythmia, congestive heart failure, ST depression ≥2 mm on resting ECG, 3rd degree atrioventricular block with no pacemaker, severe peripheral vascular disease, severe lung disease, orthopedic or neurological disability,dementia or major depression, aged >80 yr	Comparison: Aerobic rehabilitation program (E) vs. control (C) E: Supervised exercise-training, including training on a treadmill, hand-bike machine and stationary bike (2 d/wk) with progress in 8 stages, pulse rate target of 50-70% of HRmax. Group practice for inducing strength, flexibility and coordination performances (1 d/wk) In addition to provision of a home-exercise booklet (see below). C: Provision of home-exercise booklet, including instructions for muscle strength and flexibility exercises, continue normal community routine. Intensity: Exercise 35-55 min/d, 2 d/wk, during 6 wk. Group practice: 45-55 min/d, 1 d/wk, during 6 wk. Treatment contrast: 750 min.	6MWT, FSST, stairs ascending, stairs descending, HR rest, HR work, blood pressure systolic/diastolic rest/work, exercise duration, METs Measured at baseline and 6 wk	An early supervised aerobic training programme after minor ischemic stroke is feasible and well tolerated and, in a per-protocol analysis, was associated with improved walking endurance.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**

Stern et al. 1970	RCT	62 (31 / 31) with completed stroke and hemiplegia	mean: 64y, range 38-84y.	type: iCVA post-acute: median 31 d. after stroke, range 8d-5y	No	Intervention: PNF vs conventional PT E: exercise group specified special therapeutic exercise program (same exercises as C, and additional PNF and Brunnström C: no ‘specialized’ therapeutic exercises (heat and cold modalities, PROM, ambulation) Intensity: daily E: 100 min and C: 60 min, until discharge	Motility Index, ADL-score (KRISCE-scale) and strength measured at end of treatment	Facilitation exercises do not significantly improve the motility and strength deficits in these patients, because both groups showed comparable improvement.	4 failure at the questions: 3,5,6,7,8,9
Peacock et al. 1972	RCT	52 (29 / 23) who required rehabilitation	mean: 57 y.	type: ? sub-acute: < 2 wk after stroke	?	Intervention: intensive vs normal E: intensive therapy in a rehabilitation unit C: normal therapy in general ward Intensity: ?	ADL-score (similar to Rankin score), survival measured ? after stroke	?	? failure at the questions:
Smith et al. 1981	RCT 12 patients not randomi-sed	133 (46/ 43/ 44) on discharge from hospital; able to tolerate intensive therapy	mean: 65 y.	type: ? post-acute: mean: 38d. after stroke	Yes	Intervention: intensive, conventional care vs self-care E1: intensive rehabilitation E2: conventional rehabilitation C: no rehabilitation, only home-exercises and self-care Intensity: E1: 69.1 hrs; E2: 37.8 hrs and C: 10.5 hrs, during 3 mo	ADL-score (NPS), survival measured at 3 and 12 mo after stroke	Improvement was greatest in those receiving intensive therapy, intermediate in those receiving conventional treatment and at least in those receiving no routine treatment	4 failure at the questions: 3,5,6,7,9,11
Sivenius et al. 1985	RCT	95 (50 / 45) in-patients; able to tolerate intensive therapy	mean: 71y. + 9.8 y., range 61-82y.	type: all acute: within 1 wk of stroke	Yes	Intervention: intensive vs normal E: intensive therapy C: normal therapy Intensity: E: 69.1 and C: 47.2 in 3 mo; contrast (E-C): 21.9 x 30 min = 657 min; during 3 mo	ADL-score (Lehmann), strength and ROM (Katz&Ford) measured at 3, 6 and 12 mo after stroke	The conclusion is that intensified PT seems to improve the functional recovery of stroke patients. The gain of ADL and motor function was greatest during the first 3 mo after stroke in the intensive treatment group.	5 failure at the questions: 4,5,6,7,9
Sunderland et al. 1992	RCT	132 (65/67) 137 of 429 patients submitted in study 4% drop-outs, 132 completed the study	median 67.5y, range: 32-92 y	type: all but SAH and brain stem strokes excluded sub-acute: median 9 d., range 2-35 d.	Yes	Intervention: enhanced therapy vs conventional therapy E: 1) more intensive treatment for the arm, with amount and type of therapy for leg the same as C, and 2) eclectic approach with specific aims : promote more active participation in arm rehabilitation C: expert hands-on treatment based on “Bobath” en “Johnstone”- techniques, without routinely instructions to exercise between therapy sessions Intensity: E more than twice the amount of arm therapy per week, during 6 mo	EMI, subtests of Motor Club Assessment, FAT, NHPT, pain and BI measured at 1, 3 and 6 mo after stroke	At six months after stroke the enhanced therapy group showed a small but statistically significant advantage in recovery of strength, range and speed of movement. This effect seemed concentrated amongst those who had a milder initial impairment.	6 failure at the questions: 3,5,6,9
Sunderland et al. 1994	RCT	97 (48/49) of 132 patients completed the follow-up (=27% drop-outs)		chronic: mean: 52 w after stroke, range 39-64 w	Yes	Intervention: follow-up Sunderland et al. 1992	EMI, Motor Club Assessment, FAT, NHPT and BI measured at 1 year after stroke	The advantage seen for some patients with enhanced therapy at six months after stroke had diminished to a non-significant trend by one year.	4 failure at the questions: 3,4,5,6,7,9
Wade et al. 1992	RCT	94 (49 / 45) outpatients, with reduced mobility	mean: 72 y., range 61-83y.	type: all chronic: mean 4.7 y. after stroke	Yes	Intervention: treatment vs no treatment E: treated C: untreated Intensity: 5 min/d; during 3 mo	BI, NEAI, FAI, NHPT, RMI, TMW and FAC measured at 6 wk and 3, 6 and 9 mo later	Intervention of an experienced PT late after stroke specially improves mobility, albeit by small amount, but the effects did not seem to be maintained, perhaps because there is an underlying decline in mobility in these patients.	6 failure at the questions: 3,5,6,9

Richards et al. 1993	RCT	27 (10 / 8 / 9)	median: 69y.	type: all sub-acute: mean 10 d after stroke	Yes	Intervention: intensive vs conventional E: early intensive therapy incorporating the use of a tilt table, resisted exercises (Kinetron) and treadmill training C1: early conventional therapy included traditional (not specified) approach C2: conventional therapy Intensity: E~1.7 hrs/d and C1+2 ~1.3 hrs/d during 6wk	FMA, BI-ambulation, BBS, gait speed (4m) measured at 6 wk and 3 and 6 mo after baseline	At 6 wk gait velocity was similar in both conventional groups and at this point in the experimental group gait velocity was faster. This effect disappeared at 3 and 6 mo after stroke.	5 failure at the questions: 3,5,6,8,9
Werner and Kessler 1996	RCT	40 (28/12) 49 (33/16) 40 completed the study (29% drop-outs = 14 patients) and 5 patients added	mean: 61.1 + 10.2 y	type: MCA chronic: 3 y + 1.8 after stroke	Yes	Intervention: treatment vs no treatment E: intensive outpatient rehabilitation program; functional tasks (transfers, walking, self-care, feeding) and strengthening, stretching, mobilization and muscle retraining/facilitation. C: did not receive any outpatient therapy Intensity: 1 hrs PT and 1 hrs OT, 4 d/wk during 12wk	FIM-MM and SIP measured at 3 and 9 mo	Significant improvement after 3 months in treatment group. The improvement in functional tasks can be attained with therapy during the post-acute period and the gains are maintained for at least 6 months following the intervention.	4 failure at the questions: 3,5,6,8,9,11
Logan et al. 1997	RCT	111 (53 / 58) discharged from hospital and referred to OT service	mean: 73 y. + 11y	type: first stroke post-acute: between 1 + 2 mo after stroke	Yes	Intervention: enhanced OT service vs usual service E: treated by single research OT and treated sooner after discharge C: routine service by senior OT and some patients placed on waiting list Intensity: E: 222 (+ 136) min and C: 55 (+ 83) min; during 6 mo	BI and EADL measured at 3 and 6 mo after entry to the study	Three months after entry to the study the enhanced service group had better EADL than the usual service group. This benefit remained significant in only the mobility section of the EADL at 6 months	7 failure at the questions: 5,6,8
Feys et al. 1998	RCT	100 (50/50); 108 submitted in study, 7% drop-outs	mean: 64.2 y + 11.9, range 36-88 y	type: iCVA or hCVA (SAH excluded) sub-acute: 23 d. + 6 d	Yes	Intervention: additional sensorimotor stimulation vs treatment standard treatment E: rocking chair + inflatable arm splint (affected arm); arm has to push backwards as reaction on movement of rocking chair. C: rocking chair + no stimulation of affected arm (rested on cushion), but fake short-wave therapy of shoulder did not receive any outpatient therapy Intensity: both groups 30 min., 5 d/wk during 6 wk (total 30 sessions)	FMA, ARA and BI measured at 6 and 12 mo after stroke	Adding a specific intervention during the acute phase after stroke significantly improved motor recovery of the upper limb (FMA), which was apparent 1 year later, but no differential effect measured with BI and ARA.	6 failure at the questions: 3,5,6,9
Kwakkel et al. 1999 Kwakkel et al. 2002	RCT RCT	101 (33/ 31/37) with impairment of motor function of the arm, 9% drop-outs 89 completed the study 86 (28/25/33)	mean: 65.9 y + 11.5y -	type: first stroke, MCA sub-acute: mean 7 d. + 2.7 d. after stoke -	Yes Yes	Intervention: additional amount of intensity of PT (affected arm) vs additional amount of intensity of PT (affected leg) vs immobilising affected arm and leg with splint E: 30 min (5d/wk) additional arm or leg therapy based on eclectic approach (functional exercises) C: immobilisation of paretic arm and leg with an inflatable pressure splint; patient in supine for 30 min/day for 5d/wk Intensity: all groups received basic rehabilitation (15 min/d. leg training; 15 min/d arm training or leg training and 1.5 hrs ADL-training) during the 20 w. Follow-up study Kwakkel et al. 1999	BI, FAC and ARA measured at 6, 12, 20 and 26 w. after stroke BI, FAC and ARA measured at 6, 9 and 12 mo. after stroke	Greater intensity of arm rehabilitation results in small improvements in dexterity. Unable to demonstrate long-term effects of intensity of treatment on the individual patterns of functional recovery between 6 and 12 months after stroke.	7 failure at the questions: 5,6,9 6 failure at the questions: 5,6,7,9

Lincoln et al. 1999	RCT	282 (94/93/95) with arm impairment 282 completed the study	median 73 y	type: all sub-acute: median 12 d, range 1-5 wk after stroke	Yes	Intervention: additional amount of intensity of PT (affected arm) vs daily routine PT only E: two intervention groups: E1) standard PT (30-45 min/d) and additional treatment by senior research PT (facilitation, specific neuromuscular techniques and functional rehabilitation based on Bobath approach; E2) standard PT(30-45 min/d) and additional treatment by PT-assistant (positioning and care of affected arm; passive, assisted and active movements; and practice of functional activities based on teaching by PT before start of treatment. facilitation, specific neuromuscular techniques and functional rehabilitation based on Bobath approach; C: standard routine PT (Bobath approach) for 30-45 min. . No additional PT by research PT. Intensity: both E-groups received additional 2 hrs/wk during 5 wk PT (= 10hrs)	RMA, ARA, THPT, grip strength, BI and Extended ADL measured at 5 wk and after 3 and 6 mo after stroke	The increase in the amount of PT for arm impairment with a typical British approach given early after stroke did not significantly improve recovery of arm function.	6 failure at the questions: 5,6,8,9
Parry, Lincoln, Vass 1999a Parry, Lincoln, Appleyard 1999b	RCT RCT	Post-hoc analysis (Lincoln et al. 1999) Post-hoc analysis (Lincoln et al. 1999)	-	-	Yes	Groups were subdivided according to severity of initial arm impairment	-	Benefits of additional treatment were detected in the less-severe patients group; in the more severe patients no benefits were found.	6 failure at the questions: 3,4,5,6
Walker et al. 1999	RCT	185 (94 / 91) who had not been admitted to hospital	mean: 74 + 8y	type: all sub-acute: within 1 mo of their stroke	Yes	Intervention: treatment (OT) vs no treatment E: OT at home (ADL-activities) C: routine practice and no additional input from research therapist Intensity: mean 5.8 + 3.3 visits of OT; sessions of (mean) 52 + 11 min during 6 mo	BI, EADL and RMA measured at 1 and 6 mo after stroke	OT at home significantly reduced disability and handicap in patients with stroke who were not admitted to hospital	7 failure at the questions: 5,6,9
Partridge et al. 2000	RCT	114 (54 / 60)	mean: 76.5 y., range 60-94y.	type: all ?: mean ? after stroke	Yes	Intervention: intensive vs standard therapy E: doubling PT C: standard PT Intensity: E; 60 min/d vs C; 30 min/d for an unspecified period of time (~6 mo)	LROC, POR, FRT, STR, gait speed (5m) measured at 6 wk and 6 mo after stroke	Doubling PT time available for patients in a stroke unit will not provide a measurable benefit for all patients.	7 failure at the questions: 5,6,9
Gilbertson et al. 2000	RCT	138 (67 / 71)	mean: 71 y., range 28-89y	type: SAH excluded sub-acute: mean 27 d. after stroke	Yes	Intervention: Domiciliary program (OT) vs routine service E: Domiciliary program (OT), recovery goals such as regaining self care, or domestic or leisure activities C: Routine services included inpatient multidisciplinary rehabilitation. Intensity: E; around 10 visits lasting 30-45 min). C: 0 min	BI, NEADL and death	The functional outcome and satisfaction of patients with stroke can be improved by a brief occupational therapy program carried out in the patient's home immediately after discharge. Major benefits may not, however, be sustained	8 failure at the questions: 5,6
Parker et al. 2001	RCT	466 (153 / 156/ 157) 374 completed the study (20% drop-outs)	mean: 72 y.	type: all post-acute: mean 4.7 mo after stroke	Yes	Intervention: OT (leisure or ADL-based) at home vs no (OT) treatment at home E1: OT at home, based on leisure activities E2: OT at home, based on ADL-activities C: no OT within the trial Intensity: mean 8.5 sessions; mean duration of sessions: 56 min for up to 6 mo	BI, GHQ, NEAI and NLQ measured at 6 and 12 mo after discharge from hospital	Neither of the additional OT treatments showed clear beneficial effect on mood, leisure activity or independence in ADL measured at 6 or 12 months	7 failure at the questions: 5,6,8

Green et al. 2002	RCT	170 (85 / 85) who had associated persisting mobility problems	mean: 72.5 + 8.5 y.	type: all chronic: > 1 y. after stroke	Yes	Intervention: PT treatment vs no treatment E: treated at home or in outpatient rehabilitation centres C: no treatment Intensity: max. contact period of 13 wk. with minimum of 3 contacts per patient ; 30 minutes	RMI, TMW, BI and FAI measured at 3, 6 and 9 mo after stroke	Community PT treatment for patients with mobility problems 1 year after stroke leads to significant, but clinically small, improvements in mobility and gait speed that are not sustained after treatment ends	8 failure at the questions: 5,6
Slade et al. 2002	RCT	87 (47 / 40) stroke patients, total group 141 (stroke, TBI and other neurolo-gical disorders); 126 (67/59) completed the study (11% drop-outs)	mean: 53 y.	type: all post-acute: mean 47 d. after stroke	Yes	Intervention: augmented therapy (OT + PT) vs normal therapy E: 62.5% of available total time of therapist the patients had therapy C: 37.5% of available total time of therapist the patients had therapy Intensity: E had 67% more therapy than C (E~1.25 hrs/d and C less than 1 hrs/d for 5 d/wk till discharge)	BI, Mayo scale (mental status) and LOS measured at discharge	After controlling for confounders and case mix, patients in the experimental group showed a significant 14-day reduction in length of stay. Concurrently average length of stay was increased for both groups by 16 days due to delays in discharge.	6 failure at the questions: 3,5,6,7
Wellwood (GAPS) (2003; in press)	RCT	70 (35 / 35) were able to tolerate and benefit from mobility rehabilitation i.e. independent functional sitting balance 65 completed follow-up at 6 mo	mean: 67.4 + 10.5 y.	type: all sub-acute: mean 24 d after stroke	yes	Intervention: augmented PT vs standard PT E: conventional stroke services plus additional physiotherapy input (to approximately double the total daily physiotherapy time) to C: conventional in-patient stroke services including conventional PT Intensity: E: 60-80 min/d; 5 d/wk and C: 30-40 min/d; 5 d/wk during 10 wk	Mobility milestones, RMI, TMW, ARAT, BI, LOS and patient satisfaction measured at 4 wk and 3 and 6 mo after randomisation	Analysis revealed no statistically significant differences in the groups in our primary or secondary outcome measures	6 failure at the questions: 3,4,5,6

RCTs investigating Bobath/NDT (paragraaf B.4)

RCTs investigating Bobath/NDT (direct comparison)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Lum et al 2002 (preliminary: Burgar et al 2000)	6	27 (13/14)	Age: 63.2±3.6 yr Type: first Time since onset: 30.2±6.2 mos Inclusion: upper limb motor function deficit, no joint pain or ROM limitations	Comparison: Robotics vs. conventional (C) Robotics: Robotics with 6 degrees of freedom, using 4 modes: passive (5 minutes), bimanual (12 minutes), active-assisted and active-constraint (20 minutes). Emphasis on 12 targeted reaching movements that started close to the body and ended further away, in four directions: forward medial, directly forward, forward lateral, directly lateral (Four point-to-point directions: shoulder flexion/ adduction, shoulder flexion, shoulder flexion/ abduction/ external rotation, shoulder abduction/ external rotation); on varying heights: tabletop, shoulder, eye level. Progressing from easiest to most challenging mode. During active-constrained, feedback on fraction of movement completed or time to complete 3 repetitions. Tone normalization (5 min) and limb positioning at the beginning and end of each session. C: Conventional therapy, targeting proximal upper limb function based on NDT. Physical postural base of support coupled with assessing and facilitating alignment of shoulder (10 minutes), graded application of arm use in functional leisure and self-care tasks (35 minutes). Emphasis on re-education of muscles using a sensorimotor approach. Progression by increasing number of repetitions, weight of item, height at which tasks were done. Practice highest level task that was competed, with review (10 minutes). Exposure to robot (5 minutes). Intensity: 24 sessions, 1 h/session, during 2 mos. Treatment contrast: 0 h.	FMA arm, BI, FIM self-care and transfer, strength, reaching ability Measured at baseline, 1 and 2 mos, and 6 mos (follow-up)	Compared with conventional treatment, robot-assisted movements had advantages in terms of clinical and biomechanical measures.
Luft et al 2004	5	26 (11/15)	Age: 63.3±15.3 yr Type: first Time since onset: median 75.0 (IQR 37.9-84.5) mos Inclusion: ability to move affected limb (at least partial range antigravity movement)	Comparison: BATRAC vs. dose-matched therapeutic exercises (DMTE) BATRAC: Pushing and pulling bilaterally, in synchrony or alternation, 2 T-bar handles sliding in the transverse plane upon auditory cues (rates 0.67-0.97 Hz). 4x 5 min interspersed with 10 min rest. DMTE: Based on NDT principles, including thoracic spine mobilization, scapular mobilization, weight bearing, opening a closed fist. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0h.	fMRI variables, FMA arm, shoulder and elbow strength, WMFT, UMAQS Measured at baseline and 6 wk	BATRAC induced changes in movement-related cortical activation patterns (contralesional hemisphere - precentral gyrus, poscentral gyrus, and ipsilesional cerebellum), suggesting cortical reorganization. No significant difference between groups for changes in functional outcome.
Suputtitada et al 2004	6	69 (33/36)	Age: Type: first Time since onset: Inclusion: 1-10 yr post stroke, ≥20^{o} active wrist extension, 10^{o} finger extension, ARAT <51, walk indoors without stick, no sensory disorder	Comparison: Forced use (FU) vs. bimanual training (C) FU: Nonparetic hand covered by glove, Treatment in groups of 3-4. Encouraged to use affected arm at home. C: Bimanual training based on NDT if necessary support affected arm with nonaffected hand with emphasis on symmetry of posture and inhibition of inappropriate 'synergistic' movements, in groups of 3-4. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	ARAT, hand grip strength, pinch grip strength Measured at baseline and 2 wk	CIMT of unaffected upper extremities has an advantage for chronic stroke patients which ma be an efficacious techniqarm of improving motor activity and exhibiting learned nonuse.
Richards et al 2004	7	63 (32/31)	Age: 62.9±12 yr Type: first/rec isch Time since onset: 52.0±22 d Inclusion: residual deficit, affected walking ability, BI ambulation ≥10, gait speed 10-60 cm/s, no medical problems such as heart	Comparison: Locomotor training with technological devices (E) vs. control (C) E: Specialized locomotor training using tilt table if needed, limb-load monitor to induce weight bearing on affected side, reciprocal stepping on Kinetron isokinetic device, treadmill walking with full weight bearing, with goal to promote gait re-learning through locomotor activities. In addition to speech and occupational therapy. C: Conventional PT, with elements of traditional NDT approach incorporated with motor learning task-oriented approach. Locomotion started as soon as possible with external support, gradually adding stair-climbing, walking on inclined planes,	Walking speed comf, FMA leg, FMA arm, BI ambulation, TUG, BBS Measured at baseline and 8 wk and 3 mos (follow-up)	The results demonstrate that the efficacy of the task-oriented approach is not dependent on rehabilitation technology.

			conditions, no receptive and/or expressive aphasia	transfers. In addition to speech and occupational therapy. Intensity: 1 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.		
Winstein et al 2004	6	64 (21/22/21)	Age: <35 yr n=0, 35-75 yr: n=19, ≥75: n=1 Type: first/rec isch/hem/SAB Time since onset: 16.1±7.7 d Inclusion: ??	Comparison: Strength training (ST) vs. Functional task practice (FTP) vs. control (C) ST: Resistance to available arm motion to increase strength of shoulder, elbow, wrist and hand motions, using eccentric, concentric and isometric muscle contractions. Progressed to repetitions against resistance using free weights, Theraband or grip devices for fingers. In addition to standard dose PT and OT. FTP: Systematic and repetitive practice of tasks that could be performed within the level of available voluntary motion. Progressively arranged to account for proximal-to-distal recovery patterns of reaching and grasping actions. Principles of motor learning by provision of knowledge of results and progressed task difficulty. In addition to standard dose PT and OT. C: Muscle facilitation exercises emphasizing NDT, NMS primarily for shoulder subluxation, stretching exercises, ADL including self-care where upper limb was used as assist if appropriate, caregiver training. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: FTP vs. ST: 0 h. FTP/ST vs. C: 20 h.	FIM mobility, FIM self-care, FMA arm FMA ROM, FMA pain, FMA sensory, FTHUE, isometric torque, grasp and pinch force Measured at baseline, 4 wk and 6 and 9 mos (follow-up)	Task specificity and stroke severity are important factors for rehabilitation of arm use in acute stroke. Twenty hours of upper extremity-specific therapy over 4-6 weeks significantly affected functional outcomes. The immediate benefits of a functional task approach were similar to those of resistance-strength approach, however, the former was more beneficial in the long-term.
Bagley et al 2005	8	140 (71/69)	Age: 75.8±11.5 yr Type: first/rec Time since onset: 19.5±12.1 d Inclusion: sit in chair >30 min, GCS ≥11	Comparison: Standing frame (E) vs. control (C) E: Standing in Oswestry standing frame. Additional therapy as required. C: Treatment without Oswestry standing frame, but tilt table was available if required for safe handling. Centered around Bobath approach, but also including task-specific techniques. Intensity: during 14 d. Treatment contrast: 0 h.	RMI, BI, HAD anxiety, HADS depression, NEADL, RMA, MAS* balanced sitting, MAS* sitting to standing, TCT, resources Measured at baseline and 6 wk and 3 and 6 mos (follow-up)	Use of the Oswestry standing frame did not improve clinical outcome or provide resource savings for this severely disabled patient group.
Desrosiers et al 2005	6	41 (20/21)	Age: 73.2±10.4 yr Type: isch/hem Time since onset: 34.2±34.4 d Inclusion: move upper limb independently	Comparison: BAT vs. control (C) E: OT and PT. Additional practice of mainly symmetrical bilateral tasks, based on motor learning model principles including repeated practice and task variability. Standardized activities related to ADL tasks upper extremity. Type of tasks: symmetrical and asymmetrical bilateral, unilateral affected upper extremity, unilateral unaffected upper extremity. C: OT and PT. Additional functional activities and exercises to enhance strength, active, assisted and passive movements, and sensorimotor skills of the arm both uni- and bilateral. Based on some components of NDT. No asymmetrical tasks nor unilateral tasks unaffected upper extremity, not repeated in a systematic way, lower mental and physical effort. Intensity: 45 min, in total 15-20 sessions, during 5 wk (additional programmes). Treatment contrast: 0 h.	FMA arm, grip strength, BBT, PPT, finger-to-nose test, TEMPA, FIM, AMPS Measured at baseline and 5 wk	Arm training programme based on repetition of unilateral and symmetrical bilateral practice did not reduce impairment and disabilities nor improve functional outcomes in the subacute phase after stroke more than usual therapy.
Platz et al 2005	8	60 (20/20/20)	Age: 60.6±10.5 yr Type: first isch Time since onset: 6.5±3.9 wk Inclusion: FMA UE 5-34, 3 wk to 6 mos post stroke, no contractures of arm joints	Comparison: Augmented exercise therapy as Bobath (AETT Bobath) vs. AETT BASIS training vs. control (C) AETT Bobath: Bobath approach with emphasis on control of muscle tone and recruitment of arm activity in functional situations with various positions. In addition to usual standard rehabilitation therapy (see below). AETT BASIS: Systematic repetitive technique training all degrees of freedom of the arm across full ROM, encouraging selective dynamic movements. Stages: 1) selective innervation for isolated motions without postural control; 2) selective innervation for isolated motions with postural control; 3) selective innervation for complex motions with postural control. In addition to usual standard rehabilitation therapy (see below). C: Standard rehabilitation therapy, addressing e.g. ADL, arm activities, stance, gait, speech and cognition. Intensity: 45 min/d, 5 d/wk, during 4 wk. Treatment contrast: 900 min.	FMA arm, FMA sensation, FMA joint, ARAT, MAS Measured at baseline and 4 wk	The augmented exercise therapy time as Arm BASIS training enhanced selective motor control. Type of training was more relevant for recovery of motor control than therapeutic time spent.

Tang et al 2005	6	47 (22/25)	Age: 54.86±13.40 yr Type: first Time since onset: 55.27±66.67 d Inclusion: no global aphasia or severe apraxia, not delirious, stable vital signs and neurologic problems, alert, have cognitive function impairment	Comparison: Bobath vs. Problem-oriented willing-movement therapy (POWM) Bobath: Normalize motor performance and inhibit abnormal movement patterns based on NDT principles. POWM: Emphasize use of intact or relatively preserved sensory and cognitive functions to facilitate attention to achieve specific motor task, does not adhere to motor development sequence. 1) assess cognitive, perceptual and movement functions. 2) assess relatively preserved cognitive and perceptual functions. 3) assess cognitive and motor problems. 4) select treatment. 5) perform intervention. Facilitate motor learning using many repetitions, select colorful and interesting objects as targets, select interesting motor activities, allow sufficient time to anticipate, emphasize by demonstration, provide visual and auditory guidance, repeatedly demonstrate, use mirror for patients with apraxia. Intensity: 50 min/d, 5-6 d/wk, during 8 wk. Treatment contrast: 0 h.	MMSE, STREAM Measured at baseline and 8 wk	These findings suggest that, regardless of a person's cognitive function, POWM intervention is effective in improving lower-extremity and basic mobilities and indicates the need to use relatively intact cognitive function or perceptual function, or both, to improve motor rehabilitation for people with cognitive function deficits.
Van Vliet et al 2005	6	120 (60/60)	Age: 73.3±10.4 yr Type: isch Time since onset: <2 wk Inclusion: <2 wk post stroke, unconscious on hospital admission, tolerate >30 min physical tasks required in initial assessment	Comparison: Bobath vs. movement science based therapy (MSB) Bobath: Outpatient PT according to Bobath. MSB: Outpatient PT according to MSB. Intensity: 23 min/d, 5 d/wk, totaling 365 minutes. Treatment contrast: 0 h.	RMA gross function, RMA leg & trunk, RMA arm, MAS* subitems, BI, EADL, EADL domains, 10HPT, 6MWT* Measured at baseline, 1, 3 and 6 mos	There were no significant differences in movement abilities or functional independence between patients receiving a Bobath or an MSB intervention. Therefore the study did not show that one approach was more effective than the other in the treatment of stroke patients.
Wang et al 2005 Brunnstrom stage 2-3 Brunnstrom stage 4-5	6	 21 (10/11) 21 (10/11)	Age: 53.9±11.8 yr Type: isch/hem Time since onset: 21.9±7.4 d Inclusion: Brunnstrom stage 2-5 Age: 62.4±11.6 yr Type: isch/hem Time since onset: 21.6±9.3 d Inclusion: Brunnstrom stage 2-5	Comparison: Bobath vs. orthopaedic treatment Bobath: Emphasis on retraining normal alignment and normal movement patterns based on Bobath principles, facilitated through appropriate sensory and proprioceptive input, direct manual facilitation, key point control, and verbal and visual feedback. Normalizing muscle tone, re-educating postural reaction and training for trunk control. Orthopaedic: Passive, assistive, active and progressive resistive exercises, attempting to elicit motion joint by joint, all under volitional control. Characterized by functional activities, and multiple repetitions. Gait training started near horizontal bar at non-affected side. Intensity: 40 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	SIAS, MAS*, BBS, SIS Measured at baseline and 4 wk	Bobath or orthopaedic treatment paired with spontaneous recovery resulted in improvements in impairment and functional levels for patient with stroke. Patients benefit more from the Bobath treatment in MAS and SIS scores than from the orthopaedic treatment programme regardless of their motor recovery stages.
Lum et al 2006	5	30 (10/9/5/6)	Age: 62.3±2.8 yr Type: first ?? Time since onset: 13.0±2.1 wk Inclusion: no upper extremity joint pain or ROM limitations	Comparison: Robot bilateral vs. robot combined vs. robot unilateral vs. control (C) Robot bilateral: 12 targeted reaching movements, bilateral mode, rhythmic circular movements were also performed. Robot combined: 12 targeted reaching movements, half of the time in unilateral mode, half of the time in bilateral mode. Robot unilateral: 12 targeted reaching movements, progressed from easies exercise modes (passive) to most challenging (active-constraint), no bilateral exercises. C: Conventional therapy targeting proximal arm function based on NDT. Intensity: 1 h/d, 15 sessions, during 4 wk. Treatment contrast: 0 h.	FMA arm, FIM self-care and transfer, MP, MAS Measured at baseline, 4 wk and 6 mos (follow-up)	At post treatment, robotic-combined training group had significantly greater gains than the control group. However, gains in robot and control groups were equivalent at the 6 month follow-up. No significant differences were found between the robot-combined and robot-unilateral treatment. Less benefit from bilateral therapy alone, because this group had the smallest gains.
Dias et al 2007	4	40 (20/20)	Age: 70.35±7.36 yr Type: first Time since onset: 47.10±63.83 mos Inclusion: MI leg <100/ >0, absence of cardiac/ psychological/ orthopedic conditions	Comparison: Gait trainer (GT) vs. Control (C) GT: Harness secured gait trainer (REHA-STIM), stance-swing phase ratio 60-40%, pulley relieves part of body weight as required up to 30% which decreased over time, knee motion corrected manually if necessary (20 min). Joint mobilization and muscle strengthening (20 min). C: Joint mobilization and muscle strengthening (20 min). Balance and gait training using Bobath methods (20 min). Intensity: 40 min/d, 5 d/wk, during 5 wk.	MI leg, TMS, BI, FMA leg, FMA balance, 10MWT (velocity, step length, step cadence), TUG, 6MWT, FAC, RMI, MAS, step test Measured at baseline and 5 wk and 3 mos (follow-up)	Both groups of chronic hemiplegic patients improved after partial body weight support with gait trainer or Bobath treatment. Only subjects undergoing partial body weight support with gait trainer maintained functional gain after 3 months.

				Treatment contrast: 0 h.		
Thaut et al 2007	7	78 (43/35)	Age: 69.2±11 yr Type: isch/hem Time since onset: 21.3±11 d Inclusion: complete 5 stride cycles with handheld assistance	Comparison: Rhythmic auditory stimulation (RAS) vs. control (C) RAS: Walk using metronome and specifically prepared music tapes. After initial cadence assessment, cuing frequencies were matched to gait cadence for (15 min), increased in 5% increments as kinematically indicated without compromising postural and dynamic stability (15 min), practice adaptive gait patterns (15 min), fading cues intermittently to train for independent carryover (15 min). C: Train walking following NDT and Bobath principles and similar instructions about gait parameters to practice, but without RAS. Intensity: 30 min/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Walking speed, stride length, cadence, symmetry Measured at baseline and 3 wk	The data show that after 3 weeks of gait training, RAS is an effective therapeutic method to enhance gait training in hemiparetic stroke rehabilitation. Gains were significantly higher for RAS compared to NDT/Bobath training.
Wu et al 2007 A	6	47 (24/23)	Age: 55 (range 40-80) yr Type: first isch/hem Time since onset: 12.25 (range 3 wk-37 mos) mos Inclusion: FMA arm proximal part stage III-V	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Use of affected upper extremity in daily activities, mitt wear 6 hours daily. TR: Traditional therapy (NDT) emphasizing functional task practice, stretching, weight bearing, fine-motor dexterity. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematic variables, FMA arm, MAL Measured at baseline and 3 wk	In addition to improving motor performance at the impairment and functional levels, mCIMT conferred therapeutic benefits on control strategies determined by kinematic analysis.
Wu et al 2007 B	7	30 (15/15)	Age: 54.66±8.63 yr Type: first ?? Time since onset: 18.53±6.92 mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Use affected arm during functional tasks, using shaping. 15 minutes normalization muscle tone. Mitts 6 h/d during weekdays. TR: NDT emphasizing balance, stretching, weight bearing, fine motor tasks, practice on ADL with unaffected arm. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematics in unilateral and bilateral task, MAL, FIM Measured at baseline and 3 wk	Relative to TR, mCIMT produced a greater improvement in functional performance and motor control. Improvement of motor control after mCIMT was based on improved spatial and temporal efficiency, apparently more salient during bimanual rather than unilateral task performance.
Wu et al 2007 C	7	26 (13/13)	Age: 71.44±6.42 yr Type: first ?? Time since onset: 6.70±8.99 mos Inclusion: FMA arm proximal part stage III-V	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Shaping and adaptive and repetitive task practice. 15 minutes normalization muscle tone. Mitt 6 h every weekday. TR: 75% NDT emphasizing functional task practice, stretching, weight bearing, fine motor dexterity. 25% compensatory technique using unaffected upper extremity. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, FIM, MAL, SIS Measured at baseline and 3 wk	mCIMT is a promising intervention for improving motor function, daily function, and physical aspects of health related quality of life in elderly patients with stroke.
Bale et al 2008	7	18 (8/10)	Age: 60.8±13.0 yr Type: first isch/hem Time since onset: 49.4±22.1 d Inclusion: reduced muscle strength affected leg but some motor control, sit without support; no sensory sequels, arrhythmia, uncontrolled angina pectoris or hypertension	Comparison: Functional strength + conventional therapy (FST) vs. conventional (C) FST: FST to improve strength lower extremities (3 d/wk), arm function and ADL (2 d/wk). FST to facilitate appropriate power in weak muscles of the affected leg in graded activities or sequences of activities, most were weight-bearing and also challenged standing balance. 10-15 repetitions maximum. In addition to multidisciplinary rehabilitation. C: Traditional training influenced by Bobath concept, focusing on normalizing muscle tone and movements affected side, symmetrical use body, relearning ADL, often using manual guiding and facilitation techniques. Use excessive muscle power avoided. In addition to multidisciplinary rehabilitation. Intensity: 50 min/d, 5 d/wk, 4 wk. Treatment contrast: 0 h.	Weight bearing, muscle strength (knee extension, flexion), walking speed comf, walking speed max Measured at baseline and 4 wk	This pilot study indicates that functional strength training of lower extremities improves physical performance more than traditional training.
Myint et al 2008	7	48 (20/28)	Age: 63.4±13.6 yr Type: isch/hem Time since onset: 38.2±20.4 d Inclusion: ≥20° active wrist extension, ≥10° active extension all digits	Comparison: CIMT vs. control (C) CIMT: Training with unaffected arm restrained in a shoulder sling. Supervised activities including shaping, without strict algorithm of tasks with increasing level of difficulty. Sling 90% waking hours during weekdays. C: Conventional OT and PT, using combination of NDT technique (e.g. bimanual tasks upper extremity, compensatory technique ADL, strength, range of motion, positioning, mobility training). Intensity: 4 h/d, 5 d/wk, during 2 wk.	Functional test hemiparetic upper extremity, ARAT, MAL, mBI, NHPT Measured at baseline, 2 wk and 12 wk (follow-up)	Significant improvement in hand function could be achieved with constraint-induced movement therapy in subacute stroke patients, which was maintained up to 12 week follow-up.

				Treatment contrast: 0 h.		
Ng et al 2008	6	54 (16/17/21)	Age: 62.0±10.0 yr Type: first isch/hem Time since onset: 2.3±1.1 wk Inclusion: ability to stand upright (supported or unsupported) for 1 minute, FAC <3; no skin allergy, cardiac pacemaker, aphasia or cognitive deficit with inability to follow commands, severe hip/knee/ankle contracture or orthopedic problem influencing PROM	Comparison: Gait trainer (GT) + Functional electrical stimulation (FES) vs. GT vs. control (C) GT: Electromechanical gait trainer, body weight partially supported by a harness which was decreased by 5 kg, gait cycle ratio 60-40% between stance and swing phase, gait speed increase 0.1 m/s if possible. Therapist gave assistance of knee extension, verbal cueing head and trunk movements. Optional rest beak of 1-3 minutes. GT + FES: GT as above, with FES simultaneously of quadriceps and peroneal nerve. Rectangular pulse, pulse width 400 µs with rising edge and falling edge ramp set as 0.3 seconds, intensity adjusted. C: Conventional therapy, including stretching exercise based on PNF and Bobath concepts, cardiovascular exercises, strengthening exercise, ADL training, overground walking with or without walking aid or orthosis and with manual assistance from therapist depending on subject's abilities. Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	EMS, BBS, FAC, MI leg, gait speed, FIM, BI Measured at baseline and 4 wk and 6 mos (follow-up)	For the early stage after stroke, this study indicated a higher effectiveness in poststroke gait training that used an electromechanical gait trainer compared with conventional overground gait training. The training effect was sustained through to the 6-month follow-up after the intervention.
Volpe et al 2008	6	21 (11/10)	Age: 62±3 yr Type: first isch/hem Time since onset: 35±7 mos Inclusion: FMA arm shoulder-elbow >33	Comparison: Robotics vs. intensive movement protocol Robotic: Planar robot, which guided the trajectory and speed of the patient's arm to provide an adaptive sensorimotor experience, if the patient could not move the robot arm. Intensive: Static stretching (adductor/internal rotator groups of shoulder girdle and elbow flexors), systematically varied levels of active-assisted arm exercise (20 minutes bilateral arm training on arm ergometer, 3x 15 repetitions with 30 seconds rest of humeral elevation exercises with grip fasteners), goal-directed planar reaching tasks based on Carr and Sheperd principles, which were adapted using Bobath NDT (Figure-eight movements for 5 minutes, then reaching in a point-to-point fashion, side-to-side and forward for 5 minutes, 10 min Bobath-based activities, including closed- and open-chain exercises). Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, MP, MAS, SIS, ARAT, pain, BDS Measarmrd at baseline, 3 wk (mid) and 6 wk	These new protocols, rendered by either therapist or robot, can be standardized, tested, and replicated, and potentially will contribute to rational activity-based programs.
Yelnik et al 2008	7	68 (33/35)	Age: 55.5±11.6 yr Type: first isch/hem Time since onset: 217.2±92.9 d Inclusion: unable to walk for 2 wk to 3 mos, walk ≥50 m with orthosis or cane but without human assistance, no history of vestibular disorder	Comparison: Multisensorial training (E) vs. control (C) E: Physical rehabilitation based on manipulation of sensor information required to maintain balance. Emphasis on amount of exercise, most conducted in visual deprivation. C: Global sensorimotor rehabilitation based on NDT, targeting control of weight bearing and shifting in erect stance and quality of gait. Intensity: 5 d/wk, during 4 wk. Treatment contrast: 0 h.	BBS, 10MWT comf, double stancephase, time to climb 10 steps, daily time of walking, security sensation during walking, number of falls, FIM, NHP Measured at baseline and 4 wk and 3 mos (follow-up)	No evidence was found for the superiority of a multisensorial rehabilitation program in ambulatory patients with impairments beyond the time of inpatient therapy.
Lin et al 2009 A	7	60 (20/20/20)	Age: 52.14 (range 23-82) yr Type: first isch/hem Time since onset: 21.25±21.59 mos Inclusion: FMA arm III-V for proximal and distal parts arm	Comparison: dCIT vs. BAT vs. control (CT) dCIT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lifting 2 cups, picking up 2 pegs, grasping and releasing 2 towels, wiping the table with 2 hands. No at home practice. C: Usual therapy, partly based on principles of NDT: functional task practice for hand function, coordination, balance, movements of affected arm, compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, FIM, MAL, SIS Measured at baseline and 3 wk	BAT may uniqarmly improve proximal upper limb motor impairment. In contrast, distributed CIT may produce greater functional gains for the affected upper limb in subjects with mild to moderate chronic hemiparesis.
Lin et al 2010 B	6	33 (16/17)	Age: 52.08±9.60 yr Type: isch/hem	Comparison: BAT vs. control (C) BAT: Supervised training moving simultaneously affected and unaffected upper	Kinematic analysis unilateral (pressing desk bell) and	Effects of BAT for improving some aspects of motor control strategies of the affected

			Time since onset: 13.94±12.73 mos Inclusion: FMA arm III-V	extremity in functional tasks with symmetric patterns. <u>C</u>: OT focused on arm training including NDT technique, trunk-arm control, weight bearing, fine motor tasks practice, practice compensatory strategies for daily activities. <u>Intensity</u>: 2 h/d, 5 d/wk, during 3 wk. <u>Treatment contrast</u>: 0 h.	bilateral task (opening box to retrieve sticky note), FMA arm, FIM, MAL Measured at baseline and 3 wk	arm in both bilateral (time, efficiency, strategy) and unilateral tasks (time, efficiency) and reducing motor impairments, but not on functional ability.
Piron et al 2010	8	47 (27/23)	Age: 58.8±8.3 yr Type: first isch Time since onset: 15.4±12.6 mos Inclusion: FMA arm 20-66	<u>Comparison</u>: Virtual reality (VR) vs. control (C) <u>VR</u>: Reinforced feedback in a virtual environment (RFVE), perform different kinds of motor tasks while movement of entire biomechanical arm system's end section was simultaneously represented in a virtual scenario by means of motion-tracking equipment. Virtual scenarios by high-resolution LCD projector on large wall screen. Therapist determined starting position and target of each task. KP by virtual representation of end-effector. KR supplied in form of standardized scores and by displaying arm trajectory morphology on screen. KP and KR initially 90% provided, gradually decreased as performance improved. <u>C</u>: Specific exercises with upper extremity with progressive complexity based on Bobath. First control isolated motions without postural control, then postural control included, finally complex motion with postural control. <u>Intensity</u>: 1 h/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.	FMA arm, FIM, kinematics Measured at baseline and 4 wk	Both rehabilitation therapies improved arm motor performance and functional activity, but the RFVE therapy induced more robust results in patients exposed to late rehabilitation treatment.
Brock et al 2011	7	29 (14/15)	Age: 61.3±13.0 yr Type: first/rec isch/hem Time since onset: 60.3±24 d Inclusion: 4-20 wk post stroke, rehabilitation programme, walk 15 m indoors on level surface with supervision; no independent mobility indoors achieved within 4 wk post stroke, premorbid mobility limited to walking indoors only, mobility disability due to comorbidity	<u>Comparison</u>: Bobath vs. structured task practice (STP) <u>Bobath</u>: PT based on Bobath principles, to improve walking abilty in different environmental contexts by reducing severity of impairments where they impacted on function, and optimizing postural and movement strategies to improve efficiency and maximize function. Structured task practice for 1/6 of treatment time (see below). <u>STP</u>: Repeated task specific practice based on principles of motor learning, in environmental contexts frequently encountered in walking outdoors, focused on increasing endurance, walking on slopes, going up and down a single step and walking over rough ground. How to perform task, including demonstration, verbal cueing to correct ineffective adaptive motor patterns and feedback on the performance, supervision and safety. No hands-on assistance or guidance during task. ½ conducted as repetitive practice using standardized equipment, other ½ spent in environments outside. <u>Intensity</u>: 1 h/d, 6 d, during 2 wk. <u>Treatment contrast</u>: 0 h.	Adapted 6MWT, walking speed comf, BBS Measured at baseline and 4 wk	This pilot study indicates short-term benefir for using interventions based on the Bobath concept for improving walking velocity in people with stroke.
Hsieh et al 2011	8	18 (6/6/6)	Age: 56.04±13.74 yr Type: isch/hem Time since onset: 21.33±7.17 mos Inclusion: FMA arm 30-56, MAS <3	<u>Comparison</u>: Higher intensity robotics (RT) vs. lower intensity robotics vs. conventional (C) <u>Higher RT</u>: Robot-assisted arm trainer enabling symmetrical practice of 2 movement patterns: forearm pronation-supination and wrist flexion-extension; with 3 computer-controlled modes (1. passive-passive; 2. active-pasive; 3. active-active). Speed, amount resistance and ROM adjusted individually. A simple computer game provides instant visual movement feedback, therapists also provided verbal feedback. Within each session 600-800 repetitions of mode 1 (15 min), 600-800 repetitions of mode 2 (15-20 min), 150-200 repetitions of mode 3 (5 min). Warming-up passive ROM (5-10 min), after RT 15-20 min functional activity training. <u>Lower RT</u>: Same protocol as Higher RT, except for intensity: 300-400 repetitions of mode 1, 300-400 repetitions of mode 2, 70-100 repetitions mode 3. <u>C</u>: Conventional OT such as NDT with emphasis on functional tasks and muscle strengthening, including a) passive ROM, stretching, facilitatory and inhibitory technique (20 min); b) fine motor or dexterity (20 min); c) arm exercises or gross motor training (20 min); d) muscle strengthening (15-20 min); e) ADL or functional task training (15-20 min). <u>Intensity</u>: 20 sessions, 90-105 min/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.	FMA arm, MRC, MAL, ABILHAND, Urinary 8-OhdG, MFSI Measured at baseline and 4 wk	Higher intensity of RT that assists forearm and wrist movements may lead to greater improvement in motor ability and functional performance in stroke patients.

Whitall et al 2011	6	92 (42/50)	Age: 59.8±9.9 yr Type: first Time since onset: 4.5±4.1 yr Inclusion: ability flex paretic arm shoulder 3 inches from a neutral position	Comparison: BATRAC vs. dose-matched therapeutic exercises (DMTE) BATRAC: Pushing and pulling bilaterally, in synchrony or alternation, 2 T-bar handles sliding in the transverse plane upon auditory cues (rates 0.67-0.97 Hz). 4x 5 min interspersed with 10 min rest. DMTE: Based on NDT principles, including thoracic spine mobilization, scapular mobilization, weight bearing, opening a closed fist. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, WMFT, WMFT weight, grip strength, SIS, isokinetic strength, isometric strength, ROM, perception after training, fMRI Measured at baseline, 4, 6 weeks and 4 mos (follow-up)	BATRAC is not superior to DMTE, but both rehabilitation programs durably improve motor function for individuals with chronic upper extremity hemiparesis and with varied deficit severity.
Wu et al 2011	6	66 (22/22/22)	Age: 53.11 yr Type: isch/hem Time since onset: 16.20 mos Inclusion: FMA arm stage III-V	Comparison: mCIMT vs BAT vs control (C) mCIMT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lift 2 cups, picking up 2 pegs, grasping and releasing 2 towels, wiping the table with 2 hands. C: Usual therapy, about 75% based on principles of NDT: functional task practice for hand function, coordination, balance, stretching, weight bearing affected upper extremity. 25% compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematic analysis unilateral and bilateral, WMFT, MAL Measured at baseline and 3 wk	BAT and mCIMT exhibited similar beneficial effects on movement smoothness but differential effects on force at movement initiation and functional performance.

RCTs investigating Bobath/NDT (adjunctive)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Heckmann et al 1997	4	28 (14/14)	Age: 50.1±14 yr Type: first isch/hem Time since onset: 56.1±24 d Inclusion: right-handed, large supratentorial lesion; no previous stroke, dementia, bilateral lesions	Comparison: EMG-NMS vs. control (C) EMG-NMS: EMG-NMS of paretic hand and upper arm extensors, ankle extensors and knee flexors. Intensity to achieve a maximum effect of movement but not of force. EMG-activity required to trigger stimulation 80% of maximum voluntary surface EMG activity. 0.3 ms biphasic sinus-waved pulses, 80 Hz, constant current 20-60 mA for 1 s. Each group of muscles was stimulated 15 times per session. Supervised by advanced medical students. In addition to conventional therapy (see below). C: Conventional physiotherapy based on principles of Bobath (45 min/d, 5 d/wk), supplemented by OT predominantly covering ADL (>3h/wk plus≤2 h group therapy). Intensity: 15 contractions per muscle group/session, 5 d/wk, during 4 wk. Treatment contrast: ??	Spasticity, pendulum test, strength ankle extensors, BI Measured at baseline and 5 wk	The study group's results in evaluated spasticity scores, mobility parameters, and BI were superior to those of the control group, but the difference was not significant.
Werner et al 2002	7	30 (15/15)	Age: 60.3±8.6 yr Type: first isch/hem Time since onset: 6.93±2.09 wk Inclusion: 4-12 wk post stroke, FAC ≤2, sit unsupported edge of bed, stand ≥10 sec with help, hip or knee extension deficit <20°, passive dorsiflexion ankle to neutral position; no evidence of cardiac ischemia, arrhythmia or decompensation, max HR >190 bpm-age of patient, systolic blood pressure rest 200 mm Hg	Comparison: Gait trainer (E) vs. Control (C) GT: Harness-secured in gait trainer, stance-swing phase ratio 60-40%, velocity from 0-2.5 km/h. Support reduced when patient could extend hips and carry weight sufficiently on affected lower limb. Target velocity 0.25-0.40 m/s. Physical help according to individual needs. In addition to comprehensive rehabilitation program, containing at least daily individual, 45 min, PT and OT sessions following Bobath approach. C: Body-weight supported treadmill training with modified parachute harness. Treatment conditions as gait trainer. In addition to comprehensive rehabilitation program. Intensity: 15-20 min/d, 5 d/wk, 2 wk. Treatment contrast: 0 h.	FAC, MAS, 10MWT max Measured at baseline and 2 wk	The newly developed gait trainer was at least as effective as treadmill therapy with partial body weight support while requiring less input from the therapist.
Popovic et al 2003	5	28 (16/12) High-functioning (HFG): 16 (8/8) Low-functioning (LFG): 12 (6/6)	Age: 59.9±9.3 yr Type: isch/hem Time since onset: 7±2 wk Inclusion: 2 wk - 6 mos post stroke; no ADL dependency prior to stroke, severe medical condition in arm/hand, previous injury/ disease/ contracture affecting arm or hand, electrical lift support devices HFG: actively extend wrist, MCP and IP >20° LFG: extend wrist 10°-20°, extend MCP and IP of thumb and ≥2 digits 10°-20°	Comparison: FES vs. control (C) FES: Conventional therapy introduced by Bobath (26 wk), during first 3 wk exercise assisted with neural posthesis controlling the opening, grasping, and releasing functions by mimicking natural movements. Four channels of ES via self-adhesive surface electrodes on finger flexors, finger extensors, thumb extensor, thenar muscle group. Frequency 50 Hz, pulse duration 200 μs, stimulation intensity 20-45 mA. Try functionally use e.g. toothbrush, comb, telephone receiver, pen, small food, 0.33 L can, 0.33 L bottle, 1 L container, CD for computer, 0.25 L coffee mug. Trigger opening synergy with nonparetic hand at the appropriate time during reaching phase and trigger release function when they accomplished effectively the task of were not able to fulfill the task. Start with easier task, progress to more difficult tasks. As many tasks as possible within one single session. PT comprised ensuring subject held object adequate, when/ how maximize use of externally controlled hand. Sometimes without supervision. C: Conventional therapy, with same tasks as FES group but without neural prosthesis. Intensity: 30 min/d, 7 d/wk, during 3 wk. Treatment contrast: 0 h.	UEFT, drawing test, MAS, RUE/MAL Measured at baseline and 3 wk and 6, 13 and 26 wk (follow-up)	The speed of recovery in FES groups was substantially faster compared with the recovery rate in control groups during the first 3 weeks (treatment). The LFG subject showed less improvement than the HFG in both the FES and control groups.

Eich et al 2004	8	50 (25/25)	Age: 62.4±4.8 yr Type: first isch Time since onset: 6.10±2.2 wk Inclusion: walk ≥12 m with intermittent help or stand-by while walking, BI 50-80, cardiovascular stable	Comparison: Body weight-supported treadmill training (BWSTT) vs. control (C) BWSTT: Graded treadmill training, harness secured and minimally supported (≤15%) according to patients' needs at defined training heart rate (HRmax–HRrest)*0.6HRrest (30 min). If necessary help with setting paretic limb or assisting weight-shifting and hip extension. Warm-up and cool-down period of 1-2 min, optional two short pauses. PT following Bobath approach, including tone-inhibiting and gait preparatory maneuvers, walking practice on the floor and on the stairs. Necessary orthoses and walking aids were provided (30 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. C: PT (60 min). Comprehensive rehabilitation, including PT, OT, speech and neuropsychological therapy. Intensity: 60 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	10MWT maximum, 6MTW, RMA, walking quality Measured at baseline and 6 wk and 6 mos (follow-up)	Aerobic treadmill plus Bobath walking training in moderately affected stroke patients was better than Bobath walking training alone with respect to the improvement of walking velocity and capacity.
Howe et al 2005	6	35 (17/18)	Age: 71.5±10.9 yr Type: first/rec isch/hem Time since onset: 26.5±15.7 d Inclusion: no conditions affecting balance, no 'pusher syndrome'	Comparison: Lateral weight transference exercises (E) vs. control (C) E: Exercises aimed at improving lateral weight transference in sitting and standing based on work of Davies. Including repetition of self-initiated goal-oriented activities in various postures, with manual guidance and verbal encouragement. In addition to usual care, including PT. C: Usual care, including PT. Intensity: 30 min/d, 3 d/wk, during 4 wk. Treatment contrast: 6 h.	Lateral reach sitting, standing up, sitting down, static standing balance Measured at baseline and 4 wk, and 8 wk (follow-up)	A training programme aimed at improving lateral weight transference did not appear to enhance the rehabilitation of acute stroke patients. Improvements observed in postural control in standing and sitting may be attributable to usual care or natural recovery.
Popovic et al 2005	7	13 (5/8)	Age: 57.6±17.5 yr Type: isch/hem Time since onset: 92 d Inclusion: CMSMR 1-2; no skin rash, allergy, wounds, seizure episodes, edema paralyzed arm, shoulder hand syndrome	Comparison: FES vs. control (C) FES: Neuroprosthesis (Compex Motion electric stimulator) to support reaching and grasping with standard self-adhesive surface stimulation electrodes. Start by shoulder and upper arm muscles, then to distal muscles; mm. flexor digitorum superficialis, flexor digitorum profundus, median nerve/m. thenar, flexor pollicis longus, extensor digitorum flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis longus and brevis, extensor carpi ulnaris, biceps, triceps, anterior and posterior deltoid. Functional training program, start with execute task with impaired arm unassisted. Then components/sequences of tasks unable to carry out assisted with neuroprosthesis, controlled by therapist who also guided arm. Reduce assistance weekly or biweekly. Repeat task 20-30 times during session. 25-30 minutes active treatment, 15-20 min donning and doffing. In addition to conventional PT and OT (see below). C: Conventional PT and OT, including muscle facilitation exercises emphasizing NDT approach, task-specific repetitive functional training, strengthening and motor control training using resistance to available arm motion to increase strength, stretching exercises, electrical stimulation applied primarily for muscle strengthening (not FES therapy), ADL, caregiver training. 45 min/d, 3-5 d/wk, during 12-16 wk. Intensity: 45 min/d, 3-5 d/wk, during 12-16 wk. Treatment contrast: 42 h.	FIM, BI, CMSMR, FMA, RELHFT Measured at baseline and discharge	After the treatment program was completed, the patients treated with the neuroprosthesis significantly improved their reaching and grasping functions and were able to use them in ADL However, the majority of the control patients did not improve their arm and hand functions significantly and were not able to use them in ADL.
Ring et al 2005	4	22 (11/11)	Age: 54.1±11.2 yr Type: first isch Time since onset: 3.6 mos Inclusion: less than full active ROM in the involved upper limb	Comparison: Neuroprosthesis vs. control (C) Neuroprosthesis: Single fitting session of NESS Handmaster with 5 surface electrodes, followed by a protocol for home use, to achieve full arc of finger motion, using the modes intermittent finger extension, and alternating finger flexion and extension. Patients with partial active range of motion also used the functional modes for various assigned activities. In addition to rehabilitation program with OT and PT, to improve ADL and neuromuscular re-education using Bobath technique. C: Rehabilitation program with OT and PT, to improve ADL and neuromuscular re-education using Bobath technique. Intensity: Neuroprosthesis: 2x10 min to 3x50 min/d wk 1-2, 3x50 min/d during wk 3-6. Treatment contrast: 2400 min.	Active ROM, MAS, BBT, JTHFT, pain, edema Measured at baseline and 6 wk	Supplementing standard outpatient rehabilitation with daily home neuroprosthetic activation improves upper limb outcomes.

Yan et al 2005	6	41 (13/15/13)	Age: 68.2±7.7 yr Type: first isch/hem Time since onset: 8.7±5.8 d Inclusion: no receptive dysphasia or cognitive impairment (AMT <7)	Comparison: Functional electrical stimulation (FES) vs. placebo (P) vs. control (C) FES: Standard PT (60 min) based on NDT approach, and OT (60 min) focused on ADL. Two dual-channel stimulators with surface electrodes on quadriceps, hamstring, tibialis anterior, medial gastrocnemius. 30Hz, 20-30 mA, activation sequence that mimicked normal gait. P: Standard PT and OT. Electrical stimulation device with disconnected circuit. C: Standard PT and OT. Intensity: FES: 30 min/d, 5 d/wk, during 3 wk. Placebo: 60 min/d, 5 d/wk, during 3 wk. Treatment contrast: FES vs. P: 7.5 h. FES/ P vs. C: 15 h.	CSS, MIVC ankle dorsiflexor and planter-flexors, TUG Measured at baseline, wk 1, 2, 3 and 8 wk (follow-up)	Fifteen sessions of FES, applied to subjects with acute stroke plus standard rehabilitation, improved their motor and walking ability to the degree that more subjects were able to return to home.
Yang et al 2005	6	25 (13/12)	Age: 63.38±7.7 yr Type: first Time since onset: 5.45±3.03 mos Inclusion: Brunnstrom stage 3-4, walk 11 m with or without walking aid or orthosis, stable medical, no comorbidity precluding gait training, no uncontrolled health condition contraindicating exercise, no gait-influencing diseases	Comparison: Backward training (E) vs. control (C) E: Backward walking according to Davies (1990): 1) take step backwards within parallel bars therapist provides assistance to move leg in correct pattern with reducing assistance, 2) subject takes over actively with only slight help, therapist facilitates walking backwards between parallel bars, 3) walk backward actively away from parallel bars, distance and speed of walking progressively increased. In addition to conventional stroke rehabilitation programme (see below). C: Conventional stroke rehabilitation programme, focused on strengthening, function and mobility activities, gait training, gait preparatory training takes approx 20-30% of each sessions time (40 min/d, 3 d/wk, 3 wk). Intensity: 30 min/d, 3 d/wk, during 3 wk. Treatment contrast: 4.5 h.	Walking speed comf, cadence, stride length, gait cycle (time), symmetry index Measured at baseline and 3 wk	This study demonstrated that asymmetric gait pattern in patients post stroke could be improved from receiving additional backward walking therapy.
Katz-Leurer et al 2006	6	24 (10/14)	Age: 59±8 yr Type: first isch Time since onset: <30 d Inclusion: unable to sit for 10 s, unable to stand without support for >1 min, >30 d after acute hospitalization, not unconscious and/or totally incontinent after event, no significant change in blood pressure, no arrhythmia, no heart failure, not receiving beta blockers	Comparison: Cycling (E) vs. control (C) E: Train on electrically powered leg cycle ergometer, at comfortable speed, intensity <40% HRR adjusted for age. Start with short workout periods of 2 min with 1 min rest for up to 10 min, increase to 30 minutes at end of wk 1 and continue following 2 wk. In addition to regular therapy, consisting of PT based on Bobath approach, OT, speech therapy and group activity for general exercise. C: Regular therapy (see above). Intensity: 10-30 min/d, 5 d/wk, during 3 wk. Treatment contrast: 300 min.	PASS total, PASS static, PASS dynamic, FMA LE, FIM total, FIM motor Measured at baseline and 3 wk and 6 wk (follow-up)	These preliminary findings suggest that stroke patients in the subacute stage can improve their motor and balance abilities after an early short duration of cycling training.
Yavuzer et al 2006	6	25 (12/13)	Age: 56.3±7.5 yr Type: first isch/hem Time since onset: 2.4±1.7 mos Inclusion: Brunnstrom stage 1-3, stand and take ≥1 step with or without assistance; no medical contraindication to walking or electric stimulation	Comparison: Electrical stimulation (ES) vs. control (C) ES: ES to tibialis anterior with electrodes close to insertion points. Surge-alternating current, frequency 80 Hz to stimulate muscle contraction, stimulation time 10 seconds (including 2 seconds ramp up, 1 second ramp down), off time 50 seconds. Not volitionally contract muscles during ES. In addition to conventional stroke rehabilitation consisting of NDT, PT, OT, speech therapy. C: Conventional stroke rehabilitation (see above). Intensity: ES 10 min/d, 5 d/wk, during 4 wk. Treatment contrast: 200 min.	Brunnstrom stage leg, walking velocity, step length, % stance phase on paretic side, sagittal plane kinematics (ROM) Measured at baseline and 4 wk	ES of the tibialis anterior muscle combined with a conventional stroke rehabilitation program was not superior to a conventional stroke rehabilitation program alone, in terms of lower-extremity motor recovery and gait kinematics.
Masiero et al 2007	5	35 (17/18)	Age: 63.4±11.8 yr Type: first isch Time since onset: 4.8 (range 3-7) d Inclusion: no early severe spasticity	Comparison: Robotics vs. control (C) Robotics: 3-degree-of-freedom wire-based robot, allowing lying supine in bed or sit in wheelchair, programmed to perform repetitive movements (flexion/extension, adduction/abduction, pronation/supination, circular) of shoulder and elbow. After setting way points (trajectory) voluntarily contributing to movement slowly, motion speed increased according to improvements, verbally encouraged by assistant. 5-7 cycles of each 3 minutes, followed by 1-minute resting period. Visible and auditory feedback by personal computer. In addition to standard rehabilitation	MRC, FMA arm, FIM, TCT, MAS Measured at baseline, 5 wk and 3 and 8 mos (follow-up)	Patients who received robotic therapy in addition to conventional therapy showed greater reductions in motor impairment and improvements in functional abilities.

				based on Bobath. C: Exposure to robot, but exercises with unimpaired arm. Intensity: Robotics: 20-30 min, 25 sessions, 2x/d, 4 h/wk, 5 d/wk, during 5 wk. C: 30 min/d, 2 d/wk, during 5 wk. Treatment contrast: 15 h.		
Yavuzer et al 2007	8	30 (15/15)	Age: 61.9±10.01 yr Type: first isch/hem Time since onset: 3.5±2.1 mos Inclusion: Brunnstrom stage 1-3, stand and take ≥1 step with or without assistance; no medical contraindication to walking or electric stimulation	Comparison: Sensory-amplitude electric stimulation (SES) vs. control (C) SES: SES of common peroneal nerve and belly tibialis anterior muscle. Asymmetric biphasic rectangular stimulation, frequency 35 Hz, pulse width 240 µs, ≈10mA so the patient perceived a mild tingling sensation but below an observable or palpable muscle contraction. Duty cycle of 10 seconds on and 10 seconds off. In addition to conventional rehabilitation, consisting of NDT, PT, OT and speech therapy. C: Placebo SES, machine was turned on but without stimulation. In addition to conventional rehabilitation (see above). Intensity: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	Brunnstrom stage leg, walking velocity, step length, % stance phase on paretic side, sagittal plane kinematics (ROM) Measured at baseline and 4 wk	In our patients with stroke, SES of the paretic leg was not superior to placebo in terms of lower-extremity motor recovery and gait kinematics.
Bakhtiary et al 2008	8	40 (20/20)	Age: 55 (range 42-65) yr Type: ?? Time since onset: ?? Inclusion: ankle plantarflexor spasticity	Comparison: Combination (Bobath + electrical stimulation (ES)) vs. control (C) ES: Start with infrared on lower extremity (10 min) at distance of 50 cm to warm up limbs. Bobath inhibitory techniques (15 min) of passive movement of ankle joint dorsiflexion, knee joint extension, abduction and external rotation of hip joint. In addition neuromuscular electrical stimulation of m. tibialis anterior muscle (9 minutes) of supramaximal muscle stimulation (100 Hz, pulse duration 0.1 ms), 4 seconds on, 6 seconds off. C: Infrared and Bobath as above. Intensity: ES: 9 min/d, 20 sessions. Treatment contrast: 180 min.	MAS, ankle joint dorsiflexion ROM, dorsiflexor strength, soleus muscle H-reflex Measured at baseline and post-intervention	Therapy combining Bobath inhibitory technique and electrical stimulation may help to reduce spasticity effectively in stroke patients.
Dechaumont-Palacin 2008	3	13 (7/6)	Age: 64±12 yr Type: first Time since onset: 17±8 d Inclusion: supcortical lesion in pyramidal tract	Comparison: Passive wrist movement (E) vs. control (C) E:. Passive proprioceptive extension of the impaired wrist (20 min, 1 Hz, aplitude 60°). Patients were told to relax their arm to ensure a passive movement. Starting position of the paretic wrist was neutral , the hand sustained by the PT, arm along body. Patients were awake but not asked to attend or to focus on the passive movement. Standard rehabilitation according to Bobath's procedure (see below). C: Standard rehabilitation according to Bobath's procedure favoring stimulation of the proximal part of the limbs when the patient had no movement of the distal part. Intensity: 5 d/wk, during 6 wk. Treatment contrast: 0 h.	fMRI, NIHSS, BI, MAS Measured at baseline and 4 wk	We have demonstrated that purely passive proprioceptive training applied for 4 weeks is able to modify brain sensorimotor activity after a stroke.
Gok et al 2008	6	30 (15/15)	Age: 55.1±11.4 yr Type: first isch/hem Time since onset: 460.0±90.4 d Inclusion: ability to stand without assistance ≥1 min, no condition affecting balance, no neglect, no impaired vision, no medical contraindication to exercise	Comparison: Kinaesthetic ability trainer (KAT) vs. control (C) KAT: Stand with boot feet on feedback platform without holding on to handrails, shift weight forward, backward, left or right in order to keep cursor on monitor central (static pattern) or follow moving cursor (dynamic pattern). In addition to conventional stroke rehabilitation consisting of NDT techniques, PT, OT and speech therapy (2-3 h/d, 5 d/wk, 4 wk). PT focused on positioning, postural control, ROM and progressive resistive exercises, endurance, gait in which elements of Brunnstrom's movement therapy, Bobath NDT and PNF techniques were combined. C: Conventional stroke rehabilitation (see above). Intensity: 20min/d, 5 d/wk, during 4 wk. Treatment contrast: 400 min.	FIM motor, FIM locomotion, FMA leg, FMA balance, KAT balance index static, KAT balance index dynamic Measured at baseline and 4 wk	Kinaesthetic ability training in addition to a conventional rehabilitation programme is effective in improving balance late after stroke. However, this improvement is not reflected in individual functional status.
Thrasher et al 2008	6	21 (10/11)	Age: 57±14.7 yr Type: ?? Time since onset: 29.8±11.8 d Inclusion: CMSMR 1-2 for arm/hand (spastic or	Comparison: FES vs. control (C) FES: 4 pairs of surface electrodes in neuroprosthesis, near maximal contraction, participant performed task voluntarily and stimulation only used to assist the movement that the patient was unable to perform with stimulation lasting 1-3 seconds, timing controlled by therapist. Phase 1: forward reaching motion, nose reaching motion, shoulder abduction followed by elbow extension. Each task >5	RELHFT (objects, blocks, grip torque, pinch force, eccentric load), FIM, BI, CMSMR, FMA arm Measured at baseline and 14	FES therapy with upper extremity training may be an efficacious intervention in the rehabilitation of reaching and grasping function during acute stroke rehabilitation.

			flaccid paralysis of arm and hand, with little or no voluntary movement)	minutes, multiple times (20-30), each task during each session. After successful completion go to Phase 2: grasp and release function in functional training. In early stages all movements were performed with help of FES, later FES was used less and only to help particular movements. During task execution, therapist manually guided arm. Conventional OT and PT consisting of muscle facilitation exercises emphasizing NDT approach, task-specific repetitive functional training, strengthening and motor control training using resistance, electrical stimulation applied primarily for isolated muscle strengthening (not for functional training), ADL, caregiver training. <u>C</u>: Conventional OT and PT as FES group. <u>Intensity</u>: FES: 45 min/d, 5 d/wk, during 12-16 wk, including additional conventional but of shorter duration than controls. C: 45 min/d, 5 d/wk, during 12-16 wk. <u>Treatment contrast</u>: 0 h.	wk	
Yavuzer et al 2008	7	40 (20/20)	Age: 63.2±9.2 yr Type: first isch/hem Time since onset: 5.4±2.9 mos Inclusion: FMA arm I-IV, <12 mos post stroke; no severe cognitive disorders	<u>Comparison</u>: Mirror therapy (MT) vs. control (C) <u>MT</u>: Nonparetic-side wrist and finger flexion and extension movements while patients looked into the mirror, watching the image of their noninvolved hand. Asked to try to do the same movements with the paretic hand while they were moving the nonparetic hand. In addition to conventional program consisting of NDT, PT, OT, speech therapy. <u>C</u>: Same exercises but used the nonreflecting side of the mirror in such a way that the paretic hand was hidden from sight. <u>Intensity</u>: Conventional program: 2-5 h/d, 5 d/wk, during 4 wk. MT/C: 30 min/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.	FMA arm, MAS, FIM self-care Measured at baseline, 4 wk and 6 mos (follow-up)	Hand function improved more after mirror therapy in addition to conventional rehabilitation program compared with a control treatment immediately after 4 wk of treatment and at the 6-month follow-up, whereas mirror therapy did not affect spasticity.
Yavuzer et al 2008	7	20 (10/10)	Age: 58.1±10.2 yr Type: first isch/hem Time since onset: 3.3±3.3 yr Inclusion: FMA arm I-IV	<u>Comparison</u>: Virtual reality (VR) vs. control (C) <u>VR</u>: 'Playstation EyeToy' games consisting of flexion and extension of paretic shoulder, elbow and wrist, and abduction of the paretic shoulder. Encouraged to use paretic arm while playing. In addition to conventional rehabilitation (i.e. NDT, PT, OT, if necessary speech therapy). <u>C</u>: Based on mental practice treatment, watching games for same duration but did not involve into the games physically. In addition to conventional rehabilitation (i.e. NDT, PT, OT, if necessary speech therapy). <u>Intensity</u>: conventional rehabilitation: 2-5 h/d, 5 d/wk, during 4 wk. VR/C: 30 min/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.	FIM, FMA arm Measured at baseline, 4 wk and 3 mos	'Playstation EyeToy Games' combined with a conventional stroke rehabilitation program have a potential to enhance upper extremity-related motor functioning in subacute stroke patients.
Doğan-Aslan et al 2010	5	61 (30/31)	Age: 57.90±13.32 yr Type: isch/hem Time since onset: 199.30±222.22 d Inclusion: none concerning upper extremity functioning	<u>Comparison</u>: EMG biofeedback (BF) + conventional vs. conventional (C) <u>EMG-BF + conventional</u>: Spasticity treatment involving NDT methods, conventional methods, and verbal encouragement to 'relax' spastic wrist flexor muscles. EMG biofeedback applied on spastic wrist muscles hemiplegic upper extremity, muscle activity shown on computer monitor as auditory and visual signs. <u>C</u>: Passive and active movements and mobilization, PNF, stretching affected upper extremity. <u>Intensity</u>: EMG-BF: 20 min/d, 5 d/wk, during 3 wk. <u>Treatment contrast</u>: 300 min.	MAS, FMA arm, upper extremity function test, AROM wrist extension, BI Measured at baseline and 3 wk	Statistically significant greater improvements in FMA arm and BI in EMG-BF group compared to conventional therapy.
Fil et al 2011	5	62 (31/31)	Age: 66.79±9.40 yr Type: first isch/hem Time since onset: <2 d Inclusion: full ROM shoulder, no motor movement in the arm without incrase of tonus in the muscles surrounding the shoulder, subluxation not surpassing 9.5 mm	<u>Comparison</u>: Electrical stimulation (ES) vs. control (C) <u>ES</u>: ES to mid portion of deltoid muscle, supraspinatus and posterior portion deltoid, automatic pulse rate 100 µsn, frequency 60 Hz/s, stimulation 5 seconds on, 5 seconds off, voltage until visible contraction. In addition to flaccid stage physiotherapy based on Bobath concept, including arm positioning, head-neck and scapula mobilization, bilateral arm elevation, bilateral elbow flexion-extension, crossing midline, normal joint movements for elbow, wrist and shoulders, load transfer to arm in sitting position. In unconscious patients: positioning, head-neck scapula mobilization and upper extremity movements. Informing allied health personnel and relatives of patients about shoulder protection strategies.	Shoulder subluxation, MAS* Measured at baseline and discharge	Electrical stimulation in combination with Bobath technique is an efficient method for preventing shoulder subluxation in acute stroke patients.

				<u>C</u>: Physiotherapy based on Bobath concept as above. <u>Intensity</u>: 2x 10 min/d, 7 d/wk, during 11.66±1.88 d. <u>Treatment contrast</u>: 233.2 min		
Heidari et al 2011	6	16 (9/7)	Age: 57.7±6.85 yr Type: ?? Time since onset: 18.4±3.71 mos Inclusion: >6 mos post stroke, MAS wrist >1; no active movements out of flexor or extensor synergy pattern at wrist-hand complex, joint contracture, pathologic conditions involved upper extremity not related to stroke, previous splinting and Botox <6 mos	<u>Comparison</u>: Splint vs. control (C) <u>Splint</u>: Dorsal dynamic splint, first part light short cock-up splint of aluminum material covered with foam to position wrist and thumb MCP joints in 10° extension and 45° palmar abduction. Second part was finger pan made of low temperature material placed on palm of fingers with two straps passed over the dorsum of the IP joints and lucked them in full extension. Two parts connected via tow mechanical joints at MCP which allowed finger movements only in the MCP joints and a dorsal outrigger made of two metal wires. Actively flex fingers from extension position against outrigger tension. In addition to therapy according to Bobath concept. <u>C</u>: Therapy according to Bobath concept. <u>Intensity</u>: Splint 5 d/wk, 6 h/d, during 8 wk; including 2x/d 15 min finger exercise. <u>Treatment contrast</u>: 240 h.	MAS, Hoffmann reflex (Hmax/Mmax ratio) m. flexor carpi radialis, FMA wrist and finger Measured at baseline and 8 wk and 10 wk (follow-up)	Using a dynamic splint for the paretic hand following stroke could have positive functional outcomes in selected patients.
Park et al 2011	6	25 (13/12)	Age: 59.38±8.46 yr Type: isch/hem Time since onset: 28.08±12.59 mos Inclusion: 6 mos – 5 yr post stroke, walking speed <0.7 m/s, no auditory or visual deficits, no conditions that may interfere with study	<u>Comparison</u>: Community training (E) vs. control (C) <u>E</u>: Community-based ambulation training, consisting of four phases in various community situations, increasing distance covered and environmental demands. In addition to functional training based on Bobath, consisting of standing up from sitting, guided movement of trunk and lower limb to simulate normal walking, forward and backward stepping, stair climbing (1 h/d, 5 d/wk). <u>C</u>: Functional training (see above), no specific walking training. <u>Intensity</u>: 1 h/d 3 d/wk, during 4 wk. <u>Treatment contrast</u>: 12 h.	10MWT max, 6MWT, community walk test, walking ability questionnaire, ABC Measured at baseline and 4 wk	The findings demonstrate that community-based ambulation training can be helpful in improving walking ability of patients with poststroke hemparesis and may be used as a practical adjunct to routine rehabilitation therapy.
Patil et al 2011	2	16 (8/8)	Age: ?? Type: first Time since onset: >6 mos Inclusion >6 mos, Brunnstrom stage 3-5, ambulatory	<u>Comparison</u>: Thera-Band elastic resistance-assisted gait training (E) vs. control (C) <u>E</u>: Thera-band Elastic Resistance Assisted Gait training with a special technique of the Thera-band wrapped around the distal foot, lower leg, back of the knee and front of the tigh to assist in the swing phase, foot placement in stance phase, dorsiflexion and eversion. Therapist continues to guard the patient by holding the gait belt, opposite hand free to manage the resistive band. In addition to OT (see below). <u>C</u>: Gait activities working on different phases of gait or walking with assistance of the therapist. OT based on NDT techniques: preparation, facilitate movements, weight bearing unaffected leg, pelvic tilts, trunk rotations, bridging, activities for isolated movements (45 min/d, 3 d/wk, during 6 wk). <u>Intensity</u>: 15 min/d, 3 d/wk, during 6 wk. <u>Treatment contrast</u>: 0 h.	WGS, RMI Measured at baseline, 3 and 6 wk	The use of Thera-Band Elastic Resistance-Assisted Gait Training contributed to faster recovery as compared to the control group. Functionally patients showed improvement as compared to conventional therapy.
Chang et al 2011	6	37 (20/17)	Age: 55.5±12.0 yr Type: first isch/hem Time since onset: 16.1±4.9 d Inclusion: <1 mos post stroke, FAC <2; not meet criteria for contraindications by ACSM, Lokomat, no musculoskeletal disease lower limb	<u>Comparison</u>: Gait trainer (GT) vs. control (C) <u>GT</u>: Gait training using Lokomat. Levels of body-weight support, treadmill speed and guidance force were adjusted for maintenance of the knee extensor on the weak side during stance phase. BWS decreased from 40-0% and guidance force from 100-0%. Speed start at 1.2 km/h, increased to 0.2-0.4 km/h per session to max 2.6 km/h. Also motor power, muscle tone, gait coordination and gait quality were considered. In addition to conventional PT session (see below; 60 min). <u>C</u>: Conventional therapy based on NDT techniques. Patients with poor function began with sitting and standing balance training, active transfer, sit-to-stand training, strengthening exercise. As function improved, functional gait training with device, dynamic standing balance while continuing strengthening exercises. <u>Intensity</u>: actual training time 40 min/d, 5 d/wk, during 2 wk. <u>Treatment contrast</u>: 0 h.	VO_2 peak, RER at peak, cardiovascular response (HR rest, HR peak, Peak O_2 pulse, systolic blood pressure, diastolic blood pressure, RPE, V_E peak, VE vs. VCO_2 slope), FMA leg, MI leg, FAC Measured at baseline and 2 wk	Patients can be trained to increase their VO^2 and lower-extremity strength using a robotic device for stepping during inpatient rehabilitation. This training has the potential to improve cardiopulmonary fitness in patients who are not yet independent ambulators, but that may require more than 2 weeks of continued, progressive training.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Stern et al. 1970	RCT	62 (31 / 31) with completed stroke and hemiplegia	mean: ? range 38-84y.	type: iCVA post-acute: median 1mo after stroke, range 8d-5y	No	Intervention: additional PNF and Brunstromm vs conventional PT E: exercise group: additional PNF and Brunnstrom and same exercises as C C: no 'specialized' therapeutic exercises, but heat and cold modalities, PROM and ambulation Intensity: daily E>80 min and C 40 min during 59 d	Motility Index, ADL-score (KRISCE) and strength measured at end of treatment	Facilitation exercises do not significantly improve the motility and strength deficits in these patients, because both groups showed comparable improvement.	4 failure at the questions: *3,5,6,7,8,9*
Logigian et al. 1983	RCT	42 (21 / 21)	mean: 61.6 y ± 21 y	type: all chronic : mean 4.8 y ± 8.2 y. after stoke, range 6 mo-26 y.	Yes	Intervention: facilitation techniques (Rood and Bobath) vs traditional techniques E : based on facilitation approach (Rood and Bobath): include bilateral weight bearing, reflex inhibiting and tactile, vestibular and vibratory stimulation C: based on traditional approach (Kendall, Clayton and Coulter) treatment techniques include resistive exercises upper limb skateboards and pulleys. Intensity: 1 – 1.5 hrs/day in addition to other program involvements, plus all patients ½ hrs/d ROM-group. Treatment until patients functional + motor performan-ce stabilized, so weeks of treatment are variable	BI and MMT measured at start and (variable) end	Both facilitation and traditional exercise therapies improved functional and motor performance but there were no significant differences between the approaches.	3 failure at the questions: *3,4,5,6,7,8,9*
Basmajian et al. 1987	RCT	29 (13 / 16) with some ability to extend the wrist and fingers	mean: 62 ± 10 y., range 39-79y.	type: first stroke post-acute: mean 16 wk ±9.2 wk after stroke, range 4-44wk	Yes	Intervention: biofeedback therapy vs Bobath E: cognitive behavioral model (biofeedback). During skill acquisition EMG feedback goals are learned C: traditional PT based on Bobath exercises Intensity: 45 min at 3 d/wk for 5 wk	UEFT and finger oscillation test measured at 5 wk and after 9 mo (follow up)	No statistically significant superiority of one therapy over the other	5 failure at the questions: *3,5,6,8,9*
Jongbloed et al. 1989	RCT	90 (43 / 47) with weakness in UE and LE of affected side	mean: 71.3 y ± 9.1y	type: first stroke post-acute: mean 40 d. ± 42 d. after stoke	Yes	Intervention: OT sensorimotor integrative treatment approach vs traditional functional OT-approach E: approach based on combination of theories described by Bobath, Rood and Ayres, and emphasizes treating the cause of dysfunction rather than compensating or adapting the problem C: practice of particular tasks, usually ADL subdivided into: compensation and adaptation. Also splinting. Intensity: both groups for 40 min/d, 5 d/wk for 8 wk	BI, meal preparation and 8 subtests of SITB measured at 4 and 8 weeks after admission	No statistical significant differences between both treatment groups. , OT can on basis of the findings	3 failure at the questions: *3,4,5,6,8,9, 11*
Poole et al. 1990	RCT	18 (9 / 9) were able to imitate movements and/or follow commands	mean: 70 y., range 55-82y.	type: ? time since onset stroke: ?	No	Intervention: traditional OT + inflatable splints (Johnstone) vs traditional OT + no splinting E: inflatable pressure splints and shoulder exercises (elevated to 90 degrees shoulder flexion with full elbow extension and as much shoulder external rotation as possible without pain. C: not specified therapy (no inflatable splint treatment) Intensity: 5 d/wk for 30 min/d during 3 wk	FMA, pain and sensation measured at 3 wk after start treatment	No significant differences in mean change in upper extremity sensation, pain and motor function from week o to week 3 between the splint and non-splint groups.	5 failure at the questions: *3,5,6,7,9*

Gelber et al. 1995	RCT	27 (15 / 12) with pure motor stroke	mean: 71.8 y ± 9.1y	type: iCVA sub-acute: mean 13 d ± 2 d. after stoke	Yes	Intervention: NDT approach vs traditional functional retraining approach. E:NDT-approach:included tone inhibition and weight-bearing activities and encouraged patients to use the affected side; no resistive exercises and use of abnormal reflexes. C: traditional functional retraining approach, included PROM, progr. resistive exercises, early use of assistive devices+ bracing and allowed patients to use their unaffected side. Intensity: interventions for the duration of inpatient and outpatient rehabilitation.	FIM, BB and NHPT measured at discharge and 6 and 12 mo after stroke	Both treatments are equally efficacious in treating pure motor hemiparetic strokes in terms of functional outcomes, gait measures and upper extremity motor skills.	4 failure at the questions: *3,4,5,6,7,9*
Langhammer & Stanghelle 2000	RCT	61 (33 / 28) and 53 (29 / 24) completed the study (13% drop-outs)	mean: 78y. ± 9y, range 49-95y	type: first-ever stroke acute: mean ?	Yes	Intervention: Bobath vs MRP E: treatment in a 'Bobath-manner' C: treatment in a 'MRP-manner' Intensity: 5 d/wk for a minimum of 40 min/d as long as they were hospitalised	Motor Assessment Scale, SMES, BI, NHP, LOS, use assistive devi-ces and accommodation after discharge from hospital measured at baseline, 2 wk after baseline and 3 mo after onset stroke	Physiotherapy using the MRP is preferable to that using the Bobath programme in the acute rehabilitation of stroke patients	6 failure at the questions: *3,5,6,9*
Mudie et al. 2002	RCT	40 (10/ 10/ 10/ 10) with asymmetry in sitting 33 (8/ 10 / 9/ 6) at 2 wk follow up (17% drop-outs)	mean: 72.4 y ± 9 y, range 47-86 y	type: all subacute: mean 2-6 wk after stroke	Yes	Intervention: retraining sitting symmetry after stroke with 3 treatment groups vs a no specific control group E1) reaching with visual feedback training at balance platform while sitting E2) task-specific reach (max. 140% of arm length) to both sides with feet flat on the floor and E3) Bobath-training; verbally and manually facilitated by therapist during seated reaching C: the same standard PT and OT as did the 3 treatment groups received Intensity: 5d/wk, 30 min during 2 wk	Mean balance (percentage of total body weight), BI measured each treatment session and at 2 and 12 wk after ending treatment	These preliminary findings suggest that it might be possible to restore postural symmetry in sitting in the early stages of rehabilitation with therapy that focuses on creating an awareness of body position	5 failure at the questions: *3,5,8,9,11*

RCTs investigating Bobath (enhanced)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
GAPS 2004	8	70 (35/35)	Age: 68±11 yr Type: first Time since onset: 22±14 d Inclusion: sitting balance, no uncontrolled diseases	Comparison: Augmented PT (E) vs. control (C) E: Additional physiotherapy input to double total daily PT, broadly based on Bobath approach. Specific objectives including independent dynamic sitting balance, standing balance, upper limb function, walking, other functional mobility tasks. C: Conventional PT, broadly based on Bobath approach (see above). Intensity: E: 60-80 min/d, 5 d/wk (received: 43 sessions 95% CI 35-51, 62 min/d, total 34 h). C: 30-40 min/d, 5 d/wk (received: 32 sessions 95% CI 24-40, 35 min/d, total 21 h). Treatment contrast: 135 min/wk.	Mobility milestones, RMI, BI, NEADL, EuroQoL Measured at baseline and 1, 4 wk, 3, 6 mos	A modest augmented physiotherapy programme resulted in patients having more direct physiotherapy time and being more active. The inability to show statistically significant changes in outcome measures could indicate either that this intervention is ineffective or that our study could not detect modest changes.
Platz et al 2005	8	60 (20/20/20)	Age: 60.6±10.5 yr Type: first isch Time since onset: 6.5±3.9 wk Inclusion: FMA UE 5-34, 3 wk to 6 mos post stroke, no contractures of arm joints	Comparison: Augmented exercise therapy as Bobath (AETT Bobath) vs. AETT BASIS training vs. control (C) AETT Bobath: Bobath approach with emphasis on control of muscle tone and recruitment of arm activity in functional situations with various positions. In addition to usual standard rehabilitation therapy (see below). AETT BASIS: Systematic repetitive technique training all degrees of freedom of the arm across full ROM, encouraging selective dynamic movements. Stages: 1) selective innervation for isolated motions without postural control; 2) selective innervation for isolated motions with postural control; 3) selective innervation for complex motions with postural control. In addition to usual standard rehabilitation therapy (see below). C: Standard rehabilitation therapy, addressing e.g. ADL, arm activities, stance, gait, speech and cognition. Intensity: 45 min/d, 5 d/wk, during 4 wk. Treatment contrast: 900 min.	FMA arm, FMA sensation, FMA joint, ARAT, MAS Measured at baseline and 4 wk	The augmented exercise therapy time as Arm BASIS training enhanced selective motor control. Type of training was more relevant for recovery of motor control than therapeutic time spent.

RCTs investigating motor learning (paragraaf B.5)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Chan et al 2006	6	52 (26/26)	Age: 53.8±15.4 yr Type: first isch/hem Time since onset: 117.7 d Inclusion: no specific	Comparison: Motor relearning vs. control (C) Motor relearning: Programme consisting of 4 steps: 1) identification of missing performance components; 2) training using remedial exercises, 30 minutes; 3) training using functional task components, 30 minutes; 4) transfer of skills to functional task performance, 60 minutes. Progressing from sitting to standing position, static to dynamic balancing. In total 24 remedial tasks and 10 functional tasks. In addition to PT (see below). C: Skill training with same remedial and functional tasks and progression, but patients were not involved in identifying their own problems and relation between remedial tasks and entire functional task was not reinforced. In addition to PT in the form of lower limb strengthening and trunk balance exercises depending on the need. Intensity: 2 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	BBS, TUG, FIM, Lawton IADL, CIQ Measured at baseline, 2, 4 and 6 weeks	The motor relearning programme was found to be effective for enhancing functional recovery of patients who had a stroke. Both 'sequential' and 'function-based' concepts are important in applying the motor relearning approach to the rehabilitation of stroke patients.
Cirstea et al 2006, 2007	7, 5	37 (14/14/9)	Age: 55.7±15.4 yr Type: first dominant hemisphere Time since onset: 12.1±4.9 mos Inclusion: CMMSA ≥2	Comparison: Knowledge of results (KR) vs. Knowledge of practice (KP) vs. control (C) KR: Supervised movement repetition, make movements (arm movement to remembered target; 75 trials) as and precisely as possible, practice movement without vision. Terminal visual feedback about movement precision in 20% of trials: participants opened their eyes and corrected finger position closer to the final target. KP: Supervised movement repetition, make movements (arm movement to remembered target; 75 trials) as and precisely as possible, practice movement without vision. Concurrent verbal feedback about joint motion (shoulder flexion, elbow extension) during movement, in faded schedule: first 25 trials every trial, second 25 trials every second trial, last 25 trials every fifth trial. C: Same protocol in terms of repetition intensity, but they practiced finger/hand tapping Intensity: 1 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	FMA arm, composite spasticity index, TEMPA, neuropsychological tests, MRI, kinematics Measured at baseline, 2 wk and 1 mos (follow-up)	Use of KP during repetitive movement practice resulted in better motor outcomes. Stroke severity together with cognitive impairments are important factors choosing motor rehabilitation interventions after stroke. In stroke survivors, when the learners' attention was directed to the movements themselves (KP), motor improvements reflect recovery compared to when attention was directed toward movement outcomes (KR).
Ertelt et al 2007	4	16 (8/8)	Age: 57.16±8.73 yr Type: first isch MCA Time since onset: 1472.9±1258.8 d Inclusion: moderate paresis arm	Comparison: Action observation vs. control (C) Action observation: Watch 6-minute video sequences containing daily life hand and arm actions, followed by 6-minute repetitive practice of observed actions. Each action presented twice during training. While watching TV not allowed to move hands/arms. Every day three hand and/or arm movements of increasing complexity were presented, every day another. C: Watched sequences of geometric symbols and letters. Followed by practice of hand and arm actions like the experimental group. Intensity: 18 sessions, 5 d/wk, during 2.5 wk. Treatment contrast: 0 h.	FAT, WMFT, SIS, fMRI Measured at baseline, post intervention and 6 wk (follow-up)	Action observation has a positive additional impact on recovery of motor functions after stroke by reactivation of motor areas, which contain the action observation/ action executing matching system.
Gilmore et al 2007	4	19 (5/5)	Age: 72.0±14.11 yr Type: first Time since onset: 3.9±2.41 wk Inclusion: hemiparesis with no functional use of affected upper extremity	Comparison: Videotape feedback (V) vs. control (C) V: Donning socks and shoes for max 10 sessions, treatment considered successful and stopped if participant was able to independently don socks and shoes prior to 10 sessions. Therapist demonstrated whole task while participant watched. Followed by donning socks 3 times. Idem for donning shoes. Treatment sessions were videotaped. KP and KR verbal feedback after each practice performance augmented with feedback from videotape replay. Previous session's feedback was reviewed before beginning a session. C: As above, but only KP and KR verbal feedback after each practice. Previous	KB-ADL sock, KB-ADL shoe, COPM Measured at baseline and after each session	There was no significant difference between the two groups and both groups improved. However, the group that received videotape feedback thought they performed better and were more satisfied with their ability to don shoes.

				session's feedback was reviewed before beginning a session. Intensity: 6-10 sessions. Treatment contrast: ?? (assumed to be 0 h).		
Mount et al 2007	2	33 (16/17)	Age: 63±12 yr Type: ?? Time since onset: 21±19 d Inclusion: physical and perceptual ability to complete task with verbal instruction	Comparison: Trial and error learning (TEL) vs. errorless learning (EL) while performing 2 tasks: prepare wheelchair for transfer and putting on a sock with a sock-donner, each divided in 5 steps. TEL: Permitted to make errors during task seqarmnce, but with progressively more specific verbal cues to correct the errors. 1st error: told an error was made and subject try again to complete the step. 2nd error: multiple-choice carm, 3rd error: directed clarm what part needed to be addressed to complete the step, 4th error: hand-over-hand assistance with verbal cues. EL: Not to attempt to perform the next step unless he was confident that he was correct. In case of uncertainty ask therapist to show correct step, followed by hand-over-hand instruction with verbal cues. If a subject started to make an error the therapist would as quickly as possible stop the subject and provide hand-over-hand instruction with verbal cues. Intensity: ≤7 d. Treatment contrast: ??	Days to demonstrate retention of the task. Carry-over task that was similar to original task. Measured when patient was able to correctly complete a task on two consecutive trials without any physical assistance or verbal cues and prior to any instruction on that day.	When choosing the best learning method for patients undergoing rehabilitation for stroke, the nature of the task should be considered. Additional research is needed to identify the best approach for teaching activities of daily living and facilitating carry-over of learning in individuals with acute stroke.
Boyd et al 2010	5	18 (9/9)	Age: 62.7 yr Type: ?? Time since onset: >6 mos Inclusion: >6 mos post stroke; no neglect, aphasia, hemianopsia, dementia	Comparison: Task-specific training vs. control (C) Task-specific training: Serial targeting task (ST) with non-ferrous joystick, when cued, participants made flexion/extension movements of stroke-affected elbow and shoulder to guide a cursor to one of three 2 cm targets located equidistant (10 cm), held cursor inside highlighted target for 5000 ms before being cued to return to home. Respond as fast and accurately as possible. Alternate between responding to a repeated sequence of targets (8-elements long; 320 responses) and random sequences (80 responses). 400 movements/d. C: Increased use of hemiparetic arm not specific to the serial targeting task, but also relied on elbow and shoulder flexion/extension: equidistant movements to three targets to accomplish bean-bag pushing, cone stacking and erasing; movement excursion restrained to maintain similarity with ST task with 400 movements/d. Intensity: 400 rep/d, 3 d. Treatment contrast: 0 h.	fMRI (mean reaction time, movement time) Measured at baseline and 5 d	Task-specific motor learning may be an important stimulation for neuroplastic change and can remediate maladaptive patterns of brain activity after stroke.
Ausenda et al 2011	6	20 (10/10)	Age: 65.1±13.6 yr Type: first isch/hem Time since onset: 148.6±308.9 d Inclusion: active extension wrist, MCP, IP ≥10°, active movement repeated ≥3 times, passive shoulder abduction and flexion ≥90°, extrarotation ≥45°, limitation elbow extension ≤30°, passive supination forearm ≥45°, passive extension wrist and fingers to not cause flexion of MCP ≥30°.	Comparison: Experimental (E) vs. control (C) E: Repeat NHPT 10x/d with healthy hand with carefully and paying attention to the various parts of the movement. C: No intervention. Intensity: 10x/d, during 3 d. Treatment contrast: 10x/d, during 3 d.	NHPT, Sollerman's test (items) Measured at baseline and 3 d	This is the first evidence that bilateral transfer of motor skills is present in patients that suffered a stroke, and that it improves the ability of the affected hand.

RCTs investigating telerehabilitation (upper extremity) (paragraaf B.6)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)

Carey et al 2007	3	25 (13/12)	Age: 65.9±7.4 yr Type: isch Time since onset: 42.5±24.3 mos Inclusion: ≥90° passive and ≥10o active extension-flexion MCP index finger	Comparison: Tracking (Track) vs. moving (Move) Track: Finger and wrist tracking training in own homes, independent of any direct supervision. Equipment consists of laptop computer with customized tracking software. First trial supervised and perform 5-6 trials to familiarize with training. Wear custom-made electrogoniometer braces to each hand, forearms resting on chair's armrest, perform 180 tracking trials per day (e.g., square, sawtooth left, sawtooth right, triangle; frequency 0.2, 0.4, 0.6 Hz; duration 5, 10, 15 seconds; peak flexion amplitude 0, 15 or 30% of active ROM; peak extension amplitude 70, 85 or 125% active ROM), divided in 60 different blocks with 3 consecutive trials completed over 2-8 h depending on rest breaks. Paretic hand used 90% of the blocks, nonparetic hand in 10%. Index finger 50%, wrist 50%. Hand position was varied. KR provided during pause and et end of each trial with computer-calculated accuracy score. KP presented less frequently and faded, computer-generated text comment describing a feature to correct in the tracking behavior. Teleconferencing via cellular phone and web camera 5 times. Therapist had a pager in case patient had specific questions. Move: Finger and wrist moving training in own homes with set-up as tracking group. During a trial, the screen showed a sweeping cursor but did not show a target or response, no KR or KP was provided. Motivational comments were provided with same frequency, but not based on prior performance. Intensity: 10 d. Treatment contrast: 0 h.	BBT, JTHFT, ROM, fMRI Measured at baseline and 10 d	Telerehabilitation may be effective in improving performance in subjects with chronic stroke. Tracking training with reinforcement to enhance learning, however, did not produce a clear advantage over the same amount of practice of random movements.
Huijgen et al 2008	5	12 (9/3)	Age: 69±8 yr Type: ?? Time since onset: 3.0±12.6 yr Inclusion: NHPT >25 s, ≥1 peg NHPT <180 s, internet connection, living at home, no major visual problems, no problems contra-indicating autonomous exercise at home	Comparison: Home activity care desk (HCAD) vs. control (C) HCAD: Usual care (1 mos), followed by 4 training sessions with HCAD and 1 mos training at home. Hospital-based server and portable unit with seven sensorized tools. Exercises such as reaching, grasping, lateral pinch, pinch grip, holding, manipulation, finger dexterity. Two webcams for videoconferencing and recording. PT used infos for weekly videoconference with patient. C: Usual care and generic exercises prescribed by physician. Intensity: 30 min/d, 5 d/wk, during 1 mos. Treatment contrast: ??	ARAT, NHPT, VAS user satisfaction Measured at baseline, 1 mos (usual care) and 2 mos (HCAD)	A telerehabilitation intervention using HCAD may increase the efficiency of care.
Piron et al 2008	6	10 (5/5)	Age: 53±15 yr Type: isch Time since onset: 10±3 mos Inclusion: mild-intermediate arm motor impairment	Comparison: Tele-virtual reality (Tele-VR) vs. VR Tel-VR: Virtual reality equipment, consisting of 3D motion tracking system, computer screen, ISDN-connection at data rate of 128 kbit/s. PT created seqarmnce of virtual tasks. Visual feedback (i.e. knowledge of performance, knowledge of results). Patient-PT interaction facilitated by videoconferencing unit beside telerehabilitation equipment. Patients and relatives briefly trained to operate system, equipment was controlled from remote hospital workstation. VR: Same VR training but with presence of PT in hospital setting. Intensity: 1 h/d, 7 d/wk, during 1 mos. Treatment contrast: 0 h.	Patient satisfaction, FMA arm Measured at baseline and 1 mos	Patients assigned to the Tele-VR group were able to engage in therapy at home and the videoconferencing system ensured a good relationship between the patient and the physical therapist whose physical proximity was not required.
Piron et al 2009	7	36 (18/18)	Age: 66.0±7.9 yr Type: first isch Time since onset: 14.7±6.6 mos Inclusion: not defined	Comparison: Virtual reality (VR) vs. control (C) VR: Telerehabilitation system. Receiver attached to real object, with which 5 virtual tasks have to performed, following trajectory of corresponding virtual object displayed on computer screen. KP by info about movement, KR by giving reward. Therapist provided feedback through videoconference tool. C: Conventional PT for upper extremity with strategy of progressive complexity. First control isolated motions without postural control, then postural control included, finally complex motion with postural control. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA arm, MAS, ABILHAND Measured at baseline, 4 wk and 1 month (follow-up)	Both strategies were effective, but the experimental approach induced better outcomes in motor performance. These results may favor early discharge from hospital sustained by a telerehabiliation programme, with potential beneficial effects on the use of available recourses.

RCTs investigating inspiratory muscle training (paragraaf E.5.3)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Sutbeyaz et al 2010	7	45 (15/15/15)	Age: 60.8±6.8 yr Type: first isch/hem Time since onset: 156±49.7 d Inclusion: <12 mos post stroke, accomplish arm crank ergometry, no history of cardiovascular/ respiratory disease, no medications influencing metabolic or cardiorespiratory responses to exercise, no history of regular exercise training to strengthen UE and ventilatory muscles	Comparison: Breathing retraining (BRT) vs. inspiratory muscle training (IMT) vs. control (C) BRT: Diaphragmatic breathing combined with pursed-lip breathing (15 min), air shifting techniques (5 min), voluntary isocapnoeic hyperpnoea (10 min), with 5-min intervals between types of exercises. In addition to conventional stroke rehabilitation (5 d/wk, 6 wk). IMT: Use threshold inspiratory muscle training, start with load of 40% of PI_{max}, increased 5-10% each session, to 60% as tolerated. In addition to conventional stroke rehabilitation (5 d/wk, 6 wk). C: Conventional stroke rehabilitation (5 d/wk, 6 wk). Intensity: BRT: 30 min/d, 7 d/wk, during 6 wk. IMT: 2x 15 min/d, 7 d/wk, during 6 wk. Treatment contrast: BRT vs. IMT: 0 min. BRT/ IMT vs. C: 21 h.	FEV_1, FVC, VC, FEF 25-75%, PEF, MW, MIP, MEP, VO_2peak, HRpeak, $V_E$peak, PO, SaO_2, V_D/V_Tpeak, RPE, Brunnstrom stages, FAC, BI, SF-36 Measured at baseline and 6 wk	Significant short-term effects of the respiratory muscle training programme on respiratory muscle function, exercise capacity and quality of life were recorded in this study.
Britto et al 2011	7	21 (11/10)	Age: 56.66±5.56 yr Type: ?? Time since onset: >9 mos post stroke Inclusion: >9 mos post stroke, residual weakness paretic lower extremity, MIP <90% predicted, no facial palsy, use cycle ergometer, no restrictions lung function, no neurologic/ orthopedic/ unstable cardiac conditions, non-smokers or smoke-free for ≥5 yr, no thoracic or abdominal surgery	Comparison: Inspiratory muscle training (IMT) vs. control (C) IMT: Home-based IMT training, threshold 30% of MIP, adjusted biweekly in lab. Diary to register training time. 6 series of 5 min, 1 min rest interval. C: Same protocol as IMT but without resistance valve which was concealed. Intensity: 30 min/d, 5 d/wk, during 8 wk. Treatment contrast: 0 h.	MIP, IME, HAP, NHP, load Measured at baseline and 8 wk	Significant short-term effects of the IMT program for inspiratory strength and endurance were observed in chronic stroke survivors.

RCTs PEdro-score < 4

RCTs investigating tracking training for the paretic knee

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Cho et al 2007	2	10 (5/5)	Age: 46.2±7.3 yr Type: isch/hem Time since onset: 14.2±2.4 mos Inclusion: ≥1 yr post stroke, plateau max motor recovery 2 mos, no knee joint flexion contracture; no MAS >2, no visual problem	Comparison: Visual biofeedback tracking training (VBTT) vs. control (C) VBTT: Follow PC-generate sine waves with knee joint electrogoniometer, two sine waves should appear as close to overlapping as possible. 0.2 Hz, amplitude ranges -20° to +20° or 0° to 60°. PC monitor 80 cm distance. C: No therapy. Intensity: 39 min/d, 5 d/wk, during 4 wk. Treatment contrast: 780 min.	Accuracy of tracking, MI leg, mMAS* walking, 10MWT, fMRI Measured at baseline and 4 wk	We demonstrated that cortical activation changes occurred with gait function improvement in chronic stroke patients throughout the 4-week VBTT program. It seems that the cortical reorganization was induced by VBTT.

RCTs wheelchair self-propulsion

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Barrett et al. 2001	RCT (multi-center)	40 (19 / 21) with good sitting balance and without walking ability and without neglect 35 (17 / 19) completed the study, 33 (17 /16) completed the follow up	mean: 67.1 y ± 11.2, range 59-73y	types: all subacute: mean 16 d. ± 9 d. after stroke, range 9-22 d.	Yes	Intervention: encourage to self-propel vs discourage to self-propel with wheelchair on randomisation. Both groups received regular rehabilitation treatment. E: encouraged to self-propel by use of nonaffected foot for paddle and propel and use of nonaffected arm to provide extra propulsion and steering C: discouraged to self-propel: seated in suitable armchair between activities and wheelchair with brakes to prevent attempts at self-propulsion Intensity: en- or discouraged during 8 weeks	BI, NEADL, GHQ-12 and question: feel sad or depressed? measured at 3 mo and 12 mo (follow-up) after stroke	No major differences were found between the 2 groups for any of the outcome measures	7 failure at questions: *5,6,10*

Bijlage 1.2 Arm-hand activities

RCTs investigating positioning of the paretic arm (paragraaf G.1.1)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Ada et al 2005	7	32 (17/15)	Age: 70±7 yr Type: first Time since onset: 14±4 d Inclusion: MAS* item 6 0-4, no pain or loss of >20° ROM external rotation or abduction shoulder	Comparison: Positioning vs. control (C) Positioning: Shoulder exercises and routine upper extremity care such as provision of slings and supports. In addition, two sessions of shoulder positioning: 1) supine with shoulder at 45° abduction and in maximum external rotation; 2) sit at table with shoulder at 90° flexion and 90° elbow flexion so that both single joint extensors and multijoint extensors were lengthened. C: Shoulder exercises and routine upper extremity care such as provision of slings and supports. Intensity: Positioning: 2x 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 20 h.	Maximum passive ROM external rotation and flexion shoulder, MAS* (item 6) Measured at baseline and 4 wk	At least 30 minutes a day of positioning the affected shoulder in external rotation should be started as soon as possible for stroke patients who have little activity in the upper arm.
Turton et al 2005	6	29 (14/15)	Age: 70±10 yr Type: first Time since onset: <4 wk Inclusion: inability to pick up a polystyrene cup from a table with the affected hand	Comparison: Positional stretch vs. control (C) Stretch: Daily stretch regime with positioning by ward staff, in addition to standard arm care: 1) bearable wrist and finger flexor stretch on a hinged board. 2) Shoulder adductors and internal rotator stretch from Ada et al 1990 (i.e. some external rotation instead of full rotation). Each stretch twice a day and the regime continued throughout hospital admission up to 12 wk post stroke or until subject recovered arm function. C: Standard arm care. Intensity: 4x 30 min/d, 7 d/wk, up to 8 wk. Treatment contrast: ≈122 h.	PROM, AROM Measured at baseline 4, 8 and 12 weeks	The stretch treatment was not well tolerated over many weeks. Statistical power was low due to the large degree of variability of range of motion and small sample size. The regime tested cannot be recommended as a workable treatment to prevent contractures.
De Jong et al 2006	7	19 (10/9)	Age: range 36-63 yr Type: first Time since onset: 35.7±8.2 d Inclusion: FMA arm stage 0-3, no severe shoulder pain	Comparison: Positioning vs. control (C) Positioning: Well-defined positioning procedure for the hemiplegic arm while lying supine: shoulder abduction, shoulder external rotation, elbow extension and supination of the forearm as the subject could endure without pain. Arm always supported by pillow and if necessary held in position with a sandbag. Patients were instructed not to change position of the trunk. Carried out by nursing staff supervised by PT. In addition to conventional rehabilitation. Control: Conventional rehabilitation. Intensity: positioning 30 min, 2x/d, during 5 wk. Treatment contrast: 25 h.	PROM, MAS, VAS, BI Measured at baseline, wk 5 and 10 wk (follow-up)	Applying a contracture preventive positioning procedure for the hemiplegic arm slowed down the development of shoulder abduction contracture. Positioning did not show significant additional value on other outcome measures.
Gustafsson et al 2006	6	32 (17/15)	Age: 67.1±13.9 yr Type: first isch/hem Time since onset: 19.7±9.6 d Inclusion: no history of pain or injury in affected shoulder, 45° PROM abduction but less than full active flexion in affected shoulder	Comparison: Positional stretching vs. control (C) Stretching: Rehabilitation program. In addition 2 static positional stretches of stroke-affected shoulder: 1) sit with affected arm abducted to 90° and fully supported on the surface of a table with the elbow extended and forearm in neutral; 2) lying supine with shoulder abducted to 90° and in the maximal amount of achievable external rotation, the elbow flexed and forearm pronated. Position upper extremity in modular support system attached to adjustable height armrest of wheelchair when seated, 10-15° shoulder abduction, midway between external and internal rotation. When in bed, use a pillow to support affected shoulder in position midway between external and internal rotation and not horizontally abducted. C: Rehabilitation program. In addition locally fabricated cushion support for stroke-affected upper extremity when seated and in bed. Intensity: stretches 2x 20 min/d, till discharge (mean 47.8±18.0 d). Treatment contrast: 32 h.	ROM, pain movement, pain rest, mBI Measured at baseline, discharge and 6 mos post discharge (follow-up)	Participation in the management programme did not result in improved outcomes. The results of this study do not support the application of the programme of static positional stretches to maintain range of motion of the shoulder.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Dean et al. 2000	RCT	28 (14 / 14) with MAS-UE < 5 points and PROM of shoulder abduction and flexion > 90 degrees 23 completed the study (17% drop-outs)	mean: 58 y ± 11y, range 44-81y	type: ? post acute: mean 34d ± 12d after stroke, range 16-65d	Yes	Intervention: prolonged positioning of shoulder and multidisciplinary rehabilitation vs multidisciplinary rehabilitation E: multidisciplinary rehabilitation and prolonged positioning of the affected shoulder in 3 positions (each 20 min): 1) lying supine, shoulder in max. tolerable abduction and external rotation, elbow flexed; 2) lying supine, shoulder abduction to 90 degrees, max. tolerable external rotation, elbow flexed; and 3) sitting, shoulder forward flexed 90 degrees, elbow extension, wrist extension and a cylinder in hand. C: multidisciplinary rehabilitation Intensity: 60 min; 5x/wk during 6 wk	Resting pain (VAS), pain on dressing, pain-free active abduction and passive external rotation range measured at baseline and after 6wk	The effect of the positioning protocol on shoulder pain and stiffness remains unclear. The differences between the groups were not statistically significant, however, because of low statistical power the results are inconclusive.	7 failure at the questions: *5,6,8*

RCTs investigating immobilization techniques and/or positions for the paretic wrist and fingers (paragraaf G.1.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Sheehan et al 2006	6	14 (6/8)	Age: ?? Type: ?? Time since onset: 11.5 mos Inclusion: no functional use of affected hand; MAS 2-3	Comparison: Splinting vs. (no) splinting (C) Splinting: Wear splint. No other upper limb treatment intervention. C: Wear splint. No other upper limb treatment intervention. Intensity: Splint I: wk 1: no splint, wk 2-7: splint. Splint II: wk 1-2 no splint, wk 3-7 splint. Treatment contrast: 1 wk.	Amount and rate of change in resistance wrist and fingers Measured at baseline, wk 1, 2 (splint vs. no splint), 3, 7 (5 vs. 6 wk splint)	This result could indicate that five weeks of splinting is clinically worthwhile to decrease the rate of change in resistance in the wrist and finger.
Lannin et al 2007	8	63 (21/21/21/)	Age: 70.3±12.6 yr Type: ?? Time since onset: 27.8±14.5 d Inclusion: no active wrist extension	Comparison: Neutral splint vs. extended splint vs. control (C) Neutral: Custom-made static palmar mitt splint, wrist positioned in 0^o-10^o extension, wear overnight. In addition to usual rehabilitation. Extended: Custom-made static palmar mitt splint, wrist positioned in comfortable end-of-range position (>45^o wrist extension) with MCP and IP joints extended. In addition to usual rehabilitation. C: Usual rehabilitation. Intensity: 12 h/d, 7 d/wk, during 28 d. Treatment contrast: splint vs. control: 336 h.	Extensibility of wrist and finger muscles, Motor assessment scale, Tardieu scale, DASH, pain Measured at baseline, 4 wk and 6 wk (follow-up)	Splinting the wrist in either the neutral or extended wrist position for 4 weeks did not reduce wrist contracture after stroke.
Bürge et al 2008	8	30 (15/15)	Age: 68±12 yr Type: first Time since onset: 29.0±15.7 d Inclusion: FMA arm ≤45	Comparison: Orthosis vs. control (C) Orthosis: Wear individualized splint following biomechanic and reeducation principles: 1) alignment of forearm and hand, 2) maintenance of wrist in neutral position, 3) support of longitudinal and oblique hand arches, 4) low carpal trimlines and allow holding or manipulation of objects. In addition to standard care, i.e. PT 2x/d, OT 1x/d, if indicated neuropsychologic and speech therapy. C: Standard care. Intensity: >6 h/d, 5 d/wk, during 13 wk. Treatment contrast: 546 h.	VAS pain, FMA arm, ROM, edema Measured at baseline and 13 wk	Neutral functional alignment orthoses have a preventive effect on poststroke hand pain, but not on mobility and edema in the subacute phase of recovery.
Lai et al 2009	2	30 (15/15)	Age: 52±17 yr Type: ?? Time since onset: >6 mos Inclusion: MAS elbow extension ≥2, ROM elbow extension deficit >24%	Comparison: Botox + manual therapy + splint vs. Botox + manual therapy (C) Splint: Dynamic splint with two-load, prolonged-duration stretch, worn while sleeping. In addition to BotoxA and manual therapy (see below). C: Botox in biceps, brachialis, brachioradialis muscles. Manual therapy: moist heat, patient education, re-evaluation of symptoms, joint mobilization, passive ROM, AROM, PNF, therapeutic exercise. Intensity: 6-8 h/d, 7 d/wk, during 14 wk. Treatment contrast: 49 h.	AROM, MAS Measured at baseline and 14 wk.	Trends showed that patients gained greater AROM in elbow extension with decreased spasticity.
Heidari et al 2011	6	16 (9/7)	Age: 57.7±6.85 yr Type: ?? Time since onset: 18.4±3.71 mos Inclusion: >6 mos post stroke, MAS wrist >1; no active movements out of flexor or extensor synergy pattern at wrist-hand complex, joint contracture, pathologic conditions involved upper extremity not related to stroke, previous splinting and Botox <6 mos	Comparison: Splint vs. control (C) Splint: Dorsal dynamic splint, first part light short cock-up splint of aluminum material covered with foam to position wrist and thumb MCP joints in 10^o extension and 45^o palmar abduction. Second part was finger pan made of low temperature material placed on palm of fingers with two straps passed over the dorsum of the IP joints and lucked them in full extension. Two parts connected via tow mechanical joints at MCP which allowed finger movements only in the MCP joints and a dorsal outrigger made of two metal wires. Actively flex fingers from extension position against outrigger tension. In addition to therapy according to Bobath concept. C: Therapy according to Bobath concept. Intensity: Splint 5 d/wk, 6 h/d, during 8 wk; including 2x/d 15 min finger exercise. Treatment contrast: 240 h.	MAS, Hoffmann reflex (Hmax/Mmax ratio) m. flexor carpi radialis, FMA wrist and finger Measured at baseline and 8 wk and 10 wk (follow-up)	Using a dynamic splint for the paretic hand following stroke could have positive functional outcomes in selected patients.

Suat et al 2011	7	19 (10/9)	Age: 41±14.9 yr Type: ?? Time since onset: 26.2±14 mos Inclusion: walk independently, MAS hand 2-3, >6 mos post stroke, grossly support unaffected hand in bilateral activities	Comparison: Splint vs. control (C) Splint: Hand splint with 20°-25° wrist extension, thumb in opposition, fingers spread in semiflexion. Wear splint >1 h before therapy, during lower extremity activity like walking, or when needing to relax spastic muscles if they felt that they benefited from it. Keep diary. C: No intervention. Intensity: >2 h/d, 7 d/wk, during 6 mos. Treatment contrast: 346 h.	BBS, FR, TUG, L test Measured at 2, 4 and 6 mos	Hand splints with reflex inhibitory characteristics have no significant effect on balance and functional ambulation activities in chronic stroke patients.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age ± SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodological quality****
Rose and Shah 1980	RCT	30 (10/ 10/ 10) with spastic wrist flexors	mean: 64 y, range 34-87y.	type: ? post-acute: < 6 mo after stroke	No	Intervention: comparing the immediate effects of dorsal, volar splints vs no splints in reducing hypertonicity in wrist flexors E1: static dorsal splint application E2: static volar splint application C: no splints Intensity: splints were applied and worn for 2 hours	PROM, angle point of stretch reflex, resistance to passive wrist extension and force of spontaneous wrist flexion. measured before and after 2 hrs intervention	A significant reduction of hypertonicity following both dorsal and volar splint application on the passive range of motion and resistance to passive extension measures. No significant reductions in hypertonicity were noted on the angle of point of stretch reflex measure, and on the force of spontaneous flexion measure	2 failure at the questions: 3,4,5,6,7,8,9,11
Carey 1990	RCT	16 (8 / 8) at least 20 degrees of voluntary finger extension and spasticity	mean: 55.4y + 14.7 y	type: all chronic: mean 6 y + 6 y after stroke	No	Intervention: manual stretching vs no therapy E: manual stretch: subject sat in chair with forearm stabilized, midway between pronation and supination, on a table. Index finger was inserted into a ring and connected to a load cell C: no therapy Intensity: once 5 minutes	JMTT, FTT and EMG measured before and after stretching	Manual stretch applied to spastic extrinsic finger flexor muscles improves control of finger-extension movement but does not improve control of isometric finger-extension force.	5 failure at the questions: 3,5,6,7,9
Langlois et al. 1991	RCT	9 (3 / 3 / 3) with spastic hemiplegia	mean: 64.2 y range 46-78y	type: all chronic: mean: 6.3 mo after stroke	Yes	Intervention: investigate the effects of a finger spreader on the spastic musculature of the wrist E1: wearing schedule 6 hours per day E2: wearing schedule 12 hours per day E3: wearing schedule 22 hours per day Intensity: each day during 4 weeks	Spasticity: torque motion analyser measured before and after 2 and 4 weeks of intervention	The greatest change in the level of spasticity was measured in the group wearing the splint for 22 hours. However, this trend was not statistically significant.	3 failure at the questions: 3,4,5,6,7,8,9

RCTs investigating air-splints (paragraaf G.1.3)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Feys et al 1998, 2004	4	100 (50/50)	Age: 65.62±11.81 yr Type: isch/hem Time since onset: 21.40±5.94 d Inclusion: FMA arm <46, ability to sit independently or with minimum of support	Comparison: Sensorimotor vs. control (C) Sensorimotor: Sensorimotor stimulation, by performing rocking movements in a rocking chair pushing with the heels and/or hemiplegic arm. Inflatable splint used to support affected arm, shoulder in 80° flexion and slight abduction, elbow extension, wrist dorsiflexion. Chair balanced such a way that during movement the patient fell slightly forward and had to actively push backwards, encouraged to use hemiplegic arm. In addition to usual rehabilitation procedures. C: Positioned in a rocking chair, but with arm rested on a cushion on the patient's lap, no additional stimulation was given. Fake short wave therapy on the shoulder during the rocking. In addition to usual rehabilitation procedures. Intensity: 30 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, ARAT, BI, MAS Measured at baseline, 3, 6 wk and 6 and 12 mos and 5 yr (follow-up)	Adding a specific intervention during the acute phase after stroke improved motor recovery, which was apparent 1 year later.
Cambier et al 2003	5	23 (11/12)	Age: 63.9±11.2 yr Type: first Time since onset: 114.1±92.6 d Inclusion: impairment of sensory function in upper limb	Comparison: Pneumatic compression (E) vs. control (C) E: Lying supine, with inflatable splint on affected upper limb connected to an intermittent pneumatic compression machine, with a pattern of 2 minutes with 90 seconds inflation and 90 seconds deflation duty cycle. Inflation peak 40 mmHg. In addition to conventional therapy based on NDT. C: Sham short-wave therapy with device switched off on the hemiplegic shoulder for 30 minutes, in same supine position. In addition to conventional therapy based on NDT. Intensity: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	NSA, FMA arm, MAS, VAS Measured at baseline, 2 and 4 wk	The use of intermittent pneumatic compression in the rehabilitation of stroke patients may be of clinical importance for the restoration of sensory function.
Platz et al 2009	8	144 (49/48/47)	Age:58.1±2.0 yr Type: first isch Time since onset: 4.7±3.0 wk Inclusion: MI arm <100 and >25	Comparison: Splint vs. conventional motor therapy (Conv) vs. modular impairment-oriented training (IOT) Splint: Inflatable splint arm therapy, consisting of 5 different hand/arm pressure splits of various sizes, with positioning in an antispastic position. Conv: Best conventional therapy based on whatever the therapist regarded the best possible physical therapy regimen. Not restricted in terms of type of therapeutic approach, but devices such as robots or functional electrical stimulation could not be used. IOT: Standardized impairment-oriented training 1) for severe affected Arm BASIS training that address the lack of selective movements, by repetitive training of isolated motions across full ROM in that segment. During first phase, therapist takes over weight of the arm and assist movement, followed by relearning combination of dynamic and postural control for isolated motion, finally multijoint movements and coordination; 2) for mild affected Arm Ability training that trains speed, aiming, dexterity, tracking and steadiness, with variation of task difficulty and individually standardized. Knowledge of results intermittently shown by diagrams on PC screen. Intensity: 45 min/d, 5 d/wk, during 3-4 wk. Treatment contrast: 0 h.	FMA arm, TEMPA, FMA passive joint motion and pain, MAS Measured at baseline, 3-4 wk and 4 wk (follow-up)	Specificity of active training seemed more important for motor recovery than intensity (therapy time). The comprehensive modular IOT approach promoted motor recovery in patients with either severe or mild arm paresis.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age ± SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Poole et al. 1990	RCT	18 (9 / 9) were able to imitate movements and/or follow commands	mean: 70 y., range 55-82y.	type: ? time since onset stroke: ?	No	Intervention: traditional OT + inflatable splints (Johnstone) vs traditional OT + no splinting E: inflatable pressure splints and shoulder exercises (elevated to 90 degrees shoulder flexion with full elbow extension and as much shoulder external rotation as possible without pain. C: not specified therapy (no inflatable splint treatment) Intensity: 5 d/wk for 30 min/d during 3 wk	FMA, pain and sensation measured at 3 wk after start treatment	No significant differences in mean change in upper extremity sensation, pain and motor function from week 0 to week 3 between the splint and non-splint groups.	5 failure at the questions: *3,5,6,7,9*

RCTs investigating supportive devices or techniques for the prevention or treatment of hemiplegic shoulderpain (paragraaf G.1.4)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Griffin et al 2006	7	32 (10/10/12)	Age: 65.0±10.7 yr Type: first/rec isch/hem Time since onset: 9±5 d Inclusion: MAS* ≤3, no or minimal shoulder pain on Ritchie Articular Index, no shoulder pain prior to stroke	Comparison: Strapping vs. placebo strapping vs. control (C) Strapping: Two lengths of lightweight adhesive tape, applied to shoulder half way along clavicle, continued across deltoid muscle in diagonal direction and along a combine pad. Stretch applied in direction of posterior fibers of deltoid. Terminated one quarter of the way along the spine of the scapula. Second tape same direction but 2 cm below. Anchor tape secured two ends and on it was written 'do not wet, do not remove'. Reapplied very 3-4 days. Placebo strapping: Anchor tape in isolation. C: No tape. Intensity: 4 wk. Treatment contrast: 4 wk.	Number of pain free days (Ritchie Articular Index), range of shoulder MAS* Measured at baseline and 4 wk	Therapeutic strapping limited development of hemiplegic shoulder pain during rehabilitation in at risk stroke patients. Placebo strapping has an effect, with a larger study needed to detect whether there are differences between therapeutic and placebo strapping.
Appel et al 2011	4	12 (6/6)	Age: 71.3±2.7 yr Type: first isch/hem Time since onset: 6.3±4.2 d Inclusion: FMA arm 25-60	Comparison: Strapping vs. control (C) Strapping: One out of five strapping methods, depending on movement impairment during shoulder flexion to 90°. Aim to improve joint alignment and movement of scapula and/or glenohumeral joint. Strapping changed every 3 days. In addition to PT and OT. C: PT and OT. Intensity: Strapping during 4 wk. PT/OT: 2x/d, 5 d/wk. Treatment contrast: 20 d.	MAS*, FMA arm, NHPT Measured at baseline and 1, 2, 3, 5 wk SSQoL measured at 6 and 12 wk (follow-up)	Shoulder strapping may have benefit as an adjunct therapy in upper limb rehabilitation after acute stroke and a clinical trial to test this is warranted.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Inaba & Piorkowski 1972	RCT	33 (10 / 10 / 13) with shoulder pain within range 0-90 degrees (flexion or abduction)	mean: 58+10 yrange 47-69y.	type: ? post-acute: mean 4.7mo + 4.7 mo after stroke	Yes	Intervention: evaluate the effectiveness of three different treatments to reduce pain in the hemiplegic shoulder. E: Two treatment groups E1 and E2 received also the group C ROM-exercises and positioning. E1: received ultrasound prior to one session; minimum of 15 treatments; E2: same treatment but ultrasound energy was turned off. Ultrasound-characteristics: 0.5-2 Watt per square centimetre within patients tolerance. Para vertebral and shoulder joint areas each received one five-minute treatment. C: ROM-exercises and positioning only (self ROM-exercises for shoulder flexion, abduction, and external rotation with pulley 3x/wk, each motion repeated 5x/session; and arm positioning 24 hrs/d in pain-free abduction and external rotation (pillows and slings). Intensity: 4 wk period	ROM (shoulder: flexion, abduction with internal rotation, abduction with external rotation, external rotation with adducted arm) and pain measured (3x for each motion) before and after 4 wk treatment	Comparison of the mean changes in motion of the three groups showed no significant differences among the groups. Lack of change in pain-free range of motion led to the conclusion that ultrasound does not reduce pain significantly in the involved shoulders of patients with hemiplegia.	5 failure at the questions: 3,5,6,8,9

Partridge et al. 1990	RCT	65 (31 / 35) 85 of 284 patients with shoulder pain submitted in study 65 of 85 completed the study (=24% drop-outs)	mean: 64 y., range 40-86y.	type: ? chronic: mean 33 wk after stroke, range 3 wk-9.5y.	Yes	Intervention: evaluate the effectiveness of cryotherapy vs the Bobath approach, for hemiplegic shoulder pain. E: cryotherapy; patients seating with arm supported and ice towels to shoulder joint for 10 min. or within patients tolerance. Followed by simple exercise: large circular movements with affected arm (‘polish the surface’) C: Bobath approach; all patients received same advise and instructions: supporting affected arm; take care while dressing, eating and move affected arm within pain-free ROM Intensity: daily for first 5 days and after that at the PT’s discretion for a total of 4 wk	Pain rating scale in rest and on movement, frequency of pain and ROM measured at start and end of 4 wk period	No statistically significant differences between the scores of the both groups on exit were found for severity of pain at rest, on movement, or for reported distress; however the proportion of patients who reported no pain after 4 wk treatment was greater in those who received the Bobath approach.	5 failure at the questions: 3,5,6,8,9
Hanger et al. 2000	RCT, with stratification into two groups according the severity at baseline (FIM less / greater 25 points)	98 (49/49) with persisting weakness of shoulder abduction 15% drop-outs 83 (41/42) completed the study at week 6 12% drop-outs 73 completed the follow up at week 14	mean: 78.5 y + 7.8y	type: all sub-acute: 15 d + 8 d. after stroke	Yes	Intervention: comparing strapping and no-strapping of affected shoulder to prevent PSSP. Treatment group had affected shoulder strapped; Control: except strapping all interventions between 2 groups were similar (positioning, maintenance of ROM and the provision of adequate support for the arm , which could include the use of a sling when mobilizing) Intensity: strapping remained on all the time, including in the shower, and was replaced every 2-3 days (max. 3 days); during 6 weeks, or until able to achieve active abduction (90 degrees), or until discharge Strapping- technique: 3 lengths of nonstretch tape. Two main ‘supporting’ tapes starting 5 cm above elbow and moving up the arm front and back crossing the shoulder. The third tape was applied from the medial third of clavicula around surgical neck of humerus + along spine of scapula to its medial third.	VAS (pain and PROM), FIM, Motor Assessment Scale and RDI measured at 6 and 14 weeks	No significant benefit with shoulder strapping was demonstrated; it did not prevent shoulder pain, nor maintain ROM or improving functional outcome. Range of movement in hemiplegic shoulder is lost very early and any preventive treatments need to begin within the first 1-2 days after a stroke.	7 failure at the questions: 5,6,8

RCTs investigating bilateral arm training (BAT) (paragraaf G.1.5)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Van der Lee et al 1999	7	66 (33/33)	Age: median 60 (IQR 51.5-63.5) yr Type: first isch/hem Time since onset: median 3.1 (IQR 1.8-5.4) yr Inclusion: ≥20° active wrist extension, ≥10° active finger extension, ARAT <51	Comparison: BAT vs. CIMT BAT: Intensive bimanual training based on NDT, therapy focused on housekeeping activities, handicrafts, and games. Symmetry of posture and inhibition of inappropriate synergistic movements were emphasized. CIMT: Groups of four. Forced use therapy focused on housekeeping activities, handicrafts, and games, wear resting split and closed arm sling. Encouraged to wear split at home, sling only during therapy hours. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	RAP, ARAT, FMA arm, MAL, problem score Measured at baseline, 3 wk and 6 wk and 1 year (follow-up)	Small but lasting effect of forced use on dexterity affected arm (ARAT) and temporary clinically relevant effect on MAL AOU, especially in patients with sensory disorders and hemineglect. No effect on ADL.
Mudie et al 2001 acute [single session RCT]	5	18 (9/9)	Age: 71.9±5.8 yr Type: first ?? Time since onset: 1.9±1.1 mos Inclusion: MAS ≤2, produce response with nonhemiplegic arm during bilateral tasks	Comparison: BAT vs. unilateral arm training (C) BAT: Isometric contraction shoulder abduction and wrist extension. 5 trials of 5 repetitions of 5 seconds. Trial 1, 3 and 5 unilateral; trial 2 and 4 bilateral. C: Isometric contraction shoulder abduction and wrist extension. 5 trials of 5 repetitions of 5 seconds. Trial 1, 2, 3 and 5 unilateral; trial 4 bilateral. Intensity: Single session of 30 min. Treatment contrast: 0 h.	EMG activity shoulder abduction and wrist extension	No differences between groups.
Mudie et al 2001 chronic [single session RCT]	5	18 (9/9)	Age: 64.6±10.9 yr Type: first ?? Time since onset: 34.2±37.2 mos Inclusion: MAS ≤2, produce response with nonhemiplegic upper extremity during bilateral tasks	Comparison: BAT vs. unilateral arm training (C) BAT: Isometric contraction shoulder abduction and wrist extension. 5 trials of 5 repetitions of 5 seconds. Trial 1, 3 and 5 unilateral; trial 2 and 4 bilateral. C: Isometric contraction shoulder abduction and wrist extension. 5 trials of 5 repetitions of 5 seconds. Trial 1, 2, 3 and 5 unilateral; trial 4 bilateral. Intensity: Single session of 30 min. Treatment contrast: 0 h.	EMG activity shoulder abduction and wrist extension	No differences between groups.
Platz et al 2001	4	14 (7/7)	Age: 55.9±11.6 yr Type: isch Time since onset: subacute Inclusion: MRC ≥4 all major muscle groups affected arm	Comparison: BAT vs. unilateral arm training (C) BAT: Practice tasks (fast and accurate aiming movements similar to test, fast tapping movements with index finger, pick up and place small wooden sticks on top of each other) in a bilateral symmetrical manner with both the affected and non-affected arm simultaneously. C: Practice tasks with affected arm only. Intensity: 30 min, 5 consecutive days. Treatment contrast: 0 h.	Kinematics (aiming unilateral, aiming bilateral, aiming with cognitive task) Measured at baseline and 1 week	Nothing to indicate that bilateral training would result in a more favorable outcome; thus to improve 'aiming' ability among high functioning hemiparetic patients, a unilateral training is sufficient.
Cauraugh et al 2002	4	25 (10/10/5)	Age: 63.7 yr Type: ≤2 strokes Time since onset: 39.1 mos Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	Comparison: BAT + EMG-NMS vs. uni + EMG-NMS vs. control (C) BAT + EMG: EMG-triggered surface NMS-stimulation and assistance from unimpaired limb as wrist/flinger extension was executed simultaneously on both limbs. 5 seconds of stimulation, followed by 25 seconds of rest. Uni + EMG: EMG-triggered surface NMS-stimulation to assist with wrist and finger extension. 5 seconds of stimulation, followed by 25 seconds of rest. C: Voluntarily extend wrist/ fingers without receiving NMS stimulation or bilateral assistance for wrist/fingers extensors. Intensity: 3 sets of 30 successful trials per session. 1.5 h, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, reaction time, sustained muscle contraction capability (EMG) Measured at baseline and 2 wk	Significant findings for all outcomes in favor of BAT + EMG-NMS. Unilateral group exceeded control group in number of blocks moved and rapid onset of muscle contractions.
Cauraugh et al	3	20 (10/10)	Age: 63.03 yr	Comparison: BAT + EMG-NMS vs. uni + EMG-NMS	Voluntary EMG activation	Higher EMG-NMS activation levels for the

2003 A			Type: ≤2 strokes Time since onset: 33.86 mos Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	BAT + EMG-NMS: EMG-triggered surface NMS and assistance from unimpaired limb as wrist/finger extension was executed simultaneously (7 seconds ramp/stimulation, 25 seconds rest). Uni + EMG-NMS: EMG-triggered surface NMS to assist extensor muscles of wrist and fingers (7 seconds ramp/stimulation, 25 seconds rest). Intensity: 3 sessions of 30 successful trials per session. 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	threshold (wrist and finger extensors) Measured at baseline and 2 wk	coupled bilateral movement/ stimulation group than the unilateral movement/stimulation group.
Luft et al 2004	5	26 (11/15)	Age: 63.3±15.3 yr Type: first Time since onset: median 75.0 (IQR 37.9-84.5) mos Inclusion: ability to move affected limb (at least partial range antigravity movement)	Comparison: BATRAC vs. dose-matched therapeutic exercises (DMTE) BATRAC: Pushing and pulling bilaterally, in synchrony or alternation, 2 T-bar handles sliding in the transverse plane upon auditory cues (rates 0.67-0.97 Hz). 4x 5 min interspersed with 10 min rest. DMTE: Based on NDT principles, including thoracic spine mobilization, scapular mobilization, weight bearing, opening a closed fist. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0h.	fMRI variables, FMA arm, shoulder and elbow strength, WMFT, UMAQS Measured at baseline and 6 wk	BATRAC induced changes in movement-related cortical activation patterns (contralesional hemisphere - precentral gyrus, poscentral gyrus, and ipsilesional cerebellum), suggesting cortical reorganization. No significant difference between groups for changes in functional outcome.
Suputtitada et al 2004	6	69 (33/36)	Age: Type: first Time since onset: Inclusion: 1-10 yr post stroke, ≥20° active wrist extension, 10° finger extension, ARAT <51, walk indoors without stick; no sensory disorder	Comparison: BAT vs. mCIMT BAT: Bimanual training based on NDT if necessary support affected arm with nonaffected hand with emphasis on symmetry of posture and inhibition of inappropriate 'synergistic' movements, in groups of 3-4. CIMT: Nonparetic hand covered by glove, Treatment in groups of 3-4. Encouraged to use affected arm at home. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	ARAT, hand grip strength, pinch grip strength Measured at baseline and 2 wk	CIMT of unaffected upper extremities has an advantage for chronic stroke patients which ma be an efficacious technique of improving motor activity and exhibiting learned nonuse.
Cauraugh et al 2005	4	21 (10/11)	Age: 69.37±10.14 yr Type: ≤3 strokes Time since onset: 4.73±3.52 yr Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	Comparison: Coupled bilateral vs. unilateral/ active stimulation BAT + EMG-NMS: Bilateral movements in the intact wrist/fingers simultaneously with active NMS of wrist/finger extensors on impaired limb (7 seconds ramp/stimulation, 25 seconds rest). Uni + EMG-NMS: EMG-NMS triggered neuromuscular stimulation given to voluntary wrist/finger extension impaired limb (7 seconds ramp/stimulation, 25 seconds rest). Intensity: 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	Kinematics (reaction time, movement time, peak velocity, time-to-peak velocity, acceleration and deceleration phase) Measured at baseline and 2 wk	Coupled protocol training improved bimanual aiming that required shoulder and elbow joints movements.
Desrosiers et al 2005	6	41 (20/21)	Age: 73.2±10.4 yr Type: isch/hem Time since onset: 34.2±34.4 d Inclusion: move upper limb independently	Comparison: BAT vs. control (C) E: OT and PT. Additional practice of mainly symmetrical bilateral tasks, based on motor learning model principles including repeated practice and task variability. Standardized activities related to ADL tasks upper extremity. Type of tasks: symmetrical and asymmetrical bilateral, unilateral affected upper extremity, unilateral unaffected upper extremity. C: OT and PT. Additional functional activities and exercises to enhance strength, active, assisted and passive movements, and sensorimotor skills of the arm both uni- and bilateral. Based on some components of NDT. No asymmetrical tasks nor unilateral tasks unaffected upper extremity, not repeated in a systematic way, lower mental and physical effort. Intensity: 45 min, in total 15-20 sessions, during 5 wk (additional programmes). Treatment contrast: 0 h.	FMA arm, grip strength, BBT, PPT, finger-to-nose test, TEMPA, FIM, AMPS Measured at baseline and 5 wk	Arm training programme based on repetition of unilateral and symmetrical bilateral practice did not reduce impairment and disabilities nor improve functional outcomes in the subacute phase after stroke more than usual therapy.
Lum et al 2006	5	30 (10/9/5/6)	Age: 62.3±2.8 yr Type: first ?? Time since onset: 13.0±2.1 wk Inclusion: no upper extremity joint pain or ROM limitations	Comparison: Robot bilateral vs. robot combined vs. robot unilateral vs. control (C) Robot bilateral: 12 targeted reaching movements, bilateral mode, rhythmic circular movements were also performed. Robot combined: 12 targeted reaching movements, half of the time in unilateral mode, half of the time in bilateral mode. Robot unilateral: 12 targeted reaching movements, progressed from easies exercise modes (passive) to most challenging (active-constraint), no bilateral exercises.	FMA arm, FIM self-care and transfer, MP, MAS Measured at baseline, 4 wk and 6 mos (follow-up)	At post treatment, robotic-combined training group had significantly greater gains than the control group. However, gains in robot and control groups were equivalent at the 6 month follow-up. No significant differences were found between the robot-combined and robot-unilateral treatment. Less benefit from

				C: Conventional therapy targeting proximal arm function based on NDT. Intensity: 1 h/d, 15 sessions, during 4 wk. Treatment contrast: 0 h.		bilateral therapy alone, because this group had the smallest gains.
Summers et al 2007	6	12 (6/6)	Age: 59.8 (range 43-77) yr Type: first isch/hem Time since onset: 4.0 (range 0.9-10.4) yr Inclusion: most components of movement present	Comparison: BAT vs. unilateral training (C) BAT: Simultaneously lift two wooden dowels, one in each hand, and place them on targets located on a shelf. 50 trials per session. C: Lift wooden dowel with affected upper extremity, and place it on targets located on a shelf. 50 trials per session. Intensity: 6 consecutive d. Treatment contrast: 0 h.	MAS, TMS, kinematics Measured at baseline and day 7	Short-term bilateral training intervention may be effective in facilitating upper limb motor function. MAS significantly better in BAT than C, but no differences in kinematics.
Cauraugh et al 2008	3	16 (8/8)	Age: 62.76±7.31 yr Type: firs/rec Time since onset: 3.65±3.02 yr Inclusion: ≤2 strokes, ≥10° wrist/finger extension from an 80° flexed position; no other neurological deficits	Comparison: Coupled bilateral vs. unilateral/ active stimulation BAT + EMG-NMS: Coupled bilateral wrist and finger extension. EMG initial threshold level of 50 μV, 1s ramp up, 10 s biphasic stimulation 50 Hz, 20-29 μA stimulation range, pulse width 200 ms, 1 s ramp down and 25 s rest before next trial. Each session involved 90 successful movement trials. Uni + EMG-NMS: Unilateral wrist/finger extension. EMG initial threshold level of 50 μV, 1s ramp up, 10 s biphasic stimulation 50 Hz, 20-29 μA stimulation range, pulse width 200 ms, 1 s ramp down and 25 s rest before next trial. Each session involved 90 successful movement trials. Intensity: 90 min/d, 4 d, during 2 wk. Treatment contrast: 0 h.	BBT, motor reaction time, total reaction time Measured at baseline and 2 wk	These chronic stroke patients displayed robust cumulative motor improvement effects from the longitudinally distributed practice of active neuromuscular stimulation and coupled bilateral movements.
McCombe Waller et al 2008	4	18 (9/9)	Age: 57.95 (range 37.84-83.08) yr Type: isch Time since onset: 73.42 (range 18.96-242.2) mos Inclusion: complete reaching tasks study <7 sec	Comparison: BATRAC vs. dose-matched therapeutic exercises (DMTE) BATRAC: Bilateral arm training with rhythmic auditory cueing with metronome at participants' preferred speed, bilateral in phase arm reach and return, bilateral anti phase reach and return. Trunk restraint. DMTE: Unilateral arm training, based on NDT principles. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	Kinematics, FMA arm, WMFT time, WMFT weight Measured at baseline and 6 wk	Task-specificity in training since BATRAC improves performance in bilateral reaching and DMTE improves performance in unilateral reaching. Between group difference for movement unit and hand path accuracy in favor of BATRAC.
Morris et al 2008	8	106 (56/50)	Age: 67.9±13.1 yr Type: isch/hem Time since onset: 22.6±5.6 d Inclusion: MAS <6 on each upper extremity section	Comparison: BAT vs. unilateral training (C) BAT: In addition to PT, identical tasks with each arm simultaneously to enhance skill acquisition and retention through block practice in the cognitive stage of learning progressing to random practice in the associative stage of learning. Progressive, standardized graded variations with specific motor or functional goals. Core protocol consisted of 4 tasks, if this was not possible a modified protocol with simple wrist and hand movement and reaching to points marked on tabletop. Systematic feedback, as many trials as possible in each session, maximum of 30 trials of each task, total 120 trials per session. C: Same program but use of affected upper extremity only. Intensity: 20 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	ARAT, RMA, NHPT, mBI, NHP, HADS Measured at baseline, 6 and 18 wk (follow-up)	Bilateral training was no more effective than unilateral training, and in terms of overall improvement in dexterity, the bilateral training group improved significantly less.
Cauraugh et al 2009	3	30 (10/10/10)	Age: 68.38±7.91 yr Type: ≤2 strokes Time since onset: 6.12±3.19 yr Inclusion: ≥10° active extension wrist or fingers against gravity from a 80° flexed position	Comparison: Coupled bilateral + load vs. coupled bilateral no load vs. unilateral BAT + load: Wrist and finger extension movements assisted with EMG-NMS (7 seconds ramp/stimulation, 25 seconds rest) and performed with a weighted glove on unimpaired limb. BAT: Wrist and finger extension movements, assisted with EMG-NMS (7 seconds ramp/stimulation, 25 seconds rest). Uni: Unilateral movement attempts on impaired limb, no assistance from NMS or bilateral movements, no weighted glove. Intensity: 90 successful trials per session. 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, reaction time, sustained contraction task (EMG) Measured at baseline and 2 wk	Coupled bilateral load and no load groups improved motor capabilities across the test sessions.
Lin et al 2009 A	7	60 (20/20/20)	Age: 52.14 (range 23-82) yr Type: first isch/hem	Comparison: BAT vs. mCIMT vs. control (C) BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lifting 2 cups, picking up 2 pegs, grasping and	FMA arm, FIM, MAL, SIS Measured at baseline and 3 wk	BAT may uniquely improve proximal upper limb motor impairment. In contrast, mCIMT may produce greater functional gains for

			Time since onset: 21.25±21.59 mos Inclusion: FMA arm III-V for proximal and distal parts arm	releasing 2 towels, wiping the table with 2 hands. No at home practice. mCIMT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. C: Usual therapy, partly based on principles of NDT: functional task practice for hand function, coordination, balance, movements of affected arm, compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.		the affected upper limb in subjects with mild to moderate chronic hemiparesis.
Stoykov et al 2009	5	24 (12/12)	Age: 63.8±12.6 yr Type: ?? Time since onset: 9.5±5.4 yr Inclusion: FMA arm 19-40	Comparison: BAT vs. unilateral training (C) BAT: 6 training tasks of bilateral tasks, both discrete (2) and rhythmic movements (4) paced by metronome. Blocked practice with 20 repetitions (2x10) increasing to 40 (4x10), one task 100 repetitions. Increasing speed requirements, decreasing external support, increasing cues to improve quality of movement , C: Same tasks but performed unilaterally. Intensity: 1 h/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	MAS, MSS, arm strength Measured at baseline and 8 wk	Both bilateral and unilateral training are efficacious. Bilateral training may be more advantageous for proximal arm function.
Hayner et al 2010	2	12 (6/6)	Age: 54.00±11.63 yr Type: ? Time since onset: 642.33±421.121 d Inclusion: place affected hand on table, trace of movement in hand	Comparison: Bilateral arm training vs. mCIMT Bilateral: Repetitive and intrusive cuing to use both hands during all activities. Many tasks involved repetition and daily performance, promoted function and active range of motion, routine and purposeful and intended to be meaningful. Little attempt to facilitate 'normal' movement. mCIMT: Padded mitt unaffected hand, functional activities affected upper extremity. Many tasks involved repetition and daily performance, promoted function and active range of motion, routine and purposeful and intended to be meaningful. Little. Little attempt to facilitate 'normal' movement. Mitt removed for restroom use only. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	WMFT, COPM Measured at baseline, 2 wk and 6 mos (follow-up)	High-intensity OT using a mCIMT or a bilateral approach can improve upper extremity function in people with chronic upper extremity dysfunction after CVA. Treatment intensity rather than restraint may be the critical therapeutic factor.
Lin et al 2010 B	6	33 (16/17)	Age: 52.08±9.60 yr Type: isch/hem Time since onset: 13.94±12.73 mos Inclusion: FMA arm III-V	Comparison: BAT vs. control (C) BAT: Supervised training moving simultaneously affected and unaffected upper extremity in functional tasks with symmetric patterns. C: OT focused on arm training including NDT technique, trunk-arm control, weight bearing, fine motor tasks practice, practice compensatory strategies for daily activities. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematic analysis unilateral (pressing desk bell) and bilateral task (opening box to retrieve sticky note), FMA arm, FIM, MAL Measured at baseline and 3 wk	Effects of BAT for improving some aspects of motor control strategies of the affected arm in both bilateral (time, efficiency, strategy) and unilateral tasks (time, efficiency) and reducing motor impairments, but not on functional ability.
Wu et al 2010	2	6 (2/4)	Age: 56.0 (range 45-68) yr Type: ?? Time since onset: 23.5 (range 11-57) mos Inclusion: FMA arm stage III-V	Comparison: BAT vs. mCIMT BAT: Simultaneous movement of upper extremities in functional tasks in symmetric or alternating patterns that emphasized both upper extremities moving synchronously. mCIMT: Mitt wearing and intensive training of the affected arm with functional activities and behavioral shaping. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	fMRI, FMA arm, ARAT, MAL Measured at baseline and 3 wk	The findings of this preliminary research revealed that neuroplastic changes after stroke motor rehabilitation may be specific to the intervention.
Whitall et al 2011	6	92 (42/50)	Age: 59.8±9.9 yr Type: first Time since onset: 4.5±4.1 yr Inclusion: ability flex paretic arm shoulder 3 inches from a neutral position	Comparison: BATRAC vs. dose-matched therapeutic exercises (DMTE) BATRAC: Pushing and pulling bilaterally, in synchrony or alternation, 2 T-bar handles sliding in the transverse plane upon auditory cues (rates 0.67-0.97 Hz). 4x 5 min interspersed with 10 min rest. DMTE: Based on NDT principles, including thoracic spine mobilization, scapular mobilization, weight bearing, opening a closed fist. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, WMFT, WMFT weight, grip strength, SIS, isokinetic strength, isometric strength, ROM, perception after training, fMRI Measured at baseline, 4, 6 weeks and 4 mos (follow-up)	BATRAC is not superior to DMTE, but both rehabilitation programs durably improve motor function for individuals with chronic upper extremity hemiparesis and with varied deficit severity.
Wu et al 2011	6	66	Age: 53.11 yr	Comparison: BAT vs. mCIMT vs. Control (C)	Kinematic analysis unilateral	BAT and mCIMT exhibited similar

		(22/22/22)	Type: isch/hem Time since onset: 16.20 mos Inclusion: FMA arm stage III-V	BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lift 2 cups, picking up 2 pegs, grasping and releasing 2 towels, wiping the table with 2 hands. mCIMT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. C: Usual therapy, about 75% based on principles of NDT: functional task practice for hand function, coordination, balance, stretching, weight bearing affected upper extremity. 25% compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	(pressing desk bell as fast as possible with index finger affected hand) and bilateral task (pulling drawer with affected hand and retrieve eyeglass case inside with unaffected hand at comfortable speed), WMFT, MAL Measured at baseline and 3 wk	beneficial effects on movement smoothness but differential effects on force at movement initiation and functional performance.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Luft et al., 2002	RCT	7 (4 / 3)	mean: 63 y ± 13 y	type: iCVA chronic: median 37.5 mo after stroke	?	Intervention: BATRAC vs NDT E: bilateral arm training with rhythmic auditory cueing C: unilateral training based on neurodevelopment principles Intensity: ?	fMRI and TMS measured before and after treatments	Results indicate that functional reorganization in the brain can occur long after spontaneously recovery has subsided.	3 failure at questions: *3,5,6,7,9,10, 11*

RCTs investigating (modified) constraint-induced movement therapy ((m)CIMT) (paragraaf G.1.6)

Original CIMT

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Wolf et al 2010	7	222 (106/116)	Age: 61.7±13.0 yr Type: first isch/hem Time since onset: 178±64 d Inclusion: initiation of active extension wrist and fingers	Comparison: Early (E) CIMT vs. Delayed (D) CIMT E-CIMT: CIMT starting immediately after randomization. Laboratory based training, monitored behavioral shaping and repetitive task practice using impaired upper extremity. Mitt 90% waking hours. D-CIMT: Custody care during first year. CIMT starting 1 year after randomization. Laboratory based training, monitored behavioral shaping and repetitive task practice using impaired upper extremity. Mitt 90% waking hours. Intensity: Intended: 6 h/d, 5 d/wk, during 2 wk. Actual: training time increased ranging from 1.5 h first day to 4.5 h last day. Treatment contrast: 0 h.	WMFT, MAL, SIS Measured at baseline, 2 wk, 4, 8 and 12 mos (follow-up)	CIMT can be delivered to eligible patients 3 to 9 months or 15 to 21 months after stroke. Both patient groups achieved approximately the same level of significant arm motor function 24 months after enrollment.

High-intensity mCIMT

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Taub et al 1993	5	9 (4/5)	Age: 65 yr Type: ?? Time since onset: median 4.1 yr Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. control (C) mCIMT: Tasks carried out by affected upper extremity. Resting hand split and sling 90% waking hours. C: Information that they had much greater motor ability with affected upper extremity than they were exhibiting, 2x ‘physical therapy’ including determining PROM, joint play, muscle tone, sensory loss, self-range-of-movement exercises at home (daily 15 min). Intensity: mCIMT: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: ≈60 h.	EMFT, AMAT, MAL Measured at baseline and 2 wk, and 1, 2, 3, 4 wk and 2 yr (follow-up)	Prolonged restraint of unaffected upper extremity and practice on functional movements with affected upper extremity proved to be an effective means of restoring substantial motor functions.
Van der Lee et al 1999	7	66 (33/33)	Age: median 60 (IQR 51.5-63.5) yr Type: first isch/hem Time since onset: median 3.1 (IQR 1.8-5.4) yr Inclusion: ≥20° active wrist extension, ≥10° active finger extension, ARAT <51	Comparison: mCIMT vs. bimanual training mCIMT: Groups of four. Forced use therapy focused on housekeeping activities, handicrafts, and games, wear resting split and closed arm sling. Encouraged to wear split at home, sling only during therapy hours. C: Intensive bimanual training based on NDT, therapy focused on housekeeping activities, handicrafts, and games. Symmetry of posture and inhibition of inappropriate synergistic movements were emphasized. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	RAP, ARAT, FMA arm, MAL, problem score Measured at baseline, 3 wk and 6 wk and 1 year (follow-up)	Small but lasting effect of forced use on dexterity affected arm (ARAT) and temporary clinically relevant effect on MAL AOU, especially in patients with sensory disorders and hemineglect. No effect on ADL.
Wittenberg et al 2003	6	16 (9/7)	Age: 65 (range 41-81) yr Type: first isch Time since onset: 34 (range 16-86) mos Inclusion: ≥20° active wrist extension, ≥10° active finger extension	Comparison: mCIMT vs. control (C) mCIMT: Task-oriented therapy of affected upper extremity, with successive approximation procedure during combined OT, PT and recreational therapy. With hand-split and sling ensemble. Restraint of unaffected hand during waking hours. C: Aimed to improve task performance unaffected upper extremity, passive therapy (stretching and heat) affected arm for 1 h. Intensity: CIMT: 6 h/d, 4 d/wk and 4 h/d, 1 d/wk (weekends), during 10 d. C: 3 h/d, 4 d/wk, during 10 d. Treatment contrast: 42 h.	WMFT, MAL, AMPS, TMS (MEP, mapping, paired-pulse recording), PET Measured at baseline and 2 wk	The only significant between-group difference was in MAL change, but this is a confirmation that mCIMT led to a degree of increased use of the affected side in activities of daily living noticeable to the patient and reported in the MAL.
Alberts et al 2004	5	10 (5/5)	Age: 64.1 (range 41-84) yr Type: first isch/hem Time since onset: 6 (range 3-7) mos Inclusion: ≥20° active wrist extension, ≥10° active finger extension, 90° PROM shoulder flexion and abduction	Comparison: mCIMT vs. control (C) mCIMT: Supervised shaping or adaptive task practice and repetitive task practice technique. Mitt 90% waking hours. C: No therapy. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 60 h.	Maximum precision grip, key-turning experiments, WMFT, FMA arm Measured at baseline and 2 wk	Improved force control may be a mechanism contributing to the observed improvements in dexterous function in those patients undergoing mCIMT.
Suputtitada et al 2004	6	69 (33/36)	Age: Type: first Time since onset: Inclusion: 1-10 yr post stroke, ≥20° active wrist extension, 10° finger extension, ARAT <51, walk indoors without stick, no sensory disorder	Comparison: mCIMT vs. control (C) mCIMT: Nonparetic hand covered by glove, Treatment in groups of 3-4. Encouraged to use affected arm at home. C: Bimanual training based on NDT if necessary support affected arm with nonaffected hand with emphasis on symmetry of posture and inhibition of inappropriate ‘synergistic’ movements, in groups of 3-4. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	ARAT, hand grip strength, pinch grip strength Measured at baseline and 2 wk	mCIMT of unaffected upper extremities has an advantage for chronic stroke patients which ma be an efficacious technique of improving motor activity and exhibiting learned nonuse.
Brogårdh et al 2006	6	16 (9/7)	Age: 57.7 yr Type: isch/hem Time since onset: 28.9	Comparison: mCIMT + extended mitt use (E) vs. mCIMT (C) E: Mitt on affected hand 90% waking hours. Group training (2-3 patients) consisting of: shaping, task practice, fine motor practice, muscle strength, activity	MAS, Sollerman hand function test, two-point discrimination test, MAL	mCIMT, allowing several patients per therapist, seems to be a feasible alternative to improve upper limb motor

			mos Inclusion: ≥10° active dorsiflexion wrist, extend 2 fingers ≥10°, abduct thumb ≥10°	training. After training period extended mitt use at home. C: As experimental. After training period instructed to continue to use the more affected hand in real life situations. Intensity: mCIMT 6h/d, 5 d/wk, during 2 wk. Mitt use at home for 90% waking hours, every other day for periods of 2 wk during three months, in total 21 days. Treatment contrast: 0 h.	Measured at baseline, 2 wk and 3 months (follow-up)	function. The restraint alone, extended in time, did not enhance the treatment effect.
Ro et al 2006	5	8 (4/4)	Age: 58.8 yr Type: isch Time since onset: 8.5 (range 6-10) d Inclusion: ≥10° active finger extension, NIHSS motor arm 1-3	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Shaping, feedback, trial-by-trial graphic representation of performance trends. Mitt 90% waking hours. TR: Increase function with use of both hands, focused on increasing independence in ADL using compensatory technique if needed, including active and/or active-assistive range of motion, ADL using modified or compensatory methods, strengthening and coordination. Intensity: 3 h/d, 6 d/wk, 2 wk. Treatment contrast: 0 h.	TMS (map representation hand), GPT, FMA arm, MAL Measured at baseline, 2 wk and 3 mos (follow-up)	The results suggest that mCIMT may enhance cortical/subcortical motor reorganization and accelerate motor recovery when started within the first two weeks after stroke.
Boake et al 2007	6	23 (10/13)	Age: 63.1±14.3 yr Type: isch/hem Time since onset: 11 (range 5-19) d Inclusion: ≥10° active movement thump and ≥2 fingers, NIHSS score 1-3 on item 5	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Task movements affected arm, selected according motor ability. Behavioral technique of shaping and successive approximation. Wear mitten on unaffected hand during 90% waking hours. TR: Daily living tasks with either hand, intended to improve strength, muscle tone, range of motion. Intensity: 3 h/d, 6 d/wk, during 2 wk. Start inpatient, often continued outpatient. Treatment contrast: 0 h.	FMA arm, GPT, MAL, cortical hand mapping area's Measured at baseline, 2 wk and 3 mos (follow-up)	Long-term improvement in motor function of the affected upper extremity did not differ significantly between those who received CIMT and those who received TR at the same frequency and duration.
Gauthier et al 2008	4	36 (16/20)	Age: 64.5±11.9 yr Type: ?? Time since onset: 3.6±3.6 yr Inclusion: ??	Comparison: mCIMT + transfer package (TP) vs. mCIMT mCIMT + TP: One-by-one training affected arm on functional tasks. Transfer package included daily monitoring of life situation use of the affected arm in several ways and problem-solving to overcome perceived barriers to using the extremity. Restraint 90% waking hours. mCIMT: One-by-one training affected arm on functional tasks. Restraint 90% waking hours. Intensity: CIMT 3 h/d, 5 d/wk, during 2 wk. TP 30 min/d, 5 d/wk, 2 wk. Treatment contrast: 5 h.	MAL, WMFT, MRI Measured at baseline and 2 wk	mCIMT + TP showed profuse changes in gray matter in sensory and motor areas of the brain and hippocampus, accompanied by large improvements in spontaneous real-world arm function but not on WMFT, compared to mCIMT.
Myint et al 2008	7	48 (20/28)	Age: 63.4±13.6 yr Type: isch/hem Time since onset: 38.2±20.4 d Inclusion: ≥20° active wrist extension, ≥10° active extension all digits	Comparison: mCIMT vs. control (C) mCIMT: Training with unaffected arm restrained in a shoulder sling. Supervised activities including shaping, without strict algorithm of tasks with increasing level of difficulty. Sling 90% waking hours during weekdays. C: Conventional OT and PT, using combination of NDT technique (e.g. bimanual tasks upper extremity, compensatory techniques arms, ADL, strength, range of motion, positioning, mobility training). Intensity: 4 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	Functional test hemiparetic upper extremity, ARAT, MAL, mBI, NHPT Measured at baseline, 2 wk and 12 wk (follow-up)	Significant improvement in hand function could be achieved with constraint-induced movement therapy in subacute stroke patients, which was maintained up to 12 week follow-up.
Dahl et al 2008	8	30 (18/12)	Age: 62±8 yr Type: ?? Time since onset: 12±18 mos Inclusion: ≥10° active wrist extension, ≥20° active finger extension	Comparison: mCIMT vs. Control (C) mCIMT: Inpatient, complex to simple tasks related to ADL or leisure time activities. Training in groups of four. Mitt for 90% waking hours. C: Community-based follow-up according to patients' needs, involving upper extremity and lower extremity training. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: mCIMT: 5.7±0.6 h/d, mitt 13.1±2.6 h/d; CT: PT 1.7±1.3 h/wk, OT 0.8±1.5 h/wk.	WMFT, MAL, FIM Measured at baseline, 2 wk and 6 mos (follow-up)	mCIMT is effective and feasible to improve motor functioning in the short term, but no long-term effect was found.
Kim et al 2008	3	21 (13/8)	Age: 51.7±9.5 yr Type: isch/hem Time since onset: 23.8±7.0 mos Inclusion: mild weakness	Comparison: mCIMT vs. Control (C) mCIMT: Wear restraint (modified opposition restriction orthosis [MORO]), unsupervised, with every 2 wk telephone contact researchers. C: No therapy. Intensity: ≥5 h/d, 7 d/wk, during 8 wk.	MFT, PPB, MAL Measured at baseline and 8 wk	This new MORO would be effective for use in a mCIMT program in chronic hemiparetic patients with stroke.

			affected upper extremity, some fine motor ability	Treatment contrast: 280 h.		
Sawaki et al 2008	5	30 (17/13)	Age: 54.4±SEM 3.8 yr Type: first isch/hem Time since onset: 3-9 mos Inclusion: ≥20° active wrist extension, ≥10° active finger extension at thumb and 2 other digits	Comparison: mCIMT vs. Control (C) mCIMT: Intensive upper extremity training with mitt. Unimanual skill acquisition and functional retraining based on principles behavioral training. Emphasizing grasp and manipulation of objects. Also general ADL, coordination and balance. Mitt 90% waking hours including weekends. (As Wolf 2010). C: Usual and custom care. Intensity: CIMT 5 d/wk, during 2 wk. Treatment contrast: ??	WMFT, TMS Measured at baseline, 2 wk and 4 mos (follow-up)	Among subjects who had a stroke within the previous 3 to 9 months, mCIMT produced statistically significant and clinically relevant improvements in arm motor function that persisted for at least 4 months.
Brogårdh et al 2009 and 2010	6, 5	24 (12/12)	Age: 57.6±8.5 yr Type: ?? Time since onset: 7±2.7 wk Inclusion: ≥10° active dorsiflexion wrist, extend 2 fingers ≥10°, abduct thumb ≥10°	Comparison: mCIMT with mitt (E)vs. CIMT without mitt (C) E: Arm and hand exercises: task practice, fine motor practice, muscle strength training, muscle stretching, swimming-pool training, general activity training. Shaping methods included. Mitt use 90% waking hours, 14 d. C: As experimental, without mitt use. Intensity: 3 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	mMAS*, Sollerman hand function test, two-point discrimination test, MAL Measured at baseline, 2 wk and 3 and 12 months (follow-up)	No effect of using a restraint in patients with subacute stroke was found.
Dromerick et al 2009	7	52 (17/19/16)	Age: 69.3±14 yr Type: isch/hem Time since onset: 9.7±4.6 d Inclusion: FMA arm III-V, MAS arm ≥3 but wrist and finger movement not required	Comparison: High intensity mCIMT vs. low intensity mCIMT vs. control (C) High intensity mCIMT: Shaping therapy, basic ADL with supervised massed practice of skilled functional activities. Extensive verbal and written feedback about performance. Wear mitten 90% waking hours. Low intensity mCIMT: As High intensity CIMT, wear mitten 6 h/d. C: Traditional OT involving compensatory technique for ADL, range of motion and strengthening, also bilateral training, adaptive equipment and positioning, use hemiparetic upper extremity was neither encouraged nor discouraged. No massed practice, shaping or constraint. Intensity: High intensity mCIMT: 3 h/d, 5 d/w, during 2 wk. Low intensity mCIMT: 2 h/d, 5 d/wk, during 2 wk. C: 2h/d (1h ADL, 1h bilateral), 5 d/wk during 2 wk. Treatment contrast: High vs. low: 10 h. High vs. C: 10 h. Low vs. C: 0 h.	ARAT, FIM, SIS Measured at baseline, 2 wk and 90 days (follow-up)	mCIMT was equally as effective but not superior to an equal dose of traditional therapy during inpatient stroke rehabilitation. Higher intensity mCIMT resulted in less motor improvement at 90 days, indicating an inverse dose-response relationship.
Woodbury et al 2009	5	12 (6/6)	Age: 60.0±8.6 yr Type: ?? Time since onset: 36.3±35.3 mos Inclusion: active extend wrist, 2 fingers and thumb 10°	Comparison: mCIMT + trunk restraint (TR) vs. mCIMT mCIMT + TR: Supervised functional task practice using affected upper extremity, including feedback and progression in difficulty. No provision of structured shaping like original CIMT. Padded shield provided afferent arm to attempt a reaching strategy that did not include the trunk. Mitt unaffected hand 90% waking hours. mCIMT: Like CIMT + TR but without trunk restraint or trunk-shoulder-elbow coordination strategies. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	FMA arm, WMFT, MAL, kinematics Measured at baseline and 2 wk	Intensive task practice structured to prevent compensatory trunk movements and promote shoulder flexion-elbow extension coordination may reinforce development of 'normal' reaching kinematics.
Hayner et al 2010	2	12 (6/6)	Age: 54.00±11.63 yr Type: ? Time since onset: 642.33±421.121 d Inclusion: place affected hand on table, trace of movement in hand	Comparison: mCIMT vs. BAT mCIMT: Padded mitt unaffected hand, functional activities affected upper extremity. Many tasks involved repetition and daily performance, promoted function and active range of motion, routine and purposeful and intended to be meaningful. Little. Little attempt to facilitate 'normal' movement. Mitt removed for restroom use only. BAT: repetitive and intrusive cueing to use both hands during all activities. Many tasks involved repetition and daily performance, promoted function and active range of motion, routine and purposeful and intended to be meaningful. Little attempt to facilitate 'normal' movement. Intensity: 6 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	WMFT, COPM Measured at baseline, 2 wk and 6 mos (follow-up)	High-intensity OT using a mCIMT or a bilateral approach can improve upper extremity function in people with chronic upper extremity dysfunction after CVA. Treatment intensity rather than restraint may be the critical therapeutic factor.
Wang et al 2011	5	30 (10/10/10)	Age: 59.4±10.89 yr Type: isch/hem	Comparison: mCIMT vs. intensive conventional rehabilitation (ICR) vs. CR mCIMT: Tasks with affected upper extremity, including reaching, grasping, lifting	WMFT	Compared with classical intervention, modified constraint-induced movement

			Time since onset: 11.9±9.59 wk Inclusion: No excessive pain in the affected limb, ≥20° active wrist extension, ≥10° active MCP extension	and placing, using shaping principles. Resting hand splint 90% waking hours. ICR: Strength, balance, manual dexterity exercises, functional task practice when possible, stretching/weight-bearing affected arm, ADLs using less-affected side. High-intensity endurance, strength and functional practice. Focus on affected limb. CR: Strength, balance, manual dexterity exercises, functional task practice when possible, stretching/weight-bearing affected arm, ADLs using less-affected side. Focus on affected limb. Intensity: mCIMT/ICR: 3 h/d, 5 d/wk, during 4 wk. CR: 45 min/d, 5 d/wk, during 4 wk. Treatment contrast: mCIMT vs. ICR: 0 h. mCIMT/ICR vs. CR: 45 h.	Measured at baseline, 2 and 4 wk	therapy showed an apparent advantage over both conventional intervention and intensive conventional rehabilitation for patients after stroke.

Low-intensity mCIMT

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Dromerick et al 2000	5	23 (12/11)	Age: 61.5±13.7 yr Type: isch Time since onset: 6.0±2.6 d Inclusion: NIHSS motor arm 1-2	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Directed attention and effort toward affected arm and minimized use unaffected arm during functional activities. Mitt ≥6 hours daily. TR: OT including compensatory technique for ADL, upper extremity strength, range of motion, positioning. Circuit-training for bilateral self-range of motion and functional activities. Intensity: 2 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	ARAT, BI, FIM Measured at baseline and 2 wk	A clinical trial of mCIMT therapy during acute rehabilitation is feasible. mCIMT was associated with less arm impairment at the end of treatment.
Page et al 2001	3	6 (2/2/2)	Age: range 44-77 yr Type: isch Time since onset: range 2.0-5.5 mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) vs. control (C) mCIMT: Shaping technique. Bobath sling and mitt 5 h every weekday. TR: OT and PT according to PNF (80%) with some compensatory technique. C: No therapy. Intensity: mCIMT and TR: 1 h/d, 3 d/wk, during 10 wk. Treatment contrast: mCIMT vs. TR: 0 h. mCIMT/TR vs. C: 30 h.	FMA arm, ARAT, WMFT, MAL Measured at baseline and 10 wk	Results suggest that mCIMT may be an efficacious method of improving function and use of the affected arms of patients exhibiting learned nonuse.
Page et al 2002	5	14 (4/5/5)	Age: 64.8±11.7 yr Type: isch Time since onset: 4.4 mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) vs. control (C) mCIMT: OT focused on affected arm in valued functional tasks with some wrist/arm strengthening using shaping. PT on affected upper extremity stretching, dynamic stand/balance activities and gait training. Hemi sling and mitt 5 hours every weekday. TR: OT and PT according to PNF (≈80%) with some compensatory technique. C: No therapy. Intensity: mCIMT/TR: 1 h/d, 3 d/wk, during 10 wk. Treatment contrast: mCIMT vs. TR: 0 h. mCIMT/TR vs. C: 30 h.	FMA arm, ARAT, MAL Measured at baseline and 10 wk	mCIMT may be an efficacious method of improving affected arm function and use in stroke patients exhibiting learned nonuse.
Atteya 2004	3	6 (2/2/2)	Age: 54.3±6.9 yr Type: isch Time since onset: 4.7 (range 2.3-5.8) mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) vs. control (C) mCIMT: Shaping technique. Mitt and Bobath sling 5 hours every weekday. TR: Affected upper extremity therapy focused on PNF technique, with emphasis on ADL tasks (80%), compensatory technique (20%). C: No therapy. Intensity: 1 h/d, 3 d/wk, during 10 wk. Treatment contrast: CIMT vs. TR: 0 h. CIMT/ TR vs. C: 30 h.	WMFT, MAL, ARAT, FMA arm Measured at baseline and 10 wk	mCIMT may be an efficacious method of improving function and use of the affected arms in stroke patients exhibiting learned nonuse.
Page et al 2004	5	17 (7/4/6)	Age: 59.2±12.0 yr Type: isch Time since onset: 31.59 (range 1-74) mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) vs. control (C) mCIMT: Affected arm use in functional tasks (25 min), strengthening and/or compensation technique using less affected upper extremity as needed (5 min). Shaping technique. Hemisling and mitt 5 h/d every weekday. TR: Focus on PNF technique with emphasis on functional tasks, stretching affected arm (25 min). Also compensatory technique using less affected arm (5 min). C: No therapy. Intensity: 30 min/d, 5 d/wk, during 10 wk. Treatment contrast: mCIMT vs. TR: 0 h. mCIMT/ TR vs. C: 25 h.	FMA arm, ARAT, MAL Measured at baseline and after 10 wk	mCIMT may be an efficacious method of improving function and use of the more affected arms of chronic stroke patients.
Page et al 2005	4	10 (5/5)	Age: 60.4±8.3 yr Type: isch Time since onset: 4.4 (range 2-9) d Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Individualized sessions, use affected upper extremity in ADLs with shaping technique (25 min), range of motion affected arm (5 min). TR: Standard therapy, stretching affected upper extremity, manual dexterity exercises, teaching of ADLs less affected upper extremity. Intensity: 30 min/d, 3 d/wk, during 10 wk. Treatment contrast: 0 h.	FMA arm, ARAT, MAL Measured at baseline and after 10 wk	mCIMT is a promising regimen for improving more affected limb use and function in acute cerebrovascular accident.

Yen et al 2005	6	30 (13/17)	Age: 67.85±11.2 yr Type: first ?? Time since onset: 8.38±8.00 mos Inclusion: ≥20° active wrist extension, ≥10° active finger extension	Comparison: mCIMT vs. control (C) mCIMT: Shaping therapy without physical restriction unaffected upper extremity. C: Regular program, such as PT (e.g. gait training, facilitation, balance training) or OT. Intensity: 2 h/d, during 2 wk. Treatment contrast: ??	WMFT sub items Measured at baseline and 2 wk.	mCIMT is useful in improving the function of the affected upper extremity in stroke patients.
Lin et al 2007	7	34 (17/17)	Age: 57.89 (range 43-81) yr Type: first isch/hem Time since onset: 16.27 mos Inclusion: FMA arm III-V for proximal and distal parts arm	Comparison: mCIMT vs. control (C) mCIMT: Intensive training of affected arm, restriction movement unaffected upper extremity by wearing mitt 6 h/d. C: Traditional rehabilitation, strength, balance, fine motor dexterity training, functional task practice, stretching/weight bearing affected upper extremity. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h. Mitt use outside therapy.	Kinematics, MAL, FIM Measured at baseline and 3 wk	mCIMT improved motor control strategy during goal-directed reaching.
Wu et al 2007 A	6	47 (24/23)	Age: 55 (range 40-80) yr Type: first isch/hem Time since onset: 12.25 (range 3 wk-37 mos) mos Inclusion: FMA arm proximal part stage III-V	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Use of affected upper extremity in daily activities, mitt wear 6 hours daily. TR: Traditional therapy (NDT) emphasizing functional task practice, stretching, weight bearing, fine-motor dexterity. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematic variables, FMA arm, MAL Measured at baseline and 3 wk	In addition to improving motor performance at the impairment and functional levels, mCIMT conferred therapeutic benefits on control strategies determined by kinematic analysis.
Wu et al 2007 B	7	30 (15/15)	Age: 54.66±8.63 yr Type: first ?? Time since onset: 18.53±6.92 mos Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Use affected arm during functional tasks, using shaping. 15 minutes normalization muscle tone. Mitts 6 h/d during weekdays. TR: NDT emphasizing balance, stretching, weight bearing, fine motor tasks, practice on ADL with unaffected arm. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematics in unilateral and bilateral task, MAL, FIM Measured at baseline and 3 wk	Relative to TR, mCIMT produced a greater improvement in functional performance and motor control. Improvement of motor control after mCIMT was based on improved spatial and temporal efficiency, apparently more salient during bimanual rather than unilateral task performance.
Wu et al 2007 C	7	26 (13/13)	Age: 71.44±6.42 yr Type: first ?? Time since onset: 6.70±8.99 mos Inclusion: FMA arm proximal part stage III-V	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: Shaping and adaptive and repetitive task practice. 15 minutes normalization muscle tone. Mitt 6 h every weekday. TR: 75% NDT emphasizing functional task practice, stretching, weight bearing, fine motor dexterity. 25% compensatory technique using unaffected upper extremity. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, FIM, MAL, SIS Measured at baseline and 3 wk	mCIMT is a promising intervention for improving motor function, daily function, and physical aspects of health related quality of life in elderly patients with stroke.
Page et al 2008	6	35 (13/12/10)	Age: 57.9±8.4 yr Type: first Time since onset: 39.8 (range 20-60) mos Inclusion: ≥20° active wrist extension, ≥10° active extension	Comparison: mCIMT vs. traditional rehabilitation (TR) vs. control (C) mCIMT: One-to-one session, affected arm therapy including shaping. Hemisling and mitt 5 hours every weekday. TR: Affected upper extremity therapy focused on PNF technique, with emphasis on functional tasks and stretching (25 min), and compensatory technique (5 min). C: No therapy. Intensity: mCIMT and TR: 30 min/d, 3 d/wk, during 10 wk. Treatment contrast: mCIMT/TR vs. C: 15 h.	ARAT, FMA arm, MAL Measured at baseline and 10 wk	Data affirm previous findings suggesting that this reimbursable, outpatient protocol increases more affected arm use and function. Magnitude of changes was consistent with those reported in more intense protocols, such as constraint-induced therapy.
Brogårdh et al 2009 and 2010	6, 5	24 (12/12)	Age: 57.6±8.5 yr Type: ?? Time since onset: 7±2.7 wk Inclusion: ≥10° active dorsiflexion wrist, extend 2 fingers ≥10°, abduct thumb ≥10°	Comparison: mCIMT (E) with mitt vs. mCIMT without mitt (C) E: Arm and hand exercises: task practice, fine motor practice, muscle strength training, muscle stretching, swimming-pool training, general activity training. Shaping methods included. Mitt use 90% waking hours, 14 d. C: As experimental, without mitt use. Intensity: 3 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	mMAS*, Sollerman hand function test, two-point discrimination test, MAL Measured at baseline, 2 wk and 3 and 12 months (follow-up)	No effect of using a restraint in patients with subacute stroke was found.

Azab 2009	4	44 (27/17)	Age: 58±10.8 yr Type: ?? Time since onset: 81±23.2 d Inclusion: voluntarily extend fingers and wrist slightly	Comparison: Mitt (E) vs. control (C) E: Wear mitt 6-7 h/d at home, with family member instructed to encourage participant and educated on basic mCIMT procedures at home. Encouraged to practice full functional tasks that may have multiple steps for completion; encouraged to progress task goal according to motor capabilities and speed of performance. Trained to wear mitt independently at the beginning. In addition to conventional OT and PT (see below). C: Conventional OT and PT, including active range of motion of bilateral upper extremities, stretching upper extremities, hand-eye coordination activities, ambulation, strengthening exercises for bilateral upper extremities without wearing mitt. OT and PT each: 40 min/d, 3 d/wk, during 4 wk. Intensity: 6-7 h/d, 7 d/wk, during 2 wk. Treatment contrast: 182 h.	BI Measured at baseline and 4 wk and 6 mos (follow-up)	Following stroke, patients who received mCIMT every day for 4 weeks in conjunction with traditional rehabilitation therapy showed significant changes in the BI upon discharge and this positive outcome was preserved after 6 months follow-up.
Dromerick et al 2009	7	52 (17/19/16)	Age: 69.3±14 yr Type: isch/hem Time since onset: 9.7±4.6 d Inclusion: FMA arm III-V, MAS arm ≥3 but wrist and finger movement not required	Comparison: High intensity mCIMT vs. low intensity mCIMT vs. control (C) High intensity mCIMT: Shaping therapy, basic ADL with supervised massed practice of skilled functional activities. Extensive verbal and written feedback about performance. Wear mitten 90% waking hours. Low intensity mCIMT: As High intensity mCIMT, wear mitten 6 h/d. C: Traditional OT involving compensatory technique for ADL, range of motion and strengthening, also bilateral training, adaptive equipment and positioning, use hemiparetic upper extremity was neither encouraged nor discouraged. No massed practice, shaping or constraint. Intensity: High intensity mCIMT: 3 h/d, 5 d/w, during 2 wk. Low intensity mCIMT: 2 h/d, 5 d/wk, during 2 wk. CT: 2h/d (1h ADL, 1h bilateral), 5 d/wk during 2 wk. Treatment contrast: 10 h.	ARAT, FIM, SIS Measured at baseline, 2 wk and 90 days (follow-up)	mCIMT was equally as effective but not superior to an equal dose of traditional therapy during inpatient stroke rehabilitation. Higher intensity mCIMT resulted in less motor improvement at 90 days, indicating an inverse dose-response relationship.
Lin et al 2009 A	7	60 (20/20/20)	Age: 52.14 (range 23-82) yr Type: first isch/hem Time since onset: 21.25±21.59 mos Inclusion: FMA arm III-V for proximal and distal parts arm	Comparison: mCIMT vs. BAT vs. control (C) mCIMT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lifting 2 cups, picking up 2 pegs, grasping and releasing 2 towels, wiping the table with 2 hands. No at home practice. C: Usual therapy, partly based on principles of NDT: functional task practice for hand function, coordination, balance, movements of affected arm, compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, FIM, MAL, SIS Measured at baseline and 3 wk	BAT may uniquely improve proximal upper limb motor impairment. In contrast, distributed CIT may produce greater functional gains for the affected upper limb in subjects with mild to moderate chronic hemiparesis.
Lin et al 2009 B	7	32 (16/16)	Age: 55.7 (range 30-75) yr Type: first ??? Time: 15.1 (range 6-40) mos Inclusion: FMA arm proximal III-V	Comparison: mCIMT vs. control (C) mCIMT: Functional training affected arm. Shaping, adaptive, and repetitive practice of functional tasks, if needed normalization muscle tone up to 15 min. Outside therapy mitt for 5 h daily. C: NDT emphasizing functional task practice, weight bearing affected limb, fine motor dexterity activities. 25% of time compensatory technique using less affected limb to perform functional tasks and assist affected limb during task performance. Outside therapy mitt for 5 h daily. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, FIM, MAL, NEADL, SIS Measured at baseline and 3 wk	The robust effects of this form of mCIMT were demonstrated in various aspects of outcome, including motor function, basic and extended functional ability, and quality of life.
Abu Tariah et al 2010	6	20 (10/10)	Age: 54.8±10.9 yr Type: first Time since onset: 9.2±5.79 mos Inclusion: >2 mos post stroke, 40-75 yr, live with familiy caregivers at home, ≥20° active wrist extension, ≥10° active extension MCP	Comparison: mCIMT vs. traditional rehabilitation (TR) mCIMT: OT educated and trained stroke survivor and caregiver in 3-4 sessions, including: orientation CIMT approach, importance caregivers' commitment, detailed information about training activities. Treatment consisted of 1) restricting movement unaffected hand with splint 2 h/d; 2) intensive training of affected arm while restraining unaffected hand 2 h/d. Training based on self-induced voluntary movement using principles of motor learning and shaping; focusing on ADL, instrumental ADL and leisure activities. All training at home. TR: NDT approach, including weight bearing and facilitation of arm movement. In	WMFT, MAL, FMA arm Measured at baseline and 2 mos and 6 mos (follow-up)	Home based mCIMT conducted by caregivers with therapists' support is a promising approach for improving affected upper limb in stroke survivors.

			and IP, MAL >2.5; no balance problem, excessive spasticity and pain	out-patient rehabilitation department at weekdays 2 h/d and during the weekend home programme 2 h/d. Intensity: mCIMT 2 h/d, 7 d/wk, during 8 wk. Treatment contrast: 0 h.		
Lin et al 2010 A	6	13 (5/8)	Age: 49.6 yr Type: first ?? Time since onset: 18.3 mos Inclusion: 20° dorsiflexion, 10° extension MCP and IP dig II-V	Comparison: mCIMT vs. control (C) mCIMT: Mitt for 6 h daily and intensively train affected upper extremity in repetitive practice of functional activities and behavioral shaping. C: Usual therapy, based on principles of NDT: balance training, stretch affected upper extremity, fine-motor tasks, practice of activities of daily living with unaffected upper extremity. Compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, MAL, fMRI Measured at baseline and 3 wk	The preliminary findings suggest that the functional improvements produced by mCIMT were accompanied by brain plastic reorganization, especially in the contralesional hemisphere, possibly through an ipsilateral motor pathway.
Sun et al 2010	7	32 (16/16)	Age: 58.7±9.9 yr Type: isch/hem Time since onset: 2.9±1.5 yr Inclusion: ≥20° active wrist extension, ≥10° active extension MCP and IP	Comparison: BtxA + mCIMT vs. BtxA + conventional rehabilitation (CR) BtxA + mCIMT: BtxA affected upper extremity. Massed practice, shaping, behavioral contract and daily treatment diary. Mitt≥5 h/d of waking hours for 3 mos. BtxA + CR: BtxA affected upper extremity. OT and PT, based on NDT technique, focusing on normalizing tone and movement patterns, inhibition of abnormal tone and movement patters. Restoration of stance, gait, dexterity, stamina training. Upper extremity training 40% of time, mostly devoted to tone-inhibiting maneuvers and improving proximal muscle control. Intensity: 2 h/d, 3 d/wk, during 3 mos. Treatment contrast: 0 h.	MAS, MAL, ARAT Measured at baseline, 4 wk, 3 mos and 6 mos (follow-up).	Combining BtxA and mCIMT is an effective and safe intervention for improving spasticity and motor function in chronic stroke patients.
Wu et al 2010	2	6 (2/4)	Age: 56.0 (range 45-68) yr Type: ?? Time since onset: 23.5 (range 11-57) mos Inclusion: FMA arm stage III-V	Comparison: mCIMT vs. BAT mCIMT: Mitt wearing and intensive training of the affected arm with functional activities and behavioral shaping. BAT: Simultaneous movement of upper extremities in functional tasks in symmetric or alternating patterns that emphasized both upper extremities moving synchronously. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	fMRI, FMA arm, ARAT, MAL Measured at baseline and 3 wk	The findings of this preliminary research revealed that neuroplastic changes after stroke motor rehabilitation may be specific to the intervention.
Wu et al 2011	6	66 (22/22/22)	Age: 53.11 yr Type: isch/hem Time since onset: 16.20 mos Inclusion: FMA arm stage III-V	Comparison: mCIMT vs BAT vs control (C) mCIMT: Mitt for 6 h daily and intensively train affected extremity in functional tasks, e.g. reaching to move cup, picking up coins, picking up a utensil to take food, grasping and releasing various blocks. BAT: Simultaneous movements in symmetric or alternating patterns of both upper extremities in functional tasks, e.g. lift 2 cups, picking up 2 pegs, grasping and releasing 2 towels, wiping the table with 2 hands. C: Usual therapy, about 75% based on principles of NDT: functional task practice for hand function, coordination, balance, stretching, weight bearing affected upper extremity. 25% compensatory practice on functional tasks with unaffected upper extremity or both. Intensity: 2 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	Kinematic analysis unilateral and bilateral, WMFT, MAL Measured at baseline and 3 wk	BAT and mCIMT exhibited similar beneficial effects on movement smoothness but differential effects on force at movement initiation and functional performance.

Forced use

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Ploughman et al 2004	5	27 (13/14)	Age: 61.62±5.68 yr Type: first isch/hem Time since onset: 38.8±23.4 d Inclusion: CMMSA stage 2-6	Comparison: Conventional rehabilitation (CR) + forced use (FU) vs. CR CR + FU: Facilitation of proximal motor control progressing to skilled-task training upper extremity. Also strength and endurance, functional electric stimulation, gait training, education. Progressive mitten wearing 1 hour increasing to 6 hours daily at week 2 and continuing at that level for the remaining rehabilitation period. CR: Facilitation of proximal motor control progressing to skilled-task training arm. Also strength and endurance, functional electric stimulation, gait training, education. Intensity: 58.9±41.45 vs. 61.74±23.68 min/d (p=.849) Treatment contrast: 0 h. Mitten 2.7 h/d.	ARAT, CMMSA Measured at baseline and last 2 days of active rehabilitation	FU without shaping therapy appears to augment arm recovery.
Hammer et al 2009	7	30 (15/15)	Age: 66.3±10.3 yr Type: ?? Time since onset: 2.4 mos Inclusion: ≥20° active wrist extension, ≥10° active finger extension	Comparison: Rehabilitation + forced use vs. rehabilitation (C) Rehabilitation + forced use: Conventional interdisciplinary rehabilitation programme. Restraining sling up to 6 h/d, 5 d/wk during 2 wk. C: Conventional interdisciplinary rehabilitation programme. Intensity: 3 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h. Sling wear 60 h in total (applied: 37.4±11.5 h).	MAL, FMA arm, ARAT, mMAS*, MAS, 16HPT, grip ratio Measured at baseline, 2 wk and 1 and 3 mos (follow-up)	This pilot study did not reveal any additional benefit of forced use on self-rated performance in daily use of the paretic upper limb.

RCTs KNGF-guideline 2004 (original CIMT, modified CIMT, Forced use)

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Taub et al. 1993	RCT	10 at the start, 10% drop-outs 9 (4/5)	median 64 y	type: ? chronic: median 4.3 y after stroke, range 1-18y	Yes	Training with unaffected arm restrained vs attention training affected arm E: unaffected arm in splint/sling during waking hours for 2 weeks; on 10 days 6 hours training of the affected arm.	EMF, AMAT and MAL measured 2 weeks after start training and at 1 mo and 2 y after training	Restraint of the unaffected arm and practice of functional movements with the impaired limb proved to be an effective means of restoring substantial motor function in chronic stroke patients.	5 failure at questions: 3,5,6,9,11
Van der Lee et al. 1999	RCT	66 (33/33) 5% drop-outs, 62 (31/31) completed the study	median 61 y, range 22-80 y	types: all chronic: median 3 y, range 1-20 y	Yes	Forced use therapy vs bimanual training based on NDT E: 6 hrs/d unaffected arm immobilized by splint and sling, 5d/wk during 12 days.	ARAT, RAP, FMA and MAL measured at 3 and 6 wk and after 6 and 12 mo	A small but lasting effect of forced use therapy on the dexterity of the affected arm (ARAT) and a temporary clinically relevant effect on the amount of use of the affected arm during ADL (MAL amount of use). No effect on ADL (RAP)	7 failure at questions: 4,5,6
Dromerick et al. 2000	RCT	23 at the start 13% drop-outs, 20 (11/9) completed the study	mean: 66.5 y + 9.5 y, range 47-83 y	type: iCVA acute: mean 6 d + 2.6 d after stroke	Yes	CIMT vs Traditional therapy E+C: treatments for 2 hours/day, 5 d/wk for 2 wk; E: the unaffected hand wore a padded mitten for at least 6 hrs/d during 2 weeks.	ARAT, BI and FIM measured at the start and at the end of the 2-week treatment period	CIMT during acute rehabilitation was associated with less arm impairment at the end of treatment.	5 failure at questions: 3,5,6,9,11

Page et al. 2001	RCT	6 (2 / 2 / 2)	mean: 55.8 + 11.6 y, range 44-77 y	type: iCVA post-acute: mean 4.6 mo after stroke, range 2 - 5.5 mo	Yes	Training affected arm (E1) vs Traditional PT and OT (E2) vs No therapy (C) E1: 3x/wk 60 minutes during 10 weeks, in which lower arms and hands were restrained every weekday for 5 hours. The unaffected arm immobilized by splint and sling, 5d/wk for 5 hrs/d during 10 weeks. E2: 3x/wk 60 minutes during 10 weeks; traditional PT and OT	FMA, ARAT, WMFT and MAL measured at the start and at the end of the 10-week treatment period	Results suggest that modified CIMT may be an efficacious method of improving function and use of the affected arms of patients exhibiting learned non-use.	5 failure at questions: 3,5,6,10,11
Page et al. 2002	RCT	14 (4 / 5 / 5)	mean: 64.8 + 11.7 y, range 45-83 y	type: iCVA post-acute: mean 4.4 mo after stroke, range 4 - 6 mo	Yes	Training affected arm (E1) vs Traditional PT and OT (E2) vs No therapy (C) E1: 3x/wk 60 minutes during 10 weeks, in which lower arms and hands were restrained every weekday for 5 hours (stretching affected UE, dynamic stand/balance activities and gait training). The unaffected arm immobilized by splint and sling, 5d/wk for 5 hrs/d during 10 weeks. E2: 3x/wk 60 minutes during 10 weeks; traditional PT and OT, based on PNF-principles or compensatory techniques.	FMA, ARAT and MAL measured at the start and at the end of the 10-week treatment period	Modified CIMT may be an efficacious method of improving affected arm function and use in stroke patients exhibiting learned non-use	5 failure at questions: 3,5,6,10,11
Sterr et al. 2002	RCT	15 (7 / 8) 13 patients with stroke and 2 with TBI	mean: 59.2 y (range 23-77 y.)	type: all chronic: mean 4.8 y + 4.7 y. after stroke, range 1-17 y	Yes	Evaluate and compare the effects of 3-hour vs 6-hour daily training sessions in CIMT E +C: 6 hrs or 3 hrs respectively, CIMT with constraint of unaffected arm for a target of 90% of waking hours Treatment was given every weekday for 14 consecutive days	MAL and WMFT measured 2 weeks after start training and 4 follow-up measurements in the a 1-month period	The 3 –hour CIMT training schedule significantly improved motor function in chronic hemiparesis, but it was less effective than 6-hour training schedule.	4 failure at questions: 3,5,6,9,10,1 1

RCTs investigating robot-assisted training of the paretic arm (paragraaf G.1.7)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Aisen et al 1997, Volpe et al 1999	7, 5	20 (10/10)	Age: 58.5±8.3 yr Type: first isch/hem Time since onset: 2.8±1.1 wk Inclusion: ??	Comparison: Robotics vs. sham (C) Robotics: Robot (MIT-Manus) therapy consisting of interactive, goal-directed motor activity, with video monitor giving visual and auditory feedback. In case of paralysis, the limb movement was initially passive, and as motor function returned the robot required initiation of motor activity by the patient. Flexion, extension and rotational movements across elbow and shoulder joints. In addition to conventional therapy. C: Weekly to biweekly contact with robotic device, during which the patient actively moved the robotic arm and were able to observe the response on the video monitor. In addition to conventional therapy. Intensity: Robotics: 4-5 h/wk, during 9.2±2.5 wk. C: ?? Treatment contrast: ??	FIM, FMA arm, MSS, MP Measured at baseline, discharge and 3 yr (follow-up)	These results suggest that robotic manipulation of the impaired limb may favorably add to recovery following stroke and that robotics may provide new strategies for neurologic rehabilitation. In re-evaluating nearly 3 years later, robot-trained patients showed further significant decreases in impairment measures of the affected limb.
Volpe et al 2000	4	56 (30/26)	Age: 62±10.95 yr Type: isch/hem Time since onset: 14.0±6.09 d Inclusion: hemiparesis upper and lower extremity	Comparison: Robotics vs. sham (C) Robotics: Robot (MIT-Manus) therapy with focus on shoulder and elbow movement patterns, requiring to move handle at tip of robot which in turn moved a cursor on a screen. Video screen provided visual feedback, auditory feedback indicated correct movements. If patient did not respond, the robot guided the patients' hand to target. Protocol organized in three batches, each batch consisting of 20 repetitions; over minimum 25 sessions, at least 1500 repetitions of goal-directed movement to a target. In addition to conventional therapy. C Initial exposure to robot, with exception that half of trials were performed with unimpaired upper limb, if unable to perform movement, the unimpaired limb or technician assisted the movement. In addition to conventional therapy. Intensity: Robotics: 1 h/d, 5 d/wk, till discharge Treatment contrast: ??	FMA shoulder-elbow-coordination, FMA wrist-hand, MP, MSS shoulder-elbow, MSS wrist-hand, FIM Measured at baseline and discharge	Robot-delivered quantitative and reproducible sensorimotor training enhanced the motor performance of the exercised shoulder and elbow. The robot-treated group also demonstrated improved functional outcome.
Lum et al 2002 (preliminary: Burgar et al 2000)	6	27 (13/14)	Age: 63.2±3.6 yr Type: first Time since onset: 30.2±6.2 mos Inclusion: upper limb motor function deficit, no joint pain or ROM limitations	Comparison: Robotics vs. conventional (C) Robotics: Robotics with 6 degrees of freedom, using 4 modes: passive (5 minutes), bimanual (12 minutes), active-assisted and active-constraint (20 minutes). Emphasis on 12 targeted reaching movements that started close to the body and ended further away, in four directions: forward medial, directly forward, forward lateral, directly lateral (Four point-to-point directions: shoulder flexion/ adduction, shoulder flexion, shoulder flexion/ abduction/ external rotation, shoulder abduction/ external rotation); on varying heights: tabletop, shoulder, eye level. Progressing from easiest to most challenging mode. During active-constrained, feedback on fraction of movement completed or time to complete 3 repetitions. Tone normalization (5 min) and limb positioning at the beginning and end of each session. C: Conventional therapy, targeting proximal upper limb function based on NDT. Physical postural base of support coupled with assessing and facilitating alignment of shoulder (10 minutes), graded application of arm use in functional leisure and self-care tasks (35 minutes). Emphasis on re-education of muscles using a sensorimotor approach. Progression by increasing number of repetitions, weight of item, height at which tasks were done. Practice highest level task that was competed, with review (10 minutes). Exposure to robot (5 minutes). Intensity: 24 sessions, 1 h/session, during 2 mos. Treatment contrast: 0 h.	FMA arm, BI, FIM self-care and transfer, strength, reaching ability Measured at baseline, 1 and 2 mos, and 6 mos (follow-up)	Compared with conventional treatment, robot-assisted movements had advantages in terms of clinical and biomechanical measures.
Stein et al 2004 ≈ Volpe 2008?	6	28 (9/9/5/5)	Age: 53.3±16.4 yr Type: first isch/hem Time since onset:	Comparison: Active-assisted robotics vs. progressive resistance robotics Active: Robot-assisted reaching tasks in the horizontal plane that involved shoulder and elbow movements, moving between center target and eight	FMA arm, MAS, MSS, MRC, peak force	The incorporation of robot-aided progressive resistance exercises into a program of robot-aided exercise did not

			27.2±12.7 mos Inclusion: MRC shoulder/ elbow 2-4	peripheral targets arranged in a circular display. If patient could reach target independently, guidance to target to improve quality and efficiency by providing a tactile carm. Visual feedback of location and robot handle. In each session 60 repetitions. Therapist provided instructions and general encouragements, no specific feedback regarding performance. In total about 18,000 repetitive reaching movements with their paretic arm. <u>Resistance</u>: As active-assisted task, but with the provision of resistance to the desired movement. In total about 18,000 repetitive reaching movements with their paretic arm. <u>Intensity</u>: 1 h/d, 3 d/wk, during 6 wk. <u>Treatment contrast</u>: 0 h.	Measured at baseline and 6 wk	favorably or negatively affect the gains in motor control or strength associated with this training.
Daly et al 2005	5	12 (6/6)	Age: ?? Type: isch/hem Time since onset: >12 mos Inclusion: Wrist extensors MRC ≥1, FMA coordination >10	<u>Comparison</u>: Functional neuromuscular stimulation and motor learning (FNS-ML) vs. robotics-ML (ROB-ML) <u>FNS-ML</u>: Wrist and finger muscle activation with FNS with surface electrodes. Practice single and multiple joint movements, including wrist flexion/extension, finger and thumb flexion/extension, simultaneous wrist extension and finger flexion. FNS was used along with task component movements. 10 seconds stimulus, 10 seconds rest. 3.5 h task component s practice and whole task practice without technology assistance, focusing on coordination but also subject's interest and functional goals. <u>ROB-ML</u>: Shoulder-elbow robot with training in horizontal plane with supported forearm (2 degrees of freedom). Allowing for resisted, active, or assisted movement. 1.5 h training shoulder/elbow movement accuracy, trajectory maintenance, movement smoothness. Visual display provided online visual feedback. 3.5 h practice of functional task components and whole task practice without technology assistance, focusing on coordination but also subject's interest and functional goals. <u>Intensity</u>: 5 h/d, 5 d/wk, during 12 wk. <u>Treatment contrast</u>: 0 h.	AMAT, AMAT shoulder-elbow, AMAT wrist-hand, FMA arm, motor control measures Measured at baseline, 12 wk and 6 mos (follow-up)	ROB-ML produced significant gains in AMAT, AMAT shoulder-elbow, FMA arm, target accuracy en smoothness of movement. FNS-ML produced significant gains in AMAT wrist-hand and FMA arm.
Hesse et al 2005	7	44 (22/22)	Age: 65.4±11.5 yr Type: first ?? Time since onset: 5.1±1.3 wk Inclusion: MRC 0 or 1 of wrist and finger extensors	<u>Comparison</u>: Arm trainer (AT) vs. electrical stimulation (ES) <u>AT</u>: Computerized arm trainer with repetitive practice of passive and active bilateral forearm and wrist movement cycle, with modes 1) passive-passive with both arms moved by machine, 2) active-passive with nonaffected arm driving affected side, 3) active-active with both arms actively moving against resistance. Total 400 cycles or 800 repetitions, additionally 25-50 repetitions in mode 3. Practice without close supervision. In addition to conventional rehabilitation. <u>ES</u>: EMG-initiated ES of paretic wrist extensors (4-7 seconds stimulation, 8-15 seconds rest; total 60-80 repetitions). Practice without close supervision. In addition to conventional rehabilitation. <u>Intensity</u>: 20 min/d, 5 d/wk, during 6 wk. In addition to standard inpatient rehabilitation. <u>Treatment contrast</u>: 0 h.	FMA arm, MRC shoulder abductors/ elbow flexors/wrist/fingers/thumb, MAS Measured at baseline, 4 and 6 wk and 3 mos (follow-up)	AT produced superior improvement in upper limb motor control and power compared to ES in severely affected stroke patients.
Kahn et al 2006	6	19 (10/9)	Age: 55.6±12.2 yr Type: ?? Time since onset: 75.8±45.5 mos Inclusion: CMMSA 2-5; no severe sensory loss, shoulder pain, severe contracture or muscle wasting	<u>Comparison</u>: Robot trained vs. free reaching <u>Robot trained</u>: Robot-guided active-assist training with motor and chain drive robot with reaching movements over entire supported passive ROM with targets located at limit of subject's workspace; start with eight voluntary reaches. A single session consisted of 10 reaches to each of 5 targets at different locations in a workspace, for a total of 50 movements along a straight line path and followed a smooth translation profile. Active assistance until subject initiated movement through at least 1 cm along the track, 1 cm deadband in position trajectory to allow subject to be within a small margin of error along the planned path before motor provided assistance. Graphical feedback of amount of assistance provided after every 5th reach and instructed to reduce this level. <u>Free reaching</u>: Free reaching training; with matched number of reaches to same targets, but not attached to device and no limb support against gravity or mechanical constraint for arm movement. Instructed to reach as fast as possible to the target, maintain position for one second and then relax. Feedback after	Biomechanical (stiffness, reaching range, velocity), CMMSA, RLAFT Measured at baseline (3 wk), 8 wk (3 wk) and 6 mos (follow-up)	Improvements with both forms of exercise confirmed that repeated, task-related voluntary activation of the damaged motor system is a key stimulus to motor recovery following chronic stroke.

				every 5th trial. Intensity: 24x 45 min/d, during 8 wk. Treatment contrast: 0 h.		
Lum et al 2006	5	30 (10/9/5/6)	Age: 62.3±2.8 yr Type: first ?? Time since onset: 13.0±2.1 wk Inclusion: no upper extremity joint pain or ROM limitations	Comparison: Robot combined vs. robot unilateral vs. robot bilateral vs. control (C) Robot combined: 12 targeted reaching movements, half of the time in unilateral mode, half of the time in bilateral mode. Robot unilateral: 12 targeted reaching movements, progressed from easiest exercise modes (passive) to most challenging (active-constraint), no bilateral exercises. Robot bilateral: 12 targeted reaching movements, bilateral mode, rhythmic circular movements were also performed. C: Conventional therapy targeting proximal upper extremity function based on NDT. Intensity: 1 h/d, 15 sessions, during 4 wk. Treatment contrast: 0 h.	FMA arm, FIM self-care and transfer, MP, MAS Measured at baseline, 4 wk and 6 mos (follow-up)	At posttreatment, robotic-combined training group had significantly greater gains than the control group. However, gains in robot and control groups were equivalent at the 6 month follow-up. No significant differences were found between the robot-combined and robot-unilateral treatment. Less benefit from bilateral therapy alone, because this group had the smallest gains.
Masiero et al 2007	5	35 (17/18)	Age: 63.4±11.8 yr Type: first isch Time since onset: 4.8 (range 3-7) d Inclusion: no early severe spasticity	Comparison: Robotics vs. control (C) Robotics: 3-degree-of-freedom wire-based robot, allowing lying supine in bed or sit in wheelchair, programmed to perform repetitive movements (flexion/extension, adduction/abduction, pronation/supination, circular) of shoulder and elbow. After setting way points (trajectory) voluntarily contributing to movement slowly, motion speed increased according to improvements, verbally encouraged by assistant. 5-7 cycles of each 3 minutes, followed by 1-minute resting period. Visible and auditory feedback by personal computer. In addition to standard rehabilitation based on Bobath. C: Exposure to robot, but exercises with unimpaired arm. Intensity: Robotics: 20-30 min, 25 sessions, 2x/d, 4 h/wk, 5 d/wk, during 5 wk. C: 30 min/d, 2 d/wk, during 5 wk. Treatment contrast: 15 h.	MRC, FMA arm, FIM, TCT, MAS Measured at baseline, 5 wk and 3 and 8 mos (follow-up)	Patients who received robotic therapy in addition to conventional therapy showed greater reductions in motor impairment and improvements in functional abilities.
Mayr et al 2008	4	8 (4/4)	Age: 68.25±12.20 yr Type: isch/hem Time since onset: 2.38±0.74 mos Inclusion: left hemiparesis	Comparison: Robotics vs. EMG-NMS Robotics: Electromechanical arm robot (ARMOR) with 12 degrees of freedom (8 active, 4 passive), with progressive program. In addition to conventional rehabilitation. EMG-NMS: EMG-NMS with 3 electrodes, 35-50 Hz, 5 seconds stimulation, decrease in 1 second. In addition to conventional rehabilitation. Intensity: 30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	CMMSA, MAS, ROM, FDT Measured at baseline and 2 wk.	This study demonstrates the positive effect of automatised training with a new electromechanical arm robot (ARMOR).
Rabadi et al 2008	6	30 (10/10/10)	Age: 67.80±12.66 yr Type: first isch/hem Time since onset: 22.50±18.22 d Inclusion: MRC shoulder ≤2, no anterior or inferior shoulder subluxation ≥3 and/or shoulder-hand syndrome	Comparison: Therapy vs. ergometer vs. robot Therapy: Standard OT and PT; OT consists of positioning and safe-handling of paretic arm, passive and active ROM, technique incorporating motor learning, neurodevelopment and proprioceptive neuromuscular facilitative approaches. In addition, group therapy following a set protocol (self ROM exercises focusing on patient-directed movements at the affected shoulder, elbow and hand), and encouraged to use unaffected arm in actively assisting paretic arm movement. Per session 640 to-and-fro movements. Ergometer: Standard OT and PT. In addition bidirectional hand cycle, 20 minutes continuous cycling at 0 resistance, 5 minutes rest, cycle 20 minutes. Unaffected arm helped move the paretic arm, the exercise was stopped if the patient reported fatigarm or discomfort in the affected arm. On average 55-60 to-and-fro cycling movements per minute (2200 total movements per session). Robot: Standard OT and PT. In addition goal-directed, robot-assisted arm movement, and customized interactive computer-generated video programme providing visual feedback about speed and accuracy of reaching target. Initially passive, but in case of recovery assistance in initiating. Flexion, extension and rotation at elbow and shoulder. Per session 2x 20 minutes with 5 minutes rest, in total 1024 to-and-fro movements.	FMA arm, FIM, MSS Measured at baseline and discharge	This study suggests that activity-based therapies using an arm ergometer or robot when used over shortened training periods have the same effect as OT group therapy in decreasing impairment and improving disability in the paretic arm of severely affected stroke patients in the subacute phase.

				Intensity: All: 3 h/d, standard OT and PT. Therapy/ergometer/robot: 12 sessions, 40 min/d, 5 d/wk. Treatment contrast: 0 h.		
Takahashi et al 2008	5	13 (7/6)	Age: 63±16 yr Type: ?? Time since onset: 2.9±5.1 yr Inclusion: right hemiparesis, ≥10° extension MCP index finger, FMA hand 2-20, NHPT 25% longer than left hand, MAS <4	Comparison: Active assist (A-A) vs. non-assist and active assist (ANA-A) A-A: 3 degrees-of-freedom, pneumatically actuated device that assist hand in grasp and release movements, enabling real-time virtual reality hand movements. 9 cycles of 10 repetitions of grasp-release exercises, each during 11-15 seconds, robot assisted if necessary. During 75% of the cycles, an examiner placed into the area in front of the subject's palm one of several objects. Also playing a set of interactive virtual reality computer game, providing information on joint angle, emphasizing hand movement range, speed and timing. Therapist adjusted game difficulty. ANA-A: First 7,5 sessions no active assistance of robotics while performing exercises, second 7.5 sessions as A-A. Intensity: 1.5 h/d, 5 d/wk, during 3 wk. Treatment contrast: 0 h.	ARAT, BBT, FMA arm Measured at baseline, 1.5 wk (mid), 3 wk and 1 mos (follow-up)	A robot-based therapy showed improvements in hand motor function after chronic stroke.
Volpe et al 2008	6	21 (11/10)	Age: 62±3 yr Type: first isch/hem Time since onset: 35±7 mos Inclusion: FMA arm shoulder-elbow >33	Comparison: Robotics vs. intensive movement protocol Robotic: Planar robot, which guided the trajectory and speed of the patient's arm to provide an adaptive sensorimotor experience, if the patient could not move the robot arm. Intensive: Static stretching (adductor/internal rotator groups of shoulder girdle and elbow flexors), systematically varied levels of active-assisted arm exercise (20 minutes bilateral arm training on arm ergometer, 3x 15 repetitions with 30 seconds rest of humeral elevation exercises with grip fasteners), goal-directed planar reaching tasks based on Carr and Sheperd principles, which were adapted using Bobath NDT (Figure-eight movements for 5 minutes, then reaching in a point-to-point fashion, side-to-side and forward for 5 minutes, 10 min Bobath-based activities, including closed- and open-chain exercises). Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, MP, MAS, SIS, ARAT, pain, BDS Measarmrd at baseline, 3 wk (mid) and 6 wk	These new protocols, rendered by either therapist or robot, can be standardized, tested, and replicated, and potentially will contribute to rational activity-based programs.
Ellis et al 2009	5	14 (7/7)	Age: 59.14±6.87 yr Type: ?? Time since onset: chronic Inclusion: FMA arm 10-50, no greater than minimal sensory loss affected arm, full passive elbow extension, ≥90° shoulder abduction	Comparison: Progressive shoulder loading vs. control (C) Shoulder loading: Reaching movements to targets in 5 standardized directions near end of reaching ROM and spanning a large portion of work area while supporting a percentage of the weight of the arm. Goal to progressively increase percentage of arm weight actively supported by participant while reaching forward. Sit in chair with arm resting in forearm-hand orthosis attached to a haptic surface. Occasional feedback of movement performance. 3x10 repetitions, rest periods up to 30 seconds between trials and fixed 1-minute rests between sets. Start maximal effort of max 50% of distance to target, increased when 8-10 repetitions were within 0% of distance to target. Decrease arm support in steps of 25%. C: Same protocol als experimental group, but never required to actively support any weight of the arm above haptic table. Encouraged to fully acquire the targets in every repetition of practice. Intensity: 3 d/wk, 8 wk. Treatment contrast: 0 h.	Work area, isometric strength, EMG Measured at baseline and 8 wk	This study demonstrated that functionally relevant reaching range of motion (work area) can be improved in individuals with chronic hemiparetic stroke.
Housman et al 2009	4	31 (15/16)	Age: 54.2±11.9 yr Type: first isch/hem Time since onset: 84.5±96.3 mos Inclusion: FMA arm 10-30	Comparison: passive nonrobotic arm orthosis (T-WREX) vs. conventional (C) T-WREX: 5-degree of freedom passive nonrobotic arm orthosis, providing weight support for the arm across a large 3D workspace, including position sensors to interact with repetitive task-specific computer games, requiring that the patient always initiates movement, offers easily variable levels of gravity support. Patients receive auditory and visual feedback. First 3 sessions with OT to ensure competence with T-WREX and control protocols, after 3rd treatment exercise with intermittent supervision. Each session 3 repetitions of 10 therapy games, gravity-balance compensation decreased over the days. C: Conventional exercises in therapy groups and home exercise programs,	FMA arm, RFTHUE, MAL, kinematics, grip strength Measured at baseline, post intervention and 6 months (follow-up)	Gravity-supported arm exercise, using the T-WREX or tabletop support, can improve arm movement ability after chronic severe hemipmaresis with brief one-on-one assistance from a therapist (approximately 4 minutes per session).

				focusing on self-range of motion, stretches and active ROM, strengthening exercises, use affected arm as a functional assist during a prescribed list of ADLs. After 3 sessions with OT, completion of the exercises semiautonomous by progressing through handout. Intensity: 24x 1 h sessions; +/- 3 d/wk, during 8-9 wk. Treatment contrast: 0 h.		
Hu et al 2009	4	27 (15/12)	Age: 49.2±14.7 yr Type: first isch/hem Time since onset: 4.7±5.2 yr Inclusion: FMA arm 9< shoulder/elbow; 6< wrist/hand <18	Comparison: interactive robot vs. passive motion robot Interactive: Robotic system providing interactive assistive torqarm in voluntary wrist flexion and extension -45° to 60° by tracking a target cursor with angular velocity of 10°/s. Objective to minimize distance between target and actual wrist angles. Each session consisted of 14 trials, each trial contained 5 cycles of wrist flexion and extension. 2 minutes rest between trials. Passive: Robotic with standard setup for wrist extension and flexion. In each session wrist IMVF and IMVE at joint angle of 0° repeated 3 times, then 14 training trials of 5 cycles of passive wrist extension and flexion from -45° to 60° with angular velocity of 10°/s. Intensity: 20 sessions in 7 wk, most often 3-5 d/wk. Treatment contrast: 0 h.	FMA arm, MAS, ARAT, FIM, robotic parameters Measured at baseline and 7 wk	The interactive treatment improved muscle coordination and reduced spasticity after the training for both the wrist and elbow joints, which persisted for 3 months. The passive mode training mainly reduced the spasticity in the wrist flexor.
Kutner et al 2010	5	17 (7/10)	Age: 57.4±13.4 yr Type: first isch/hem Time since onset: 234.4±121.8 d Inclusion: passive ROM ≥45° abduction/flexion/or external rotation shoulder or pronation forearm; active wrist extension ≥10° ; active extension MCP and IP joints thumb; ≥10° extension ≥2 additional digits	Comparison: Repetitive task practice (RTP) only vs. combined RTP and robotics RTP: Challenging tasks on basis of personal preference, relevance and interest. Variables manipulated related to temporal and spational domains for task completion. Upon selection, tasks were broken into segments that required successful completion before the entire task was put together. Activities and feedback provided were consistent with models of massed RTP practice schedule (i.e. summary feedback). Combined: Half of the time therapist-supervised RTP as above, other half robotic-assisted training aiming to 1) improve active ROM wrist and fingers and initiation of distal movements with visual feedback; 2) increase active wrist extensor muscle activity via feedback and assistive motion of the fingers and wrist; 3) decrease flexor tone of fingers and wrist via feedback and assistive motion of the fingers and wrist. Intensity: 60 h, during 3 wk. Treatment contrast: 0 h.	SIS Measured at baseline, 3 wk and 2 mos (follow-up)	Robotic-assisted therapy may be an effective alternative or adjunct to the delivery of intensive task practice interventions to enhance hand function recovery in patients with stroke.
Lo et al 2010	6	127 (49/50/28)	Age: 66±11 yr Type: first/rec isch/hem Time since onset: 3.6±4.0 yr Inclusion: FMA arm 7-38	Comparison: Robotics vs. intensive comparison vs. usual care Robotics: Robotic system with shoulder-elbow unit for horizontal movements, antigravity unit for vertical movements, wrist unit for flexion-extension, abduction-adduction and pronation-supination and grasp-hand unit for closing and opening movements. Four supervised training blocks of 3 wk: 1) planar shoulder-and-elbow training device; 2) antigravity shoulder and grasp-hand device; 3) wrist robot; 4) all three devices. High-intensity, repetitive, task-oriented movements (1024 per session on average); providing assistance if patients were unable to initiate or complete a movement independently. Intensive comparison: Structured conventional rehabilitation, e.g., assisted stretching, shoulder-stabilization activities, arm exercises, functional reaching. Usual care: Customary care, i.e. medical management, clinic visits as needed, and in some cases rehabilitation services, not dictated by protocol. Intensity: Robotics/ intensive comparison: 36x 1 h sessions, during 12 wk. Treatment contrast: Robotics/intensive comparison: 0 h. Robotics/intensive comparison vs. usual care: ??	FMA arm, WMFT, SIS 3.0, VAS, MAS Measured at baseline, 6,12, 24 and 36 wk	In patients with long-term upper-limb deficits after stroke, robot-assisted therapy did not significantly improve motor function at 12 weeks, as compared with usual care or intensive therapy.
Burgar et al 2011	6	44 (17/19/18)	Age: 58.6±2.3 yr Type: first/rec Time since onset: 16.6±2.4 d Inclusion: No upper limb joint pain that restricted normal movement, no	Comparison: Robot high intensity (Robot-hi) vs. Robot-low intensity (Robot lo) vs. control (C) Robot-hi: MIME device with hemiparetic forearm secured in a splint, containing four training modes: unilateral (passive, active-assisted, active-constrained) and bimanual. Starting with practice of targeted two-dimensional reaching movements, progressed to more complex three-dimensional out-of-synergy movements. Movements with continuous directed visualization of the limbs,	FMA arm, FMA proximal, FIM arm, MP, MAS, WMFT Measured at baseline, posttreatment and 6 mos (follow-up)	As used during acute rehabilitation, motor-control changes at follow-up were no less with MIME than with additional conventional therapy. Intensity of training with MIME was positively correlated with motor-control gains.

			absent proprioception at elbow and shoulder joint	using physical objects as targets to maintain a more functional and goal-directed set of tasks. Progression from passive, with paretic upper-limb motion controlled by contralateral limb of by the robot, to practice unilateral active-assisted movements, followed by practice of actively resisted movements. Advancing to more challenging tasks. Trunk movement limited by contoured seat back. In addition to regular PT, OT and speech therapy. Robot-lo: See Robot-hi. C: Usual therapy to improve function of paretic limb with treatment interventions addressing edema, loss of flexibility, loss of strength, decreased postural control, abnormal motor activation, lack of coordination. Also tissarm and joint mobilization, neuromuscular reeducation strategies, isolated progressive resistive exercises, functional activities of daily living. Exposure to MIME with robotic positioning targets for static and dynamic tracking, reaching, and self ROM tasks. The robot did not apply any forces. Intensity: C and Robot-lo: up to 15x 1h sessions, during 3 wk (applied: mean±SEM 9.4±0.9 and 8.6±0.7 h). Robot-hi: Up to 30x 1h sessions, during 3 wk (applied: mean±SEM 15.8±2.2 h). Treatment contrast: Robot-hi vs. C: 6.4 h. Robot-hi vs. Robot-lo: 7.2 h. Robot-lo vs. C: 0.8 h.		
Conroy et al 2011	6	62 (20/21/21)	Age: 57±12 yr Type: first/rec isch/hem Time since onset: 3±2 yr Inclusion: >6 mos post stroke (isch), >12 mos post stroke (hem), MMT ≤3; no serious complicating medical illness <6 mos, contractures/ orthopedic problems, visual loss, botox injection <3 mos	Comparison: Planar robot vs. planar + vertical robot vs. control (C) Planar: Robot-assisted planar horizontal reaching (InMotion 2.0 shoulder/arm while seated wearing torso harness, focused on completion of shoudler and elbow movements toward 8 visual targets in point-to-point circular pattern within gravity compensated plane. Robots modifies 1) the time allotted to make movement, 2) primary stifness of impedance controller that guides the movement, 3) if possible decrease assistance. As many reps as possible, assistance if neccesary. Summary graph performance after every 80 movements. Typical session 64 unasissted and 1280 assist-as-needed point-to-point movements for total of 1344 movements. Planar + vertical: Planar shoulder-elbow robot for gravity-compensated horizontal reaching (30 min) followed by 1-degree of freedom linear robot (InMotion linear robot) in its vertical position for reaching against gravity (30 min). Arm positioning included 45-65o shoulder abduction, movements directed toward 3 visually guided targets in a linear pattern. Typical combined session consisted of 32 unassisted and 640 assist-as-needed movements with planar roboti, 32 unasissted and 640 assist-as-needed movements with vertical robot for total of 1344 movements. Control: Exercises emphasizing active movement of affected arm. Arm ergometer, timed target-specific skateboard activity reaching from a center point outward, shoulder and elbow ROM exercises, task-specific and functional reaching activities for cone reaching and simulated drinking from cup (40 min). Assistance of therapist provided as needed, passive and guided strethcing activities (10 min) with repositioning (10 min). Approximately 650 total arm motions per session. Intensity: 60 min/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, WMFT time, SIS Measured at baseline and 6 wk and 12 wk (follow-up)	Chronic upper extremity deficits because of stroke are responsive to intensive motor task training. However, training outside the horizontal plane in a gravity present environment using a combination of vertical with planar plane robots was not superior to trainng with the planar robot.
Hsieh et al 2011	8	18 (6/6/6)	Age: 56.04±13.74 yr Type: isch/hem Time since onset: 21.33±7.17 mos Inclusion: FMA arm 30-56, MAS <3	Comparison: Higher intensity robotics (RT) vs. lower intensity robotics vs. conventional (C) Higher RT: Robot-assisted arm trainer enabling symmetrical practice of 2 movement patterns: forearm pronation-supination and wrist flexion-extension; with 3 computer-controlled modes (1. passive-passive; 2. active-pasive; 3. active-active). Speed, amount resistance and ROM adjusted individually. A simple computer game provides instant visual movement feedback, therapists also provided verbal feedback. Within each session 600-800 repetitions of mode 1 (15 min), 600-800 repetitions of mode 2 (15-20 min), 150-200 repetitions of mode 3 (5 min). Warming-up passive ROM (5-10 min), after RT 15-20 min functional activity training. Lower RT: Same protocol as Higher RT, except for intensity: 300-400 repetitions of mode 1, 300-400 repetitions of mode 2, 70-100 repetitions mode 3.	FMA arm, MRC, MAL, ABILHAND, Urinary 8-OhdG, MFSI Measured at baseline and 4 wk	Higher intensity of RT that assists forearm and wrist movements may lead to greater improvement in motor ability and functional performance in stroke patients.

				<u>C</u>: Conventional OT such as NDT with emphasis on functional tasks and muscle strengthening, including a) passive ROM, stretching, facilitatory and inhibitory technique (20 min); b) fine motor or dexterity (20 min); c) arm exercises or gross motor training (20 min); d) muscle strengthening (15-20 min); e) ADL or functional task training (15-20 min). <u>Intensity</u>: 20 sessions, 90-105 min/d, 5 d/wk, during 4 wk. <u>Treatment contrast</u>: 0 h.		
Masiero et al 2011	6	21 (11/10)	Age: 72.4±7.1 yr Type: first isch/hem Time since onset: 10.1±4.5 d Inclusion: MP 8-12 with no ability for active movement against gravity or weak resistance, MAS <3	<u>Comparison</u>: Robotics vs. control (C) <u>Robotics</u>: 80 minutes of conventional functional rehabilitation consisting of proprioceptive exercises, functional reeducation, gait training, OT, passive and active-assisted mobilization of hand and wrist. 2x 20 minutes of proximal paretic arm training with NeReBo, portability and usable at bedside, with 5 degrees of freedom, which provides basic visual and auditory feedback. 5-7 cycles lasting 3 minutes each, followed by 30-60 seconds resting period. Actively contribute to exercises and slowly perform movements to avoid abnormal muscular activity, hand placed in a neutral position splint. Torso movements prevented by seat belts. Verbally encouraged. <u>C</u>: Conventional functional rehabilitation as robotics group. 40 minutes of proximal paretic arm training. <u>Intensity</u>: 120 min/d, 5 d/wk, during 5 wk. <u>Treatment contrast</u>: 0 h.	MRC, FMA arm, FMA shoulder elbow coordination, FMA wrist hand, MAS, FAT, BBT, FIM, motor FIM, MAS Measured at baseline, 5 wk, and 3 mos (follow-up)	Our results show that on both motor and functional scales, experimental patients presented gains comparable to those of control patients at the end of robot therapy, indicating a substantial equivalence between treatment groups.

RCTs investigating mirror therapy for the paretic arm (MT) (paragraaf G.1.8)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Altenschuler et al 1999	5	9 (4/5)	Age: 58.22±6.42 yr Type: isch/hem Time since onset: 4.8±8.2 yr Inclusion: >6 mos post stroke	Comparison: Mirror therapy (MT) vs. control (C) MT: Practice schedule while watching the good arm in the mirror, typically moving proximal to distal, using “bootstrapping” i.e. working from movements patients could perform to those they could not. C: Practice schedule while watching the unaffected arm through transparent plastic, typically moving proximal to distal, using “bootstrapping” i.e. working from movements patients could perform to those they could not. Intensity: 2x 15 min/d, 6 d/wk, during 8 wk (cross-over at 4 wk). Treatment contrast: 0 h.	Ratings based on video: movement ability in terms of ROM, speed and accuracy Measured at 4 and 8 wk	Mirror therapy may be benficial for at least some patients with hemiparesis follwing stroke.
Rothgangel et al 2004 Outpatient	6	6 (3/3)	Age: median 73.0 (range 62-87) yr Type: ?? Time since onset: median 12 (range 9-15) mos Inclusion: ARAT ≥1; no bilateral infarcts, severe neglect, severe visual problems, problems with understanding, comorbidities	Comparison: Mirror therapy (MT) vs. control (C) MT: Patient looked in mirror while practicing. 10 min tone inhibition or increase (resp. active movements with unaffected upper extremity, affected arm facilitated by therapist; active bilateral gross arm movements, assisted by therapist). C: Same exercises, but without mirror, i.e. direct observation affected upper extremity. Intensity: 2x30 min/d, 2 d/wk, during 5 wk. Treatment contrast: 0 h.	ARAT, MAS, PSK Measured at baseline, 2.5, 5 wk and 10 wk (follow-up)	Clinically relevant differences on ARAT outcome between outpatient groups. Significant differences on PSK between groups in favor of MT; but ‘flawed by patients’ perspective. Less effect of MT on MAS.
Rothgangel et al 2004 Inpatient	6	10 (5/5)	Age: median 79 (range 49-87) yr Type: ?? Time since onset: median 7.0 (range 3-14) mos Inclusion: ARAT ≥1; no bilateral infarcts, severe neglect, severe visual problems, problems with understanding, comorbidities	Comparison: Mirror therapy (MT) vs. control (C) MT: Patient looked in mirror while practicing. 10 min tone inhibition or increase (resp. active movements with unaffected upper extremity, affected arm facilitated by therapist; active bilateral gross arm movements, assisted by therapist). C: Same exercises, but without mirror, i.e. direct observation affected upper extremity. Intensity: 2x30 min/d, 4 d/wk, during 5 wk. Treatment contrast: 0 h.	ARAT, MAS, PSK Measured at baseline, 2.5, 5 wk and 10 wk (follow-up)	Significant differences on ARAT outcome between inpatient groups in favor of MT group after 5 wk but groups differed at baseline.
Yavuzer et al 2008	7	40 (20/20)	Age: 63.2±9.2 yr Type: first isch/hem Time since onset: 5.4±2.9 mos Inclusion: FMA arm I-IV, <12 mos post stroke; no severe cognitive disorders	Comparison: Mirror therapy (MT) vs. control (C) MT: Nonparetic-side wrist and finger flexion and extension movements while patients looked into the mirror, watching the image of their noninvolved hand. Asked to try to do the same movements with the paretic hand while they were moving the nonparetic hand. In addition to conventional program consisting of NDT, PT, OT, speech therapy. C: Same exercises but used the nonreflecting side of the mirror in such a way that the paretic hand was hidden from sight. Intensity: Conventional program: 2-5 h/d, 5 d/wk, during 4 wk. MT/C: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA arm, MAS, FIM self-care Measured at baseline, 4 wk and 6 mos (follow-up)	Hand function improved more after mirror therapy in addition to conventional rehabilitation program compared with a control treatment immediately after 4 wk of treatment and at the 6-month follow-up, whereas mirror therapy did not affect spasticity.
Cacchio et al 2009 A	7	48 (24/24)	Age: 58.3±10.5 yr Type: first isch/hem Time since onset: 5.1±2.5 mos Inclusion: CRPS I, VAS	Comparison: Mirror therapy (MT) vs. control (C) MT: Unaffected upper limb movements, observing the reflexion of unaffected arm in mirror while performing flexion/extension shoulder, elbow and wrist and prone-supination of the forearm. Self selected speed, no verbal feedback. In addition to conventional stroke rehabilitation, i.e. neurorehabilitation technique, OT, and if	VAS, WMFT, MAL Measured at baseline, 4 wk and 6 mos (follow-up)	Mirror therapy effectively reduces pain and enhances upper limb motor function in stroke patients with upper limb CRPS I.

			>4; no other obvious explanation for the pain, intraarticular injection <6 mos, systemic corticosteroids <4 mos, surgery to shoulder or neck, serious uncontrolled conditions, visual impairments interfere with aims of study	required speech therapy. C: Same exercise but reflecting part mirror covered with paper. Intensity: Conventional program: 1 h/d, 5 d/wk, during 4 wk. MT/C: 30 min/d, 5 d/wk, during 2 wk, followed by 1 h/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.		
Cacchio et al 2009 B	5	24 (8/8/8)	Age: median 62 (range 53-71) yr Type: isch/hem Time since onset: median 14 (range 7-21) mos Inclusion: CRPS I	Comparison: Mirror therapy (MT) – active vs. MT – covered vs. mental imagery (MI) MT active: Cardinal (proximal to distal) movements of affected upper extremity, view reflected image of unaffected arm in mirror. MT covered: Cardinal (proximal to distal) movements of affected arm, view a covered mirror. MI: Mental imagery. Intensity: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	VAS, WMFT, allodynia, edema Measured at 4 wk	Unlike imagery therapy, mirror therapy effectively reduces pain and enhances motor function in the arm of patients with stroke and CRPS I.
Dohle et al 2009	6	48 (24/24)	Age: 54.9±13.8 yr Type: first isch Time since onset: 26.2±8.3 d Inclusion: severe hemiparesis, <8 wk post stroke; no disease interfereing with ability to sit or move either upper limb	Comparison: Mirror therapy (MT) vs. control (C) MT: Standardized protocol using shaping technique, requiring execution of arm, hand, finger postures in response to verbal instructions. Move affected limb "as well as possible." Watching mirror image of unaffected arm. In addition to standard therapy consisting of OT, PT, ADL training. C: Standardized protocol using shaping technique, requiring execution of arm, hand, finger postures in response to verbal instructions. Move affected limb "as well as possible." No mirror. In addition to standard therapy consisting of OT, PT, ADL training. Intensity: 30 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm Measured at baseline and 6 wk	Regarding motor function, there was no significant therapy effect in any of the 3 motor subscores across all patients. MT early after stroke is a promising method to improve sensory and attentional deficits and to support motor recovery in a distal plegic limb.
Michielsen et al 2011	8	40 (20/20)	Age: 55.3±12.0 yr Type: first isch/hem Time since onset: 4.7±3.6 yr Inclusion: FMA arm stage III-V, home dwelling, ≥1 yr post stroke; no neglect, comorbidities influencing upper extremity usage	Comparison: mirror therapy (MT) vs. placebo mirror (C) MT: Bimanual exercises, based on Brunnstrom phases and functional exercises (e.g. moving objects). Affected hand behind mirror while looking at reflection of unaffected hand in mirror. Cover placed over unaffected hand. C: Same exercises but without mirror. Intensity: Supervised 1h/d 1 d/wk; home 1h/d 5 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, Jamar, Tardieu scale, VAS, ARAT, ABILHAND questionnaire, Stroke-ULAM, EQ-5D, change activation balance (fMRI) Measured at baseline, 6 wk and 6 months (follow-up)	Some effectiveness for mirror therapy in chronic stroke for upper extremity motor function, which disappeared at follow-up and did not transfer to activities or participation levels. Mirror therapy caused a shift in activation balance M1 toward the lesioned hemisphere after intervention. Unclear if change persisted as cortical activation was not measured at follow-up.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**

Altschuler et al. 1999	RCT, cross over design	9 (5 / 4) with mild to extremely severe stroke	mean: 58.2 y range 53-73y	type: ? chronic: mean 4.8 y + 8.2 y. after stoke, range 6 mo-26 y.	No	Intervention: mirror therapy vs placebo mirror. E: moving both hands or arms symmetrically (moving the affected arm as best they could), while watching the unaffected arm in mirror C: moving both hands or arms symmetrically (moving the affected arm as best they could), while watching the unaffected arm through the clear plastic sheet. Intensity: 15 min, twice a day, 6 d/wk, during 8 wk (cross over after 4 wk).	Ratings based on video of movements of UE measured at cross over point (4 wk) and at end treatment (8 wk)	Mirror therapy may be beneficial for at least some patients with hemiparesis following stroke.	4 failure at the questions: 3,5,6,8,9,10
Rothgangel & Morton, 2002	RCT	16 (8 / 8) with ARA-score > 1	mean: 75.6 y + 9.9 y, range 49-87y	type: ? chronic: mean 10 mo + 5.5 mo after stroke	Yes	Intervention: mirror therapy vs without mirror E: standardized therapy protocol, using a mirror, including: control of muscle tone and functional exercises with arm and hand. C: same exercises as E, but without mirror Intensity: 30 min, 2-4 d/wk; during 5 wk	MAS, ARA and PSK measured at 2½ + 5 wk and 10 wk after baseline (follow-up)	Mirror therapy can be a positive factor towards the recovery of arm and hand function even with patients who were considered to be beyond recovery	5 failure at the questions: 4,5,6,9,11

RCTs investigating virtual reality for the paretic arm (VR) (paragraaf G.1.9)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Carey et al 2002	3	10 (5/5)	Age: 65.7±13.3 yr Type: first Time since onset: 4.7±6.3 yr Inclusion: ≥6 mos post stroke, ≥20° movement MCP index finger, slowed hand opening from fisted position; no implanted metal devices, pregnancy, claustrophobia	Comparison: Tracking vs. control (C) Track: Sit in chair, perform 20 randomly selected 60 tracking protocols, with varying target parameters and tracking conditions (e.g. sawtooth, square and triangle). Frequency 0.13-0.8 Hz, amplitude of finger 20-100% of full range. Tracking 90% with paretic hand, 10% non-paretic hand. Hand position varied between pronated, supinated or mid-position. In 5% of protocols was the tracking cursor invisible. Three trials of each protocol performed consecutively with 10-15 s rest between trials. Verbal feedback after completion of third trial. C: No therapy, continue use arm with normal daily routine. Intensity: 18-20 sessions of 45-60 min, 2-5 d/wk. Treatment contrast: 997.5 min.	BBT, tracking accuracy, fMRI Measured at baseline and post intervention	Individuals with chronic stroke receiving intensive tracking training showed improved tracking accuracy and grasp and release function, and these improvements were accompanied by brain reorganization.
Piron et al 2003, 2007	3	38 (25/13)	Age: 61.5±9.4 yr Type: isch Time since onset: 2.5±1.5 mos Inclusion: mild/intermediate arm motor impairment, <3 mos post stroke	Comparison: Virtual reality (VR) vs. control (C) VR: Reinforced feedback in virtual environment consisting of PC workstation, high-resolution LCD projector, 3D motion-capture system, dedicated software. Grasping a real object and virtual handling object matched real object. See own movement on screen and correct trajectory. Rewarding signal when required task was completed adequately. Complexity can be increased or decreased by PT. In addition to conventional therapy (see below). C: Conventional rehabilitation therapy focused on the upper limb. In addition to conventional therapy for lower limb and balance impairments, aphasia or other cognitive deficits. Intensity: 1 h/d, 5 d/wk, during 5-7 wk. Treatment contrast: 0 h.	FMA arm, FIM Measured at baseline and after therapy	Recovery of arm motor function in patients after a recent stroke appear to be speeded up by an augmented feedback provided in a virtual-environment.
Jang et al 2005	6	10 (5/5)	Age: 54.4 (SE 5.3) yr Type: isch/hem Time since onset: 13.4 (SE 2.2) mos Inclusion: ability to move elbow against gravity	Comparison: Virtual reality (VR) vs. control (C) VR: Task-oriented training paradigm with faded feedback, with augmented feedback about KR and KP. VR consist of television monitor, video camera, cyber gloves, virtual objects and scenes, large screen. Protocol consists of reaching, lifting and grasping motor skills, with games programmed to exercise 1 or multiple aspects of upper extremity and trunk movement. Exercise repeated 5 times for each game. C: No therapy. Intensity: 1 h/d, 5 d/wk, during 5 wk. Treatment contrast: 25 h.	BBT, FMA arm, MFT, fMRI variables, MAL Measured at baseline and 4 wk	This is a novel demonstration of VR-induced neuroplastic changes and associated motor recovery in chronic stroke.
Carey et al 2007	3	25 (13/12)	Age: 65.9±7.4 yr Type: isch Time since onset: 42.5±24.3 mos Inclusion: ≥90° passive and ≥10° active extension-flexion MCP index finger	Comparison: Tracking vs. moving Track: Finger and wrist tracking training in own homes, independent of any direct supervision. Equipment consists of laptop computer with customized tracking software. First trial supervised and perform 5-6 trials to familiarize with training. Wear custom-made electrogoniometer braces to each hand, forearms resting on chair's armrest, perform 180 tracking trials per day (e.g., square, sawtooth left, sawtooth right, triangle; frequency 0.2, 0.4, 0.6 Hz; duration 5, 10, 15 seconds; peak flexion amplitude 0, 15 or 30% of active ROM; peak extension amplitude 70, 85 or 125% active ROM), divided in 60 different blocks with 3 consecutive trials completed over 2-8 h depending on rest breaks. Paretic hand used 90% of the blocks, nonparetic hand in 10%. Index finger 50%, wrist 50%. Hand position was varied. KR provided during pause and et end of each trial with computer-calculated accuracy score. KP presented less frequently and faded, computer-generated text comment describing a feature to correct in the tracking behavior. Teleconferencing via cellular phone and web camera 5 times. Therapist had a pager in case patient had specific qarmstions.	BBT, JTHFT, ROM, fMRI Measured at baseline and 10 d	Telerehabilitation may be effective in improving performance in subjects with chronic stroke. Tracking training with reinforcement to enhance learning, however, did not produce a clear advantage over the same amount of practice of random movements.

				Move: Finger and wrist moving training in own homes with set-up as tracking group. During a trial, the screen showed a sweeping cursor but did not show a target or response, no KR or KP was provided. Motivational comments were provided with same frequency, but not based on prior performance. Intensity: 10 d. Treatment contrast: 0 h.		
Fischer et al 2007	4	15 (5/5/5)	Age: 60±14 yr Type: ?? Time since onset: 7±9 yr Inclusion: CMMSA 2-3	Comparison: Pneumatic orthosis (PO) vs. cable orthosis (CO) vs. control (C) PO: 30 functional grasp-and-release tasks involving mixture of virtual objects and actual objects. PO assists hand opening, electro-goniometers or therapist determined if hand was sufficiently open to grasp object. Audio feedback according to level of activity of extensor digitorum communis as recorded from EMG. CO: 30 functional grasp-and-release tasks involving mixture of virtual objects and actual objects. CO assists hand opening, audio feedback of cable tension. Audio feedback according to level of activity of extensor digitorum communis as recorded from EMG. C: Grasp-and-release of objects without any assistance of hand opening. Audio feedback according to level of activity of extensor digitorum communis as recorded from EMG. Intensity: 1 h/d, 3 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, WMFT time, RLA, BBT, spasticity, isometric strength, velocity, ROM, gripstrength Measured at baseline and 6 wk and 10 wk (follow-up)	Participants in all 3 groups demonstrated a decrease in time to perform some of the functional tasks. Overall gains were slight.
Broeren et al 2008	4	16* (11/11) *6 crossed over	Age: 67.0±12.5 yr Type: isch/hem Time since onset: 62.3±28.4 mos Inclusion: BBT <55	Comparison: Virtual reality (VR) vs. control (C) VR: Additional VR in activity centre, by playing 3D computer games with the arm unsupported during playing, focusing on engaging the whole arm. Semi-immersive workbench, participant reached into virtual space and interact with 3D objects using haptic device. Telemedicine based on Skype with a camera used as communication tool between therapist and personnel at activity centre. C: No additional intervention. Intensity: 45 min/d, 3 d/wk, during 4 wk. Treatment contrast: 540 min.	BBT, ABILHAND, TMT-B, kinematics Measured at baseline and 4 wk	VR can be used beneficially not only by younger participants but also by older persons to enhance their motor performance after stroke.
Crosbie et al 2008	6	18 (9/9)	Age: 56.1±14.5 yr Type: first Time since onset: 10±6.4 mos Inclusion: <24 mos post stroke, MI arm ≥25; no comorbid condition, pace maker	Comparison: Virtual reality (VR) vs. control (C) VR: Virtual reality with HMD, Lycra data glove, Ascension Flock-of-Birds magnetic sensor system for real-time 6-df tracking, with series of reaching and grasping tasks. Three sensors to shoulder, elbow and wrist, fourth on HMD. Auditory and visual feedback. C: Therapy focused on upper limb based on conventional rehabilitation technique, including muscle facilitation technique, stretching exercise, strengthening activities and inclusion of more affected upper limb in functional tasks. Intensity: 9 sessions, 1 h/session, during 3 wk. Treatment contrast: 0 h.	MI arm, ARAT Measured at baseline and 3 wk and 6 wk (follow-up)	This study demonstrated the feasibility of a randomized controlled trial of VR based therapy for the upper limb compared to standard therapy.
Piron et al 2008	6	10 (5/5)	Age: 53±15 yr Type: isch Time since onset: 10±3 mos Inclusion: isch, mild-intermediate arm motor impairment	Comparison: Tele-virtual reality (Tele-VR) vs. VR Tel-VR: Virtual reality equipment, consisting of 3D motion tracking system, computer screen, ISDN-connection at data rate of 128 kbit/s. PT created seqarmnce of virtual tasks. Visual feedback (i.e. knowledge of performance, knowledge of results). Patient-PT interaction facilitated by videoconferencing unit beside telerehabilitation equipment. Patients and relatives briefly trained to operate system, equipment was controlled from remote hospital workstation. VR: Same VR training but with presence of PT in hospital setting. Intensity: 1 h/d, 7 d/wk, during 1 mos. Treatment contrast: 0 h.	Patient satisfaction, FMA arm Measured at baseline and 1 mos	Patients assigned to the Tele-VR group were able to engage in therapy at home and the videoconferencing system ensured a good relationship between the patient and the physical therapist whose physical proximity was not required.
Yavuzer et al 2008	7	20 (10/10)	Age: 58.1±10.2 yr Type: first isch/hem Time since onset: 3.3±3.3 yr	Comparison: Virtual reality (VR) vs. control (C) VR: 'Playstation EyeToy' games consisting of flexion and extension of paretic shoulder, elbow and wrist, and abduction of the paretic shoulder. Encouraged to use paretic arm while playing. In addition to conventional rehabilitation (i.e. NDT,	FIM, FMA arm Measured at baseline, 4 wk and 3 mos	'Playstation EyeToy Games' combined with a conventional stroke rehabilitation program have a potential to enhance upper extremity-related motor functioning in

			Inclusion: FMA arm I-IV	PT, OT, if necessary speech therapy). C: Based on mental practice treatment, watching games for same duration but did not involve into the games physically. In addition to conventional rehabilitation (i.e. NDT, PT, OT, if necessary speech therapy). Intensity: conventional rehabilitation: 2-5 h/d, 5 d/wk, during 4 wk. VR/C: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.		subacute stroke patients.
Piron et al 2009	7	36 (18/18)	Age: 66.0±7.9 yr Type: first isch Time since onset: 14.7±6.6 mos Inclusion: not defined	Comparison: Virtual reality (VR) vs. control (C) VR: Telerehabilitation system. Receiver attached to real object, with which 5 virtual tasks have to performed, following trajectory of corresponding virtual object displayed on computer screen. KP by info about movement, KR by giving reward. Therapist provided feedback through videoconference tool. C: Conventional PT for upper extremity with strategy of progressive complexity. First control isolated motions without postural control, then postural control included, finally complex motion with postural control. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA arm, MAS, ABILHAND Measured at baseline, 4 wk and 1 month (follow-up)	Both strategies were effective, but the experimental approach induced better outcomes in motor performance. These results may favor early discharge from hospital sustained by a telerehabilitation programme, with potential beneficial effects on the use of available recourses.
Carmeli et al 2010	6	32 (18/16)	Age: 57.8±8.9 yr Type: isch/hem Time since onset: <10 wk Inclusion: 10° extension and/or flexion wrist or fingers, flex/extend 5 times without losing active ROM	Comparison: rehabilitation + Hand Tutor vs. rehabilitation + arm program (C) E: Physical therapy and occupational therapy: passive and active therapeutic exercises focusing on ROM, strength, endurance training wrist and fingers; use functional board. Hand tutor program by PT assistant: augmented finger and wrist motion feedback, 6 one-minute periods alternating between rest and track. C: Physical therapy and occupational therapy as experimental. Additional traditional hand therapy: passive and active therapeutic exercises focusing on ROM, strength, endurance training wrist and fingers; use functional board. Intensity: PT and OT as usual. Hand Tutor or traditional hand therapy session 20-30 min, 5 d/wk, during 3 wk. Treatment contrast: 375 min.	FMA arm, BBT Measured at baseline, after 10 d, 3 wk and 10 d follow-up	The results from this pilot study support further investigation of the use of the Hand Tutor in combination with traditional occupational therapy and physical therapy during post stroke hand function rehabilitation.
Piron et al 2010	8	47 (27/23)	Age: 58.8±8.3 yr Type: first isch Time since onset: 15.4±12.6 mos Inclusion: FMA arm 20-66	Comparison: Virtual reality (VR) vs. control (C) VR: Reinforced feedback in a virtual environment (RFVE), perform different kinds of motor tasks while movement of entire biomechanical arm system's end section was simultaneously represented in a virtual scenario by means of motion-tracking equipment. Virtual scenarios by high-resolution LCD projector on large wall screen. Therapist determined starting position and target of each task. KP by virtual representation of end-effector. KR supplied in form of standardized scores and by displaying arm trajectory morphology on screen. KP and KR initially 90% provided, gradually decreased as performance improved. C: Specific exercises with upper extremity with progressive complexity based on Bobath. First control isolated motions without postural control, then postural control included, finally complex motion with postural control. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA arm, FIM, kinematics Measured at baseline and 4 wk	Both rehabilitation therapies improved arm motor performance and functional activity, but the RFVE therapy induced more robust results in patients exposed to late rehabilitation treatment.
Sucar et al 2010	3	42 (20/22)	Age: 47.9 yr Type: isch/hem Time since onset: 24.4 mos Inclusion: able to lift arm against gravity	Comparison: Virtual reality (VR) vs. control (C) VR: Gesture therapy guided by a therapist. Simulated environment with a gesture tracking software, in which movement of affected upper extremity is tracked based on an image seqarmnce obtained by low-cost camera. Three key elements: therapy activities, progress charts, therapist page. Visual feedback of task performance, trunk compensation by sounding an alarm or block communication with virtual environment. C: Conventional OT, different exercises of the affected arn guided by a therapist, using didactic material such as cones, balls, etc. Intensity: 1 h/d, 3 d/wk, during 7 wk. Treatment contrast: 0 h.	FMA arm, MI, Intrinsic Motivation Survey Measured at baseline and 7 wk	Both types of treatment have a significant impact according to both clinical scales; however we can not report a significant effect of Gesture Therapy over conventional occupational therapy.
Saposnik et al 2010	5	22 (11/11)	Age: 67.3 (range 46-83) Type: first isch/hem	Comparison: Virtual reality (VRWii) vs. recreational therapy (RC) VR: Nintendo Wii (Sports and Cooking mamma) involving arm movements	Safety outcomes, short version of WMFT, BBT, SIS	VRWii gaming technology represents a safe, feasible, and potentially effective

			Time since onset: 22.7±8.6 d Inclusion: CMMSA <3 in arm or hand	shoulder flexion and extension, shoulder rotation, elbow extension, wrist supination and pronation and different degrees of wrist flexion and extension as well as thumb flexion. Remain in sitting position and primarily use more affected arm. RC: Leisure activities such as playing cards, stamping a seal while playing bingo, or playing Jenga. Remain in sitting position and primarily use more affected arm. Intensity: 1 h, 8 sessions in 14-day period. Treatment contrast: 0 h.	Measured at baseline, 2 wk and 4 wk (follow-up)	alternative to facilitate rehabilitation therapy and promote motor recovery after stroke.
Da Silva Cameirão et al 2011	4	16 (8/8)	Age: 63±11 yr Type: first isch/hem Time since onset: 11.5±5.1 d Inclusion: MRC 2-3	Comparison: Virtual reality (VR) vs. control (C) VR: Rehabilitation Gaming System (RGS) consisting of analysis and tracking system, 2 data gloves, intelligent controller, virtual environment. Tasks of increased complexity (hitting, grasping, placing) to train speed, ROM, grasp and release. In addition to conventional therapy. C: Group 1: extended OT with emphasis on motor tasks similar to ones promoted by RGS, in addition to conventional therapy. Group 2: games with Wii system, in addition to conventional therapy. Intensity: 20 min/d, 3 d/wk, during 12 wk. Treatment contrast: 0 h.	BI, MI, FMA arm, FMA proximal, FMA distal, CAHAI Measured at baseline, 5, 12 wk, and 24 wk (follow-up)	Our results suggest that rehabilitation with the RGS facilitates the functional recovery of the upper extremities and that this system is therefore a promising tool for stroke neurorehabilitation.

RCTs investigating electrostimulation of the paretic arm (paragraaf G.1.10)

RCTs investigating neuromuscular stimulation (NMS; category 6 and 8)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Bowman et al 1979	3	30 (??/??)	Age: ???? Type: first isch Time since onset: range 3 wk – 4 mos Inclusion: 5°-30° active wrist extension	Comparison: Positional feedback stimulation training (PFST) vs. control (C) PFST: Resistance to wrist extension adjusted weekly, which did not allow voluntary extension beyond 30°, threshold electrical stimulation 5° below maximum voluntary ability, stimulation to fully extend wrist, on time 6-8 seconds, rest 20 seconds. 20-100 repetitions per session. In addition to conventional therapy for hand and wrist, individualized, often including passive ROM, active resistive exercises, classic neuromuscular facilitation, ADL. C: Conventional therapy as experimental. Intensity: PFST: 2x 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 20 h.	Maximal isometric wrist extension torque, voluntary patterned and selective range of motion Measured at baseline, and 1, 2, 3, and 4 wk	Treatment using automated PFST equipment allows controlled repetitive isotonic exercise and facilitation of wrist extension without continuous one-on-one therapist/patient supervision.
King 1996	4	22 (11/11)	Age: range 59-72 yr Type: ???? Time since onset: ???? Inclusion: None concerning arm functioning	Comparison: Electrical stimulation (ES) vs. control (C) ES: Wrist placed in torque meter and passively extended until 15 cm-kg, in this position 10 min NMS of wrist flexor group, with surface electrodes on proximal and distal volar surface forearm. Synchronous mode, 45 Hz, 250 µs pulse width, ramp up/down time 3/0 sec, on/off time 10 sec, amplitude 15-20 mA, resulting in involuntary contract-relax motion. C: Wrist placed in torque meter and passively extended until 15 cm-kg kept passively stretched in this position 10 min. Intensity: 10 min. Treatment contrast: 0 h.	Torque wrist Measured at baseline and 10 min	This study demonstrated that ES is effective in reducing abnormally increased tone in wrist flexors.
Chae et al 1998	6	28 (14/14)	Age: 59.7±13.0 yr Type: first/rec isch/hem Time since onset: 15.7±6.5 d Inclusion: FMA arm <44	Comparison: Neuromuscular stimulation (NMS) vs. control (C) NMS: Standard PT, OT and speech therapy. In addition, supervised surface NMS of extensor digitorum communis and extensor carpi radialis, with 10 seconds on and 10 seconds off. C: Standard PT, OT and speech therapy. In addition, supervised surface NMS with electrodes paced away from all motor points, producing only cutaneous stimulation just beyond sensory threshold without motor activation. Intensity: 1 h/d, 15 sessions. Treatment contrast: 0 h.	FMA arm, FIM Measured at baseline, after treatment, 4 and 12 wk (follow-up)	Data suggests that NMS enhances the upper extremity motor recovery of acute stroke survivors. However, the sample size in this study was too small to detect any significant effect of NMS on self-care function.
Powell et al 1999	7	60 (30/30)	Age: 69.0±10.8 yr Type: isch/hem Time since onset: 23.9±7.7 d Inclusion: wrist extension MRC >5	Comparison: NMS vs. control (C) NMS: NMS with self-adhesive electrodes of wrist and finger extensors, muscle contraction/relaxation time ratio was progressively increased by shortening the relaxation period (from 5/20 seconds on/off to 5/15, then to 5/10, and then 5/5 seconds). Standard therapy using a combination of Bobath and movement science approaches. C: Visit from intervention PT to discuss progress in rehabilitation. Standard therapy using a combination of Bobath and movement science approaches. Intensity: NMS: 3x30 min/d, 7 d/wk, during 8 wk. C: 10 min/d, 3 d/wk, during 8 wk. Treatment contrast: 80 h.	Strength wrist extension, active and passive ROM, ARAT, grip strength, NHPT Measured at baseline, 4, 8, and 20 and 32 weeks (follow-up)	NMS of the wrist extensors enhances the recovery of isometric wrist extensor strength in hemiparetic stroke patients. Upper limb disability was reduces after 8 weeks of NMS therapy, with benefits most apparent in those with residual motor function at the wrist. However, it is not clear how long the improvements in upper limb disability are maintained after NMS is discontinued.
Hemmen et al 2002 en 2007	6	27 (14/13)	Age: 62.1±12.7 yr Type: first isch Time since onset: 44.9±14.5 d Inclusion: wrist strength MRC 2-3	Comparison: EMG-NMS vs. electrical stimulation (ES) EMG-NMS: Surface electrodes, concentrate on making an imaginary wrist extension, after picking up the wrist extensor EMG signal, this was amplified and used for assisted contraction of wrist extensors paretic arm and clear dorsiflexion of the wrist over the total ROM starting from neutral position. ES: Repetitively stimulate wrist extensor muscles for 12 seconds, followed by a 5	FMA arm, ARAT Measured at baseline, 3 mos and 12 mos (follow-up)	EMG-triggered feedback stimulation did not lead to more arm-hand function improvement relative to conventional electrostimulation.

				seconds rest. No additional instructions related to arm or hand performance. Intensity: 30 min/d, 5 d/wk, during 12 wk. Treatment contrast: 0 h.		
De Kroon et al 2004	6	28 (13/15)	Age: 58±17.3 yr Type: isch/hem Time since onset: 14.7±11.8 mos Inclusion: MAS ≥1, wrist extensor strength MRC <5, 10° voluntary wrist extension	Comparison: Electrical simulation (ES) hand flexors/extensors vs. ES extensors ES flex/ext: Alternating ES of flexors and extensors of wrist and fingers, with NESS Handmaster including 5 surface electrodes, using exercise mode at home. ES ext: ES of extensors wrist and fingers with NESS Handmaster including 5 surface electrodes, using exercise/open mode at home. Intensity: 3x 20-60 min/d, 7 d/wk, during 6 wk. Stimulation check by therapist every week during first 2 wk, then every 2 wk. Treatment contrast: 0 h.	ARAT, grip strength, MI Measured at baseline, 6 wk and 12 wk (follow-up)	The difference between the two stimulation strategies was not statistically significant.
Mann et al 2005	6	22 (11/11)	Age: 68 (range 57-86) yr Type: isch/hem Time since onset: 5.7 (range 1-12) mos Inclusion: able to take hemiplegic hand to the mouth, sensory impairment	Comparison: NMS vs. control (C) NMS: 2-channel stimulator with self-adhesive electrodes placed on elbow extensors and wrist and finger extensors. Stimulation 8 seconds on, 8 seconds off, ramped over 2 seconds, frequency 20 Hz, to give full extension without discomfort. C: Passive stretching exercises of elbow, wrist and fingers. Intensity: 2x 10-30 min/d during 1st wk, then 30 min/d, during 11 wk. Treatment contrast: 0 h.	ARAT, sensation Measured at baseline and 12 wk	A significant treatment effect of electrical stimulation over passive exercise has been demonstrated.
Ring et al 2005	4	22 (11/11)	Age: 54.1±11.2 yr Type: first isch Time since onset: 3.6 mos Inclusion: less than full active ROM in the involved upper limb	Comparison: Neuroprosthesis vs. control (C) Neuroprosthesis: Single fitting session of NESS Handmaster with 5 surface electrodes, followed by a protocol for home use, to achieve full arc of finger motion, using the modes intermittent finger extension, and alternating finger flexion and extension. Patients with partial active range of motion also used the functional modes for various assigned activities. In addition to rehabilitation program with OT and PT, to improve ADL and neuromuscular re-education using Bobath technique. C: Rehabilitation program with OT and PT, to improve ADL and neuromuscular re-education using Bobath technique. Intensity: Neuroprosthesis: 2x10 min to 3x50 min/d wk 1-2, 3x50 min/d during wk 3-6. Treatment contrast: 2400 min.	Active ROM, MAS, BBT, JTHFT, pain, edema Measured at baseline and 6 wk	Supplementing standard outpatient rehabilitation with daily home neuroprosthetic activation improves upper limb outcomes.
Church et al 2006	8	176 (90/86)	Age: median 75.5 (IQR 64-81) yr Type: first/rec isch/hem Time since onset: median 5 (IQR 4-7) d Inclusion: upper limb problem caused by stroke	Comparison: Surface neuromuscular electrical stimulation (sNMS) vs. control (C) sNMS: Surface electrodes over supraspinatus and posterior deltoid, level of stimulation increased until a comfortable gross muscle contraction was visible. 15 seconds on, 15 seconds off. C: Sham stimulator, identical to intervention, but an internal disconnection prevented any current from being delivered. Intensity: 3x 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	ARAT, FAT, MI, SCT, pain scales, NEADL, NHP, OHS, patients' view regarding sNMS Measured at 4 wk (all except ARAT) and 3 mos	A 4-week program of sNMES to the shoulder after acute stroke does not improve functional outcome and may worsen arm function in severely impaired stroke patients. "Routine" use of sNMES to the proximal affected upper limb after acute stroke cannot be recommended.
Alon et al 2007	5	15 (7/8)	Age: ???? Type: first isch Time since onset: 18.0±8.7 d Inclusion: FMA arm 11-40, no clinical evidence limited passive ROM, ≥60% full finger flexion and extension response to stimulation (only FES group)	Comparison: FES vs. control (C) FES: Standard task-specific rehabilitation of PT, OT and speech therapy, during OT/PT FES was applied that induced contraction of the wrist/finger flexors and extensors to open and close the paretic hand. Also applied the stimulation without specific exercises outside supervised therapy. 7 seconds stimulation, 7 seconds rest, with patterns of opening and closing that enabled the patient to grasp, move and release objects with the paretic hand. C: Standard task-specific rehabilitation of PT, OT and speech therapy. Intensity: FES: starting with 4x 10 min/d, increased to 4x 1 h/d, with 2 sessions per day as part of OT/PT, 12 wk. Treatment contrast: ????	BBT, JTHFT (light object lift subset), modified FMA arm Measured at baseline, baseline, 4, 8 and 12 wk	Upper extremity task-oriented training that begins soon after stroke that incorporates FES may improve upper extremity functional use in patients with mild/moderate paresis more than task-oriented training alone.
McDonnell et al 2007	8	20 (10/10)	Age: 60.1±10.5 yr Type: first isch	Comparison: Afferent stimulation (E) vs. control (C) E: Electrical peripheral nerve stimulation with surface electrodes on motor point of	ARAT, FMA arm, MAL, maximal pinch grip	All patients showed improvement in scores of upper limb function following the

			Time since onset: 4.6±2.6 mos Inclusion: active ROM ≥60° shoulder elevation and 10° wrist extension, passive ROM affected side at least 75% normal in shoulder, elbow, wrist and hand with minimal or no pain	finger and thumb extensors immediately before training in each session. Intensity at a level just sufficient to evoke a visible motor response. Patients were instructed to pay attention to the relaxed, stimulated hand. Task-specific training involving repetitive practice of standardized and individualized everyday tasks, including reaching, wrist extension against resistance, fine motor tasks. Feedback on performance. Home exercises while keeping a logbook. C: Sham electrical nerve stimulation immediately before training in each session, immediately before training in each session. Task-specific training involving repetitive practice of standardized and individualized everyday tasks, including reaching, wrist extension against resistance, fine motor tasks. Feedback on performance. Home exercises while keeping a logbook. Intensity: 1 h/d stimulation and 1 h/d task-specific training, 3 d/wk, during 3 wk. Treatment contrast: 0 h.	Measured baseline, 3 wk and 3 mos (follow-up)	interventions. However, the simulation group, but not the control group, improved significantly on 2 key features of the dexterous grip-lift task.
Alon et al 2008	4	26 (13/13)	Age: 63.15±11.36 yr Type: first isch Time since onset: 17.4±7.6 d Inclusion: FMA arm 2-10	Comparison: FES vs. control (C) FES: Standard task-specific rehabilitation of PT, OT and speech therapy, during OT/PT FES with surface electrodes was applied that induced contraction of the wrist/finger flexors and extensors to open and close the paretic hand. Also applied the stimulation without specific exercises outside supervised therapy. 7 seconds stimulation, 7 seconds rest, with patterns of opening and closing that enabled the patient to grasp, move and release objects with the paretic hand. C: Standard task-specific rehabilitation of PT, OT and speech therapy. Intensity: FES: starting with 4x 10 min/d, increased to 4x 1 h/d, with 2 sessions per day as part of OT/PT, 12 wk. Treatment contrast: ????	BBT, JTHFT (light object lift subset), modified FMA arm Measured at baseline, baseline, 4, 8 and 12 wk	FES + exercise as used in this preliminary study is likely to minimize motor loss, but it may not significantly enhance the ability to use the upper extremity after ischemic stroke.
De Kroon et al 2008	6	22 (11/11)	Age: 60.6±10.9 yr Type: isch/hem Time since onset: median 16.5 (range 6-48) mos Inclusion: MAS ≥1, wrist extensor strength MRC <5, 10° voluntary wrist extension	Comparison: Cyclic electrical simulation vs. EMG-NMS Cyclic: Electrical stimulation with surface electrodes on dorsal side forearm to evoke extension wrist and fingers. Cyclic mode stimulation without active involvement of the subject. Application stimulation at home. EMG-NMS: Electrical stimulation with surface electrodes on dorsal side forearm to evoke extension wrist and fingers. Auto mode triggered by voluntary EMG activity, biphasic pulses, 35 Hz for 6 seconds, 1 second ramp-up and 1 second ramp-down, 9 seconds off. Intensity: 3x 30 min/d, 7 d/wk, during 6 wk. Stimulation check by therapist every week during first 2 wk, then every 2 wk. Treatment contrast: 0 h.	ARAT, grip strength, MI arm, FMA arm Measured at baseline, 4 and 6 wk and 6 wk (follow-up)	The present study did not detect a significant difference between EMG-triggered and cyclic electrical stimulation with respect to improvement of motor function of the affected arm in chronic stroke.
Hsu et al 2010	6	66 (22/22/22)	Age: 60.2±10.9 yr Type: isch/hem Time since onset: 23.3±17.9 d Inclusion: FMA arm ≤IV	Comparison: High-NMS vs. Low-NMS vs. control (C) High-NMS: NMS with portable neuromuscular stimulator with 2 channels. Surface electrodes on 1) supraspinatus and posterior deltoid in case of shoulder subluxation, 2) extensor digitorum communis and extensor carpi radialis in case of some visible grasping movement or moderate flexor spasticity (MAS >2), 3) extensor digitorum communis, extensor carpi radialis, flexor digitorum communis in case of completely paralysis. In addition to regular rehabilitation. Low-NMS: NMS like High-NMS. In addition to regular rehabilitation. C: Regular rehabilitation. Intensity: High-NMS: 60 min/d, 5 d/wk, during 4 wk. Low-NMS: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: High-NMS vs. Low-NMS: 10 h. High-NMS vs. C: 20 h. Low-NMS vs. C: 10 h.	FM arm, ARAT, MAL	Higher and lower doses of NMS led to similar improvements in motor function. A minimum of 10 hours of NMS in combination with regular rehabilitation may improve recovery of arm function in stroke patients during the acute stage.
Koyuncu et al 2010	5	50 (25/25)	Age: 60.7±9.49 yr Type: first/rec isch/hem Time since onset: 180 (range 30-1440) d Inclusion: shoulder subluxation and shoulder pain	Comparison: FES vs. control (C) FES: Rehabilitation program using conventional methods. In addition FES to supraspinatus and posterior deltoid muscles, with two superficial electrodes, intensity adjusted to produce humerus elevation together with some abduction and flexion to withdraw the humerus head into the glenoid cavity. Contraction-relaxation ratio adjusted progressively from 10/12 seconds to 30/2 seconds. A shoulder sling and armchair were used during treatment to provide proper position to protect the shoulder joint.	VAS resting, passive ROM, active ROM, shoulder subluxation Measured at baseline and 4 wk	The results of our study have shown that applying FES treatment to the supraspinatus and posterior deltoid muscles in addition to conventional treatment when treating the subluxation in hemiplegic patients is more beneficial than conventional treatment itself.

				C: Rehabilitation program using conventional methods. Intensity: 5x/d, 1 h/d, 5 d/wk during 4 wk. Treatment contrast: 20 h.		
Fil et al 2011	5	62 (31/31)	Age: 66.79±9.40 yr Type: first isch/hem Time since onset: <2 d Inclusion: full ROM shoulder, no motor movement in the arm without incrase of tonus in the muscles surrounding the shoulder, subluxation not surpassing 9.5 mm	Comparison: Electrical stimulation (ES) vs. control (C) ES: ES to mid portion of deltoid muscle, supraspinatus and posterior portion deltoid, automatic pulse rate 100 µsn, frequency 60 Hz/s, stimulation 5 seconds on, 5 seconds off, voltage until visible contraction. In addition to flaccid stage physiotherapy based on Bobath concept, including arm positioning, head-neck and scapula mobilization, bilateral arm elevation, bilateral elbow flexion-extension, crossing midline, normal joint movements for elbow, wrist and shoulders, load transfer to arm in sitting position. In unconscious patients: positioning, head-neck scapula mobilization and upper extremity movements. Informing allied health personnel and relatives of patients about shoulder protection strategies. C: Physiotherapy based on Bobath concept as above. Intensity: 2x 10 min/d, 7 d/wk, during 11.66±1.88 d. Treatment contrast: 233.2 min	Shoulder subluxation, MAS* Measured at baseline and discharge	Electrical stimulation in combination with Bobath technique is an efficient method for preventing shoulder subluxation in acute stroke patients.
Lin et al 2011	6	37 (19/18)	Age: 62.2±8.7 yr Type: first isch/hem Time since onset: 43.5±25.2 d Inclusion: shoulder flexion MRC ≤3, age 44-88	Comparison: NMS vs. control (C) FES: 2-channel NMS with surface electrodes on middle of supraspinatus muscle, deltoid muscle and wrist extensor, with fixed protocol. Stimulation 30 Hz, ramp up and down team of each 1 second, symmetrical biphasic waveform pulse, to produce 30-50° full wrist extension with duty cycle of 5 seconds on and 5 seconds off. Total stimuli 180 cycles per session. Focus on movement induced by NMS. In addition to standard treatment, including physical therapy and occupational therapy. C: Standard treatment, including PT and OT. Intensity: Standard treatment: 30 min/d, 5 d/wk, during 3 wk. FES: 30 min/d, 5 d/wk, during 3 wk. Treatment contrast: 7,5 h.	FMA arm, MAS, mBI Measured at baseline, 2, 3 wk, and 1, 3 and 6 mos (follow-up)	Three weeks of neuromuscular electrical stimulation to the affected upper extremity of patients with stroke improves motor recovery. The effect persists for at least 6 months.
Sentandreu Maño et al 2011	4	20 (10/10)	Age: 74.67±6.8 yr Type: isch/hem Time since onset: 6.39±3.27 mos Inclusion: MAS ≤4, finger extension ≥5°	Comparison: NMS vs. control (C) NMS: Neuromuscular stimulation of wrist and finger extensors, with surface electrodes, rectangular biphasic symmetrical pulses, 50 Hz, till maximal finger and wrist extension was achieved. Contraction/relaxation first week 5-25 seconds, third 5-20 seconds, fourth 5-15 seconds, fifth and sixth 5-10 seconds, seventh and eight; 5-5 seconds. Ramp-up and ramp-down 2 seconds. In addition to conventional rehabilitation (see below). C: Conventional rehabilitation, symmetrical posture, tonus regulation, flexibility, balance and walking re-education. Intensity: NMS: 20-30 min/d, 3 d/wk, during 8 wk. Treatment contrast: 600 min.	ROM, grip strength Measured at baseline 4 and 8 wk	The observed changes seem to be associated with the presence of intervention and they suggest that the NMS protocol applied could be a useful complementary rehabilitation treatment to improve hand motor impairment in carefully selected patients after stroke.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age + SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**

Bowman et al. 1979	RCT	30 (15/15) lacking normal voluntary wrist extension	age: ?	type: TEI post-acute: range 3wk to 4 mo after stroke, mean + SD:?	No	Intervention: Additional positional feedback and electrical stimulation treatment vs Conventional treatment Intensity: E+C: 5 d/wk for 4 wk E: additional 2x/d 30 minutes for 4 wk NMS-characteristics: stimulation duty cycle: 2-10 s. followed by off-period of 10-60 s.; pulse width 200 μs., frequency 35Hz Electrodes: stimulation of (not specified) wrist extensor muscles	Wrist extension torque and ROM measured weekly for 4 wk-period	PFST showed great increase of wrist isometric extension torque and ROM	3 failure at the questions: 3,4,5,6,8,9, 10
Packman-Braun 1988	RCT	18 6 randomly assigned treatment groups, full wrist extension ROM	mean: 67y	type: ? post-acute: mean < 3 mo after stroke, range 1mo-4y	No	Intervention: Testing in random order different stimulus duty-cycle ratios of 1:1, 1:3 and 1:5 Intensity: for each ratio: max 30 minutes treatment time or to reach point of fatigue NMS-characteristics:; rise time of 2 s.; fall time set at 0 s. on time set at 7 s. (=2 s. rise and 5 s. peak on-time; off time set at 5, 15 or 25 s to provide duty cycles ratios of 1:1, 1:3 and 1:5; asymmetrical biphasic square waveform (40mA); pulse with 300 μs and frequency 36Hz Electrodes: stimulation of (not specified) wrist extensor muscles of dorsal forearm	Muscle fatigue measured in three separate testing sessions at 48 hrs intervals (Monday, Wednesday and Friday)	Analysis of the results of this study revealed that the duty-cycle ratio is an important factor affecting the onset of muscle fatigue. Furthermore a duty-cycle ratio of at least 1:5 should be used to enhance the effects of NMS to the wrist extensor muscles of patients with hemiparesis.	4 failure at the questions: 3,4,5,6,7,9
Chae et al. 1998	RCT	46 (25/21) with upper ex-tremity paresis (FMA<44) 39% drop-outs after randomisa-tion for reasons of pain/discom-fort,28 (14/14) completed the study	mean: 59.7y + 13.1y	type: all sub-acute: mean 15.7d + 6.5d after stroke	Yes	Intervention: Additional surface NMS vs additional placebo stimulation Intensity: E+C: 1 hrs/d, total of 15 sessions (= 3wk) NMS-characteristics: stimulation duty cycle 10s. on and 10s. off, pulse was a symmetric biphase (0-60mA), pulse width 300 μs., frequency 25-50Hz Electrodes: E: stimulation of the mm. ext. dig. comm. and ext. carpi rad. and C: electrodes placed away from all motor points, producing only cutaneous stimulation just beyond sensory threshold and without motor activation	FMA and FIM measured after treatment and 4 and 12 wk after treatment	NMS enhances the upper extremity motor recovery of acute stroke survivors. However, the sample size was too small to detect any significant functional benefit of neuromuscular stimulation on self-care function	6 failure at the questions: 3,5,6,9
Powell et al. 1999	RCT	60 (30/30) MRC wrist-extension < 4/5, 20% drop-outs 48 (25/23) completed the study 60 of 621 patients submitted	mean: 67.7y + 11.5y	type: all sub-acute: mean 23.4d + 6.6d after stroke	Yes	Intervention: Standard treatment plus ES vs standard treatment Intensity: E: 3x/d 30 minutes for 8 wk NMS-characteristics: 1s. ramp-up and 1.5s. ramp-down; muscle contraction/relaxation ratio was progressively increased by shortening the relaxation period (from 5/20 s. on/off time, to 5/10 and 5/5 s.); pulse width 300 μs and frequency 20Hz Electrodes: stimulation of mm. ext. carpi rad., ext. carpi uln. and ext. dig. comm.	ARAT, grip strength (Jamar hand dynamometer), muscle tone and NHPT measured at 4 wk, 8 wk (=end of the treatment), 20 and 32 wk (= 24 wk after finish treatment)	ES of wrist extensors enhanced the recovery of isometric wrist extensor strength in hemiparetic stroke patients; upper limb disability was reduced after 8 wk of ES therapy, with benefits most apparent in those with some residual motor function at the wrist. Not clear how long improvements maintained after ES is discontinued.	7 failure at the questions: 5,6,9
Baker & Parker 1986	RCT	63 (31/32) with a minimum of 5 mm chronic GHS	mean: 55.5 y, range 27-74 y	type: ? post-acute: mean 47 d after stroke, range 14-258 d	Yes	Intervention: NMES vs Conventional treatment (hemi-slings or wheelchair arm supports); NMES = NMS Intensity: 5 days/week, 1.5 to 6-7 hrs/d for 6 wk NMS-characteristics: ON-OFF ratio = 1:3; increasing in stimulation tolerance were attained by lengthening ON-time by 2 s.-intervals every 1 or 2 d (max. 24 s., max.ON-OFF ratio is 24:2), frequency varied between 12-25Hz Electrodes: stimulation of the posterior deltoideus and supraspinatus muscles	X-ray and perceived pain measured at 6 wk and 3 mo after start treatment	NMES of the muscles surrounding the shoulder is an effective method of early mobilisation, especially for the patient experiencing shoulder pain. Shoulder subluxation reduced significantly at the completion of a six week NMES program.	4 failure at the questions: 3,5,6,7,8,9

Faghri et al. 1994 Faghri et al. 1997	RCT	26 (13/13) with shoulder muscle flaccidity / paralysis same subjects	mean: 67 y + 13 y	type: ? sub-acute: mean 16.5 d + 5 d after stroke	No No	Intervention: Additional NMS vs Conventional PT (no placebo-NMS); NMS named FNS in this study Intensity: 1.5 hrs up to 6 hrs/d (7d/wk) for 6 weeks, followed by a nontreatment period of 6 wk NMS-characteristics: contraction/relaxation ratio pro-gresssively increased (10/12 s. to 30/2 s. ON-OFF), frequency 35 Hz to create a tetanized contraction Electrodes: stimulation of supraspinatus and posterior deltoideus muscles	SLROM, EMG, modified Bobath assessment chart and X-ray measured 6 and 12 wk after start of training.	NMS was effective in reducing the severity of shoulder subluxation and pain, and possibly facilitating recovery of arm function FNS could facilitate the arm and shoulder muscles recovery process	4 failure at the questions: 3,5,6,7,8,9 4
Linn et al. 1999	RCT	40 (20/20) MMT< 2	mean: 72 y, range 45-84 y	type: all acute:within 48 hrs of their stroke	Yes	Intervention: Additional ES vs Conventional PT + OT Intensity: 4x/day (30-60 minutes); 7d/wk during 4 wk NMS-characteristics: duty cycle 15 s. on, including ramp up of 3s. and ramp down of 3 s. and 15 s. off; asymmetrical biphasic pulses with a pulse width of 300 µs. and frequency of 30Hz Electrodes: stimulation of supraspinatus and posterior deltoideus muscles.	PHLR, Motor Assessment Scale and X-ray measured at 4 and 12 wk after stroke	Electrical stimulation can prevent shoulder subluxation (significant less subluxation and pain after treatment), but this effect was not mentioned after the withdrawal of treatment	7 failure at the questions: 3,5,6
Wang et al. 2000	RCT	32 (8 / 8 / 8 / 8) with a minimum of 9.5 mm of acromiohumeral distance;divided in 2 groups: long and short duration	mean: 57.3 y, range 40-72 y	type: all E1: sub-acute: mean 15 d + 3d after stroke E2: chronic: mean 430d + 46d after stroke	Yes	Intervention: NMS vs Routine therapy; E1: short duration of hemiplegia (< 21 d); E2: long duration of hemiplegia (> 365 d); E1+E2: A-B-A study design: A=NMS, B=routine therapy; each period lasted 6 wk (total 18 wk);. Intensity: 5 sessions/wk; started with 3x/30min/d to single 6 hrs/d during 1st wk, following 5 weeks 6hrs/d NMS-characteristics: on-off ratio = 1:3; increasing in stimulation tolerance achieved by prolonging ON-time by 2 s.-intervals every 1 or 2 d (max. 24 s., max.ON-OFF ratio is 24:2); frequency individually varied. Electrodes: stimulation of the posterior deltoideus and supraspinatus muscles	X-ray measured at 6, 12 and 18 weeks	This study suggests that hemiplegic subjects with short postonset duration are effectively trained for shoulder subluxation by the first NMS treatment program. The same NMS showed not to be effective when applied to the subjects with subluxation of more than 1 year.	4 failure at the questions: 3,4,5,6,8,9
Wang et al. 2002	RCT	same study		same study	Yes	same study	BFM measured at 6, 12 and 18 weeks	This study suggests that patients with hemiplegia of short duration are effectively trained by NMS for motor recovery.	5 failure at the questions: 3,5,6,8,9

RCTs investigating electromyographic neuromuscular stimulation (EMG-NMS; Category 5)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Francisco et al 1998	4	9 (4/5)	Age: 60.3±15.6 yr Type: first isch Time since onset: 17.5±2.4 d Inclusion: detectable surface EMG signal, volitional wrist extension in synergy or in isolation with muscle grade of <3/5	Comparison: EMG-NMS vs. control (C) EMG-stim: Standard stroke rehabilitation (see below). In addition, surface electrodes on extensor carpi radialis, asked to volitionally extend wrists, duty cycle of 5 seconds on and 5 seconds off. C: Standard stroke rehabilitation e.g. neuromuscular reeducation, ROM exercises, strengthening and neuromuscular facilitation procedures, functional training and use of physical modalities and adaptive equipment as indicated. In addition, ROM and strengthening exercises of impaired wrist. Intensity: Additional therapy: 2x30 min, 5 d/wk, during rehabilitation. Treatment contrast: 0 h.	FMA arm, FIM subitems Measured at admission and discharge	Data suggest that EMG-NMS enhances the arm function of acute stroke survivors.
Cauraugh et al 2000	2	11 (7/4)	Age: 61.64±9.57 yr Type: ???? Time since onset: 3.49±2.56 yr Inclusion: <75% motor recovery, voluntarily extend wrist 20° against gravity from a 90° flexed position	Comparison: EMG-NMS vs. control (C) EMG-NMS: Surface electrodes with initiation of wrist/finger extension so that a target threshold level of EMG activity was voluntarily achieved, which triggered the neuromuscular electrical stimulation to assist the muscles to reach a full range of motion. Before session: passive range of motion activity, gentle stretching wrist and finger flexors. C: Passive range of motion activity, gentle stretching wrist and finger flexors. Lift wrist for 2 sessions of 30 trials. Intensity: 2x30 min, 3 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, FMA arm, MAS, kinematics (force-generation), EMG activity Measured at baseline and 24 wk	The treatment program decreased motor dysfunction and improved the motor capabilities in this group of post stroke individuals.
Cauraugh et al 2002	4	25 (10/10/5)	Age: 63.7 yr Type: ≤2 strokes Time since onset: 39.1 mos Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	Comparison: Bilateral arm training (BAT) + EMG-NMS vs. uni + EMG-NMS vs. control (C) BAT + EMG: EMG-triggered surface NMS-stimulation and assistance from unimpaired limb as wrist/finger extension was executed simultaneously on both limbs. 5 seconds of stimulation, followed by 25 seconds of rest. Uni + EMG: EMG-triggered surface NMS-stimulation to assist with wrist and finger extension. 5 seconds of stimulation, followed by 25 seconds of rest. C: Voluntarily extend wrist/ fingers without receiving NMS stimulation or bilateral assistance for wrist/fingers extensors. Intensity: 3 sets of 30 successful trials per session. 1.5 h, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, reaction time, sustained muscle contraction capability (EMG) Measured at baseline and 2 wk	Significant findings for all outcomes in favor of BAT + EMG-NMS. Unilateral group exceeded control group in number of blocks moved and rapid onset of muscle contractions.
Hemmen et al 2002 en 2007	6	27 (14/13)	Age: 62.1±12.7 yr Type: first isch Time since onset: 44.9±14.5 d Inclusion: wrist strength MRC 2-3	Comparison: EMG-NMS vs. electrical stimulation (ES) EMG-NMS: Surface electrodes, concentrate on making an imaginary wrist extension, after picking up the wrist extensor EMG signal, this was amplified and used for assisted contraction of wrist extensors paretic arm and clear dorsiflexion of the wrist over the total ROM starting from neutral position. ES: Repetitively stimulate wrist extensor muscles for 12 seconds, followed by a 5 seconds rest. No additional instructions related to arm or hand performance. Intensity: 30 min/d, 5 d/wk, during 12 wk. Treatment contrast: 0 h.	FMA arm, ARAT Measured at baseline, 3 mos and 12 mos (follow-up)	EMG-triggered feedback stimulation did not lead to more arm-hand function improvement relative to conventional electrostimulation.
Cauraugh et al 2003 B	4	26 (10/10/6)	Age: 66.4±9.7 yr Type: ≤2 strokes Time since onset: 2.8±1.9 yr Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	Comparison: BAT + EMG-NMS 10 sec vs. BAT + EMG-NMS 5 sec vs. control (C) BAT + EMG 10 sec: EMG-NMS (Automove) stimulation 10 seconds of wrist and fingers coupled with bilateral movement training. BAT + EMG 5 sec: EMG-NMS stimulation 5 seconds of wrist and fingers coupled with bilateral movement training. C: No active EMG-NMS stimulation assistance supplemented the wrist/finger voluntary movement attempts. Intensity: 3 sets of 30 successful trials. 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, reaction time, sustained force generation (EMG)	Across the mixed design analysis, distinct improvements in motor capabilities were found for the 5 and 210 second stimulation duration groups in comparison to the 0 seconds duration control group.

Cauraugh et al 2003 C	5	34 (14/14/6)	Age: 66.1 yr Type: ≤2 strokes Time since onset: 3.2 yr Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position	Comparison: BAT blocked vs. BAT random vs. control (C) BAT blocked: EMG-NMS (Automove) combined with blocked practice, i.e. same movement repetitively performed on successive trials. Wrist/finger extension, elbow joint extension, shoulder joint abduction. BAT random: EMG-NMS combined with random practice, i.e. different movements on successive trials. Wrist/finger extension, elbow joint extension, shoulder joint abduction. C: Each joint/set muscles passively moved, voluntarily execute wrist/finger extension, elbow joint extension, shoulder joint abduction. No active stimulation assistance. Intensity: 3 sets of 30 successful trials. 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	BBT, reaction time, sustained muscle contraction Measured at baseline and 2 wk	Upper extremity rehabilitation intervention of active stimulation and blocked practice perform as well as stimulation/random practice.
Popovic et al 2003	5	28 (16/12) High-functioning (HFG): 16 (8/8) Low-functioning (LFG): 12 (6/6)	Age: 59.9±9.3 yr Type: isch/hem Time since onset: 7±2 wk Inclusion: 2 wk - 6 mos post stroke; no ADL dependency prior to stroke, severe medical condition in arm/hand, previous injury/ disease/ contracture affecting arm or hand, electrical lift support devices HFG: actively extend wrist, MCP and IP >20° LFG: extend wrist 10°-20°, extend MCP and IP of thumb and ≥2 digits 10°-20°	Comparison: FES vs. control (C) FES: Conventional therapy introduced by Bobath (26 wk), during first 3 wk exercise assisted with neural posthesis controlling the opening, grasping, and releasing functions by mimicking natural movements. Four channels of ES via self-adhesive surface electrodes on finger flexors, finger extensors, thumb extensor, thenar muscle group. Frequency 50 Hz, pulse duration 200 µs, stimulation intensity 20-45 mA. Try functionally use e.g. toothbrush, comb, telephone receiver, pen, small food, 0.33 L can, 0.33 L bottle, 1 L container, CD for computer, 0.25 L coffee mug. Trigger opening synergy with nonparetic hand at the appropriate time during reaching phase and trigger release function when they accomplished effectively the task of were not able to fulfill the task. Start with easier task, progress to more difficult tasks. As many tasks as possible within one single session. PT comprised ensuring subject held object adequate, when/ how maximize use of externally controlled hand. Sometimes without supervision. C: Conventional therapy, with same tasks as FES group but without neural prosthesis. Intensity: 30 min/d, 7 d/wk, during 3 wk. Treatment contrast: 0 h.	UEFT, drawing test, MAS, RUE/MAL Measured at baseline and 3 wk and 6, 13 and 26 wk (follow-up)	The speed of recovery in FES groups was substantially faster compared with the recovery rate in control groups during the first 3 weeks (treatment). The LFG subject showed less improvement than the HFG in both the FES and control groups.
Kimberley et al 2004	6	16 (8/8)	Age: 60.1±14.5 yr Type: ?? Time since onset: 35.5±25.1 mos Inclusion: ≥10° active flexion/extension MCP index finger	Comparison: EMG-NMS vs. control (C) FES: Intensive home EMG-NMS, with asymmetrical rectangular biphasic constant current, 50 Hz, intensity to produce finger- and wrist-extension movements. Pulse 5 seconds, 1 second ramp-up, 1 second ramp-down, 15 seconds rest. Half of the time active effort to trigger stimulated response, other half of the time automatical stimulation. One instruction at visit, maintaining contact by telephone weekly. No instructions to encourage increased hand use or modify behavior in any other way. C: As EMG-NMS but with sham stimulation. Intensity: 6 h/d, 10 days, during 3 wk. Treatment contrast: 0 h.	BBT, MAL, JTHFT, isometric strength, finger-movement tracking, fMRI Measured at baseline and 3 wk	NMS may have an important role in stimulating cortical sensory areas allowing for improved motor function.
Cauraugh et al 2005	4	21 (10/11)	Age: 69.37±10.14 yr Type: ?? Time since onset: 4.7±3.52 yr Inclusion: ≥10° active extension wrist or fingers against gravity from a 90° flexed position, ≤3 strokes	Comparison: Coupled bilateral (BAT) vs. unilateral/ active (Uni) stimulation (EMG-NMS) BAT + EMG-NMS: Bilateral movements in the intact wrist/fingers simultaneously with active EMG-NMS of wrist/finger extensors on impaired limb (7 seconds ramp/stimulation, 25 seconds rest). Uni + EMG-NMS: EMG-NMS triggered neuromuscular stimulation given to voluntary wrist/finger extension impaired limb (7 seconds ramp/stimulation, 25 seconds rest). Intensity: 1.5 h/d, 2 d/wk, during 2 wk. Treatment contrast: 0 h.	Kinematics (reaction time, movement time, peak velocity, time-to-peak velocity, acceleration and deceleration phase) Measured at baseline and 2 wk	Coupled protocol training improved bimanual aiming that required shoulder and elbow joints movements.
Daly et al 2005	5	12 (6/6)	Age: ?? Type: isch/hem Time since onset: >12 mos	Comparison: Functional neuromuscular stimulation and motor learning (FNS-ML) vs. robotics-ML (ROB-ML) FNS-ML: Wrist and finger muscle activation with FNS with surface electrodes.	AMAT, AMAT shoulder/elbow, AMAT wrist/hand, FMA arm, motor control measures	ROB-ML produced significant gains in AMAT, AMAT shoulder/elbow, FMA arm, target accuracy en smoothness of

			Inclusion: Wrist extensors MRC ≥1, FMA coordination >10	Practice single and multiple joint movements, including wrist flexion/extension, finger and thumb flexion/extension, simultaneous wrist extension and finger flexion. FNS was used along with task component movements. 10 seconds stimulus, 10 seconds rest. 3.5 h task component s practice and whole task practice without technology assistance, focusing on coordination but also subject's interest and functional goals. ROB-ML: Shoulder-elbow robot with training in horizontal plane with supported forearm (2 degrees of freedom). Allowing for resisted, active, or assisted movement. 1.5 h training shoulder/elbow movement accuracy, trajectory maintenance, movement smoothness. Visual display provided online visual feedback. 3.5 h practice of functional task components and whole task practice without technology assistance, focusing on coordination but also subject's interest and functional goals. Intensity: 5 h/d, 5 d/wk, during 12 wk. Treatment contrast: 0 h.	Measured at baseline, 12 wk and 6 mos (follow-up)	movement. FNS-ML produced significant gains in AMAT wrist/hand and FMA arm.
Gabr et al 2005	3	12 (8/4)	Age: 59.75 (range 44-75) yr Type: ?? Time since onset: 52.75 (range 13-131) mos Inclusion: passive ROM wrist extension 45^{o}, passive movement without difficulty in distal ICP joints of affected fingers, inability to active extend affected wrist	Comparison: Electromyography-triggered stimulation (ETMS) vs. control (C) ETMS: ETMS with 3 surface electrodes over motor point on wrist extensor group, used at home after individual education session. Extension exercises without participation in any actual activity. 10 second cycles. Home diary to record use device. C: Home exercise program for affected arm, after individual education session. Exercises written on sheet: supination/pronation, flexion/extension fingers, wrist extension and flexion, elbow flexion/extension, shoulder adduction/abduction. Home use diary to record compliance. Intensity: ETMS: 2x 35 min/d, 5 d/wk, during 8 wk. Treatment contrast: 0 h.	FMA arm, ARAT, ROM Measured at baseline and 8 wk.	ETMS use is feasible in the home environment. Neither participation in a traditional home exercise programme nor ETMS use conveyed changes on the FMA arm or ARAT. However, ETMS use increased active affected limb extension.
Popovic et al 2005	7	13 (5/8)	Age: 57.6±17.5 yr Type: isch/hem Time since onset: 92 d Inclusion: CMSMR 1-2; no skin rash, allergy, wounds, seizure episodes, edema paralyzed arm, shoulder hand syndrome	Comparison: FES vs. control (C) FES: Neuroprosthesis (Compex Motion electric stimulator) to support reaching and grasping with standard self-adhesive surface stimulation electrodes. Start by shoulder and upper arm muscles, then to distal muscles; mm. flexor digitorum superficialis, flexor digitorum profundus, median nerve/m. thenar, flexor pollicis longus, extensor digitorum flexor carpi radialis, flexor carpi ulnaris, extensor carpi radialis longus and brevis, extensor carpi ulnaris, biceps, triceps, anterior and posterior deltoid. Functional training program, start with execute task with impaired arm unassisted. Then components/sequences of tasks unable to carry out assisted with neuroprosthesis, controlled by therapist who also guided arm. Reduce assistance weekly or biweekly. Repeat task 20-30 times during session. 25-30 minutes active treatment, 15-20 min donning and doffing. In addition to conventional PT and OT (see below). C: Conventional PT and OT, including muscle facilitation exercises emphasizing NDT approach, task-specific repetitive functional training, strengthening and motor control training using resistance to available arm motion to increase strength, stretching exercises, electrical stimulation applied primarily for muscle strengthening (not FES therapy), ADL, caregiver training. 45 min/d, 3-5 d/wk, during 12-16 wk. Intensity: 45 min/d, 3-5 d/wk, during 12-16 wk. Treatment contrast: 42 h.	FIM, BI, CMSMR, FMA, RELHFT Measured at baseline and discharge	After the treatment program was completed, the patients treated with the neuroprosthesis significantly improved their reaching and grasping functions and were able to use them in ADL However, the majority of the control patients did not improve their arm and hand functions significantly and were not able to use them in ADL.
Hara et al 2006	6	16 (8/6)	Age: 57.6 (range 43-77) yr Type: first/rec Time since onset: 16 mos (range 12-34) mos Inclusion: spastic hemiparesis, Stroke Impairment Assessment Set arm 3-4, finger 1a-2.	Comparison: FES vs. control (C) FES: Hybrid power-assisted Functional electrical stimulation with motor point block at spastic finger flexor muscles. 2-channel EMG-NMS with surface electrodes on motor points extensor muscles impaired arm. Start with passive ROM and gentle stretching finger and wrist muscles by trainer. Then EMG-NMS with bilateral movement training and cup grasping. OT for patient goals. C: Extend impaired wrist and fingers voluntarily. OT for patient goals. Intensity: 40 min/d, 2 d/wk, during 4 wk. Treatment contrast: 0 h.	Active ROM wrist and finger extension, MAS, 10CMT, NHPT	The hybrid therapy was effective for patients with chronic spastic hemiparesis.

Bhatt et al 2007	4	22 (7/7/6)	Age: 67.71±3.54 yr Type: ?? Time since onset: 30.71±7.95 mos Inclusion: ≥10° active extension-flexion movement at index finger MCP	<u>Comparison</u>: Electrical stimulation (ES) vs. tracking training (TR) vs. combination (CM) <u>ES</u>: EMG-NMS with electrodes over bellies wrist and finger extensor muscles, 7 seconds with 15 seconds rest. <u>TR</u>: With electrogoniometer on index fingers, track randomly selected waveforms, per session 20 protocols of 3 trials each. In 90% of protocols use affected upper extremity, in 10% unaffected upper extremity. Augmented feedback (KR) after every trial. <u>CM</u>: Started with EMG-NMS like ES group, but during rest phase track target waveforms with KP after every trial, identical to TR group. <u>Intensity</u>: 10x 1 h/d, during 2-3 wk. <u>Treatment contrast</u>: 0 h.	BBT, JTHFT, finger tracking test (with fMRI) Measured at baseline and 2-3 wk	Our results did not demonstrate a clear functional advantage of the combined intervention over electrical stimulation or tracking training treatments given alone. But, out results did show that only the combined intervention group had a significant association between functional recovery and brain reorganization.
Kowalczewski et al 2007	6	19 (10/9)	Age: 60.6±5.8 yr Type: first isch/hem Time since onset: 48±17 d Inclusion: inability to voluntarily grasp and release any 3 objects on the workstation, FMA arm arm/hand <4, tolerance level of FES needed for hand opening	<u>Comparison</u>: High-intensity FES vs. low-intensity FES <u>High FES</u>: FES-assisted exercise on workstation. Manipulating 3 objects for 20 min per object, with focus on reaching, grasping and manipulating, repeated as often as possible. If needed wearing a conventional partial weight-support sling and frame to assist in the movements. In addition to regular PT . <u>Low FES</u>: Sensory electric stimulation 4 d/wk and FES-assisted exercise. 1 d/wk In addition to regular PT. <u>Intensity</u>: High FES: 1 h/d, 5 d/wk, during 3-4 wk. Low FES: sensory ES 15 min/d, 4 d/wk, during 3-4 wk, FES 1 h/d, 1 d/wk, during 3-4 wk. <u>Treatment contrast</u>: 12 h.	WMFT, FMA arm, MAL, kinematics Measured at baseline, 3-4, wk and 3 and 6 mos (follow-up)	Subjects performing high-intensity FES showed significantly greater improvements on the WMFT than those performing the low-intensity FES. However, this was not reflected in subjects' self-assessments (MAL) or in their FMA arm scores, so the clinical significance of the result is open to debate. The combined kinematic score data suggest that high-intensity FES may be advantageous in neuroprosthetic applications.
Barker et al 2008 and 2009	7, 6	33 (10/13/10)	Age: 61±15.5 yr Type: first Time since onset: 5±4.9 yr Inclusion: MRC 1-3 triceps, inability to complete a standardizes supported reaching task	<u>Comparison</u>: EMG stimulation + training (EMG-stim) vs. training vs. control (C) <u>EMG-stim</u>: Non-robotic upper limb training device (SMART Arm) with three surface electrodes to augment elbow extension. Required to initiate the reaching task and when the level of activation of triceps brachii reached an initial target threshold of EMG activity, electrical stimulation to triceps brachii was automatically triggered. 10 seconds on, 10-20 seconds rest. Restrained by a seat belt in order to restrict compensatory trunk movements and encourage recovery of premorbid movement patterns. Continue exercise at home. <u>Training</u>: Use SMART arm but without stimulation. <u>C</u>: No intervention. <u>Intensity</u>: EMG-stim/training: 1 h/d, 3 d/wk, during 4 wk. <u>Treatment contrast</u>: EMG-stim/training vs. C: 12 h. EMG-stim vs. training: 0 h.	Triceps brachii strength, MAS, upper limb items MAS*, kinematics (maximum isometric force, maximum distance reached) Measured at baseline, 4 wk and 12 wk (follow-up)	The findings suggest that increased activation of triceps as an agonist and an improved coordination between triceps and biceps could have mediated the observed changes in arm function. The changes in EMG activity were small relative to the changes in arm function indicating that factors, such as the contribution of other muscles of reaching, may also be implicated.
De Kroon et al 2008	6	22 (11/11)	Age: 60.6±10.9 yr Type: isch/hem Time since onset: median 16.5 (range 6-48) mos Inclusion: MAS ≥1, wrist extensor strength MRC <5, 10° voluntary wrist extension	<u>Comparison</u>: Cyclic electrical simulation vs. EMG-NMS <u>Cyclic</u>: Electrical stimulation with surface electrodes on dorsal side forearm to evoke extension wrist and fingers. Cyclic mode stimulation without active involvement of the subject. Application stimulation at home. <u>EMG-NMS</u>: Electrical stimulation with surface electrodes on dorsal side forearm to evoke extension wrist and fingers. Auto mode triggered by voluntary EMG activity, biphasic pulses, 35 Hz for 6 seconds, 1 second ramp-up and 1 second ramp-down, 9 seconds off. <u>Intensity</u>: 3x 30 min/d, 7 d/wk, during 6 wk. Stimulation check by therapist every week during first 2 wk, then every 2 wk. <u>Treatment contrast</u>: 0 h.	ARAT, grip strength, MI arm, FMA arm Measured at baseline, 4 and 6 wk and 6 wk (follow-up)	The present study did not detect a significant difference between EMG-triggered and cyclic electrical stimulation with respect to improvement of motor function of the affected arm in chronic stroke.
Hara et al 2008	5	20 (5/5/10)	Age: 56.0 (range 24-77) yr Type: first/rec Time since onset: 13 (12-16) mos Inclusion: passive ROM wrist to 45°, and affected shoulder flexion to 140°, Stroke Impairment Assessment Set arm 2-4, finger 1a-2	<u>Comparison</u>: FES vs. control (C) <u>FES wrist and finger</u>: After initial outpatient session, train at home EMG-NMS with 3 surface electrodes, to promote wrist, finger extension movement during coordinate movement, with greater muscle contraction by NMS in proportion to the integrated EMG signal picked up. Home protocol, supination/pronation, flexion/extension fingers, wrist extension/flexion wrist. Instrumental tasks of reaching, grasping, moving and releasing object. ADL activity training. OT directed toward patient goals. <u>FES shoulder</u>: After initial outpatient session, train at home EMG-NMS with 3 surface electrodes, to promote shoulder flexion movement during coordinate	Active ROM, MAS, EMG, 10CMT, NHPT Measured at baseline and 5 mos	Daily power-assisted FES home program therapy can effectively improve wrist and finger extension and shoulder flexion.

				movement, with greater muscle contraction by NMS in proportion to the integrated EMG signal picked up. Home protocol, elbow flexion/extension, shoulder abduction. Instrumental tasks of reaching, grasping, moving and releasing object. ADL activity training. OT directed toward patient goals. C: Supervised training of wrist extension and fingers, flexion shoulder voluntarily, stretched and passive ROM. OT directed toward patient goals. Intensity: FES: 30-60 min/d, 6 d/wk, during 5 mos. C: 40 min, 1x/wk, during 5 mos. Treatment contrast: FES wrist and finger vs. shoulder: 0 h. FES vs. C: 4600 min		
Mayr et al 2008	4	8 (4/4)	Age: 68.25±12.20 yr Type: isch/hem Time since onset: 2.38±0.74 mos Inclusion: left hemiparesis	Comparison: Robotics vs. EMG-NMS Robotics: Electromechanical arm robot (ARMOR) with 12 degrees of freedom (8 active, 4 passive), with progressive program. In addition to conventional rehabilitation. EMG-NMS: EMG-NMS with 3 electrodes, 35-50 Hz, 5 seconds stimulation, decrease in 1 second. In addition to conventional rehabilitation. Intensity: 30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	CMMSA, MAS, ROM, FDT Measured at baseline and 2 wk	This study demonstrates the positive effect of automatised training with a new electromechanical arm robot (ARMOR).
Shin et al 2008	4	14 (7/7)	Age: 61.0±7.5 yr Type: isch/hem Time since onset: 18.6±4.2 mos Inclusion: voluntarily extend >20° MCP of dig III from a 90° flexed position, MAS <2	Comparison: EMG-NMS vs. control (C) EMG-NMS: EMG-NMS of wrist extensors with 3 surface electrodes. 5 seconds simulation, 4 seconds rest. Electric stimulation was set to initiate after 20 seconds if the subject could not exceed the target threshold. Low-intensity physical activities were allowed. C: Low-intensity physical activities were allowed. Intensity: 2x 30 min/d, 5 d/wk, during 10 wk. Treatment contrast: 50 h.	BBT, strength, tracking test, EMG, fMRI Measured at baseline and 10 wk.	We demonstrated that 10-week EMG-NMS can induce functional recovery and change of cortical activation pattern in the hemiparetic hand of chronic stroke patients.
Thrasher et al 2008	6	21 (10/11)	Age: 57±14.7 yr Type: ?? Time since onset: 29.8±11.8 d Inclusion: CMSMR 1-2 for arm/hand (spastic or flaccid paralysis of arm and hand, with little or no voluntary movement)	Comparison: FES vs. control (C) FES: 4 pairs of surface electrodes in neuroprosthesis, near maximal contraction, participant performed task voluntarily and stimulation only used to assist the movement that the patient was unable to perform with stimulation lasting 1-3 seconds, timing controlled by therapist. Phase 1: forward reaching motion, nose reaching motion, shoulder abduction followed by elbow extension. Each task >5 minutes, multiple times (20-30), each task during each session. After successful completion go to Phase 2: grasp and release function in functional training. In early stages all movements were performed with help of FES, later FES was used less and only to help particular movements. During task execution, therapist manually guided arm. Conventional OT and PT consisting of muscle facilitation exercises emphasizing NDT approach, task-specific repetitive functional training, strengthening and motor control training using resistance, electrical stimulation applied primarily for isolated muscle strengthening (not for functional training), ADL, caregiver training. C: Conventional OT and PT as FES group. Intensity: FES: 45 min/d, 5 d/wk, during 12-16 wk, including additional conventional but of shorter duration than controls. C: 45 min/d, 5 d/wk, during 12-16 wk. Treatment contrast: 0 h.	RELHFT (objects, blocks, grip torque, pinch force, eccentric load), FIM, BI, CMSMR, FMA arm Measured at baseline and 14 wk	FES therapy with upper extremity training may be an efficacious intervention in the rehabilitation of reaching and grasping function during acute stroke rehabilitation.
Chan et al 2009	7	20 (10/10)	Age: 46±17 yr Type: first ?? Time since onset: 18.1±16.1 mos Inclusion: FMA arm finger mass extension “0”	Comparison: BAT + FES vs. BAT BAT + FES: Stretching or passive mobilization activities (10 min), FES with bilateral upper limb training (20 min, 8 seconds of stimulation) while wearing a wrist extension splint with≥20 repetitions of two of the four tasks per session: moving a bowl, pushing basketball, simulated feeding and drinking. Occupational therapy including training ADL and exercise training, mainly targeted at proximal upper limb control. BAT: Same exercises but without FES (but sham “stimulation”, i.e. sensation) Intensity: 1.5 h, 15 sessions Treatment contrast: 0 h.	FMA arm, FTHUE, AROM wrist extension, MAS, functional reaching distance, grip power, FIM Measured at baseline and 15 sessions	Bilateral upper limb training with FES could be an effective method for upper limb rehabilitation of stroke patients after 15 training sessions (FMA arm, FTHUE, AROM).

Mangold et al 2009	6	23 (12/11)	Age: 62±16.2 yr Type: first isch/hem Time since onset: median 7.3 (IQR 5.8, 8.2) wk Inclusion: CMSRM arm and/or hand ≤3	Comparison: FES + conventional vs. conventional (C) FES: Surface electrodes on proximal and distal muscles and integrated into stimulation sequence to reach, grasp and release an object. If necessary, therapist manually treated spasticity, used a help arm to reduce gravity, and provided manual assistance to support the grasp action and to prevent movements that might cause damage such as pathologic scapula movements. In addition to mobilization and selective movements of shoulder, hand, arm, and grasping exercises supported by therapist if necessary. To small degree ADL and sensory retraining were practiced, as supported by therapist or performed bimanually. C: Mobilization and selective movements of shoulder, hand, arm, and grasping exercises supported by therapist if necessary. To small degree ADL and sensory retraining were practiced, as supported by therapist or performed bimanually. Intensity: FES: 45 min/d, 3 d/wk, during 4 wk, additional OT 45 min/d, 2 d/wk, during 4 wk. C: 45 min/d, 3-5 d/wk, during 4 wk. Treatment contrast: 0 h.	Extended BI, CMSRM, MAS Measured at baseline, 4 wk and 6 (follow-up)	We did not find clear evidence for superiority or inferiority of FES.
Shindo et al 2011	6	20 (10/10)	Age: 58.2±18.6 yr Type: first isch/hem Time since onset: 34.4±14.5 d Inclusion: not fully extend paretic fingers, not extend paretic fingers individually, passive ROM wrist extension >0^{o}, -10^{o} for MCP extension, muscle activities in affected extensor digitorum communis with surface electrodes	Comparison: HybridAssistive neuromuscular dynamic stimulation (HANDS) vs. control (C) HANDS: Wrist splint and integrated volitional electric stimulation. IVES non-invasive closed-loop EMG-controlled single-channel neuromuscular electrical stimulator in EDC, stimulus with extension of four fingers besides thumb to 0^{o} during voluntary finger extension. In addition to standard rehabilitation, consisting of PT/OT and speech therapy if indicated. C: Wear splint, in addition to standard rehabilitation. Intensity: 8 h/d, 7 d/wk, during 3 wk. Treatment contrast: 0 h.	FMA arm, ARAT, MAL Measured at baseline and 3 wk	HANDS therapy in addition to conventional therapy may improve hand function in patients with moderate to severe hand impairment during early rehabilitation.
Tarkka et al 2011	4	20 (10/10)	Age: 53±6 yr Type: isch/hem Time since onset: 2.4±2.0 yr Inclusion: ≥6 mos post stroke, severe functional deficits affected upper limb; no cardiac pace-maker, epilepsy	Comparison: FES vs. control (C) FES: Hand and arm exercises combined with ES, with 4-channel programmed FES device. Surface electrodes to facilitate hand opening and closing. Temporal pattern varied according to practiced tasks and functional ability. Task usually took 2-3 seconds to complete. C: Conventional PT with paying attention to arm and hand with voluntary movement exercises and passive manual stretching. Intensity: 2x 30 min/d, 5 d/wk, during 2 wk. Treatment contrast: 0 h.	WMFT, TMS Measured at baseline and 2 wk and 6 mos (follow-up)	Despite the small number of heterogeneous subjects, functional exercise augmented with individualized electrical therapy of the paretic upper limb may enhance neuroplasticity, observed as corticospinal facilitation, in chronic stroke subjects, along with moderate improvements in the voluntary motor control in the affected upper limb.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**

Francisco et al. 1998	RCT	9 (5 / 4) with wrist extension with muscle grade less than 3 (range 0-5) 9 of 16 completed the study (44% drop-outs)	mean: 64.9 y. +15.9 y.	type: iCVA sub-acute: mean 18d. + 2.4d. after stroke	Yes	Intervention: EMG-triggered feedback therapy and PT vs only PT E: EMG-triggered feedback therapy with Automove stimulator C: PT; neuromuscular re-education, ROM-exercises, strengthening, neuromuscular facilitation and functional training Electrodes: wrist extensors Intensity: 30 min, 5 d/wk for 6 wk	FMA (UE) and FIM measured at 6 wk	Subjects treated with EMG-triggered neuromuscular stimulation exhibit significantly greater gains in FMA and FIM scores compared with controls	5 failure at the questions: 3,5,6,8,9
Cauraugh et al. 2000	RCT	11 (7 / 4) with UE-impairments (less than 20 degrees of voluntary wrist extension)	mean: 61.6 y. + 9.6y.	type: all chronic: mean 3.5 y. + 2.6y. after stroke	No	Intervention: EMG-triggered feedback therapy and PT vs only PT E: EMG-triggered feedback therapy with Automove stimulator C: PT; UE was moved trough a range of motion and stretched, then they tried to voluntary lift their wrist Electrodes: wrist extensors Intensity: 60 min, 3 d/wk for 2 wk	BB, FMA, Motor Assessment Scale and muscle force measured at 2 wk	Evidence support the use of EMG-triggered neuromuscular electrical stimulation treatment to rehabilitate wrist and finger extension movements of hemiparetic individuals more than 1 year after stroke	3 failure at the questions: 3,4,5,6,7,9, 11
Hemmen et al. (congress abstract, 2002)	RCT	27 (14 / 13)	mean: 61.4 y. + 2.4y., range 31-76y.	type: all post-acute: mean 55d. + 7.6d. after stroke, range 22-222d.	?	Intervention: EMG-triggered feedback therapy and movement imaginary vs conventional electrostimulation E: EMG-triggered feedback therapy and movement imaginary with Automove stimulator C: conventional electrostimulation Electrodes: wrist extensors Intensity: 30 min, 5 d/wk for 12 wk	FMA and ARAT measured at 12 wk and 1 y. after start treatment	No statistically significant effect between the 2 groups for Fugl-Meyer scores and ARAT-scores at 12 wk and 1 year after start treatment.	5 failure at the questions: 3,5,6,7,9

RCTs investigating transcutaneous electro neurostimulation (TENS; Category 4)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Tekeoğlu et al 1998	4	60 (30/30)	Age: 55.9±7.0 yr Type: ?? Time since onset: 40.8±11.4 d Inclusion: discrete loss of motor function but able to stand and walk if assisted	Comparison: TENS vs. placebo (C) TENS: TENS with two surface electrodes on extensor muscles of elbow, other two electrodes on peroneal nerve posterior to head of fibula. Square pulses 0.2 ms, 100 Hz. Intensity at bearable pain threshold. In addition to Todd-Davies exercise programme. C: Sham stimulation. In addition to Todd-Davies exercise programme. Intensity: TENS/sham 30 min/d, 5 d/wk, during 8 wk. Treatment contrast: 0 h.	MAS, BI Measured at baseline and 8 wk	TENS appears to be an effective adjunct in the regaining of motor functions and improving ADL in hemiplegic patients, but the accidental imbalance in severity of disability at entry makes interpretation uncertain.
Sonde et al 1998, 2000	3, 4	44 (26/18) 28 (18/10)	Age: 71±6.0 yr Type: first Time since onset: 9.1±2.2 mos Inclusion: FMA arm 0-50	Comparison: Transcutaneous electric nerve stimulation (TENS) vs. control (C) TENS: Out-patient PT 2d/wk. In addition, low frequency (1.7 Hz) TENS with surface electrodes on wrist extensors of affected arm, and elbow extensors or shoulder abductors, initiated by physical therapist and after 3rd occasion treatments performed by patients themselves at home. C: Outpatient PT, 2 d/wk. Intensity: 60 min/d, 5 d/wk, during 3 mos. Treatment contrast: 60 h.	FMA arm, MAS, VAS, BI, active and passive ROM, deep and superficial sensibility Measured at baseline and 3 mos	Stimulation by means of Low-TENS could be a valuable complement to the usual training of arm and hand function in the rehabilitation of stroke patients. Low-TENS started 6-12 months after stroke may not have a specific effect on arm motor function years after completion of treatment.
Klaiput et al 2009 [single session RCT]	7	20 (10/10)	Age: 64.50±10.98 yr Type: first/rec isch/hem Time since onset: 38.90±54.06 d Inclusion: ability to perform lateral and tip pinch with the paretic hand	Comparison: FES vs. control (C) FES: Periperhal sensor electrical stimulation over median and ulnar nerves at the wrist to the level of appreciating paresthesias. C: Peripherhal sensor electrical stimulation over median and ulnar nerves at the wrist to the level of perception. Intensity: 2 h, 1x. Treatment contrast: 0 h.	ARAT, tip and lateral pinch strength Measured before and after stimulation	Peripheral sensory stimulation of the paretic hand may increase pinch strength of acute and subacute stroke patients immediately after stimulation.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Leandri et al. 1990	RCT	60 (20/20/20) with hemiplegic shoulder pain	mean: 66y + 5.8y	type: iCVA post-acute: mean 3.1 mo + 2.3 mo after stroke	No	High-density TENS vs low density TENS vs placebo stimulation E1: high-intensity TENS: 5x/wk basic-PT + 3x/wk high-density TENS; square pulses of 0.2 ms., frequency 100Hz; intensity at threshold level (4-9mA) for low-TENS and at 3 times the threshold level for high-TENS: E2: low-intensity TENS: 5x/wk basic-PT + 3x/wk low-density TENS C: 5x/wk basic-PT + placebo-stimulation Treatment protocol consisted 12 sessions (4wk)	PROM measured at 4 and 12 wk after start treatment	High-intensityTENS may be a valuable technique in treating hemiplegic shoulder pain, whereas traditional low-density TENS seems to be of no use in such case.	4 failure at the questions: 3,5,6,8,9,10

Tekeoglu et al. 1998	RCT	60 (30/30)	mean: 54.1y + 6.2y	type: ? post-acute: mean 43 d + 12d	Yes	Active TENS vs placebo-TENS E: electrodes on triceps brachii (extensors elbow) and peroneal nerve posterior; square pulses of 0.2 ms.; at frequency of 100Hz; E+C:exercise program daily(5x/wk) + 5x/wk,0.5hrs/d active or placebo-TENS during 8 wk (40 sessions)	AS and BI measured at 8 wk after start treatment	TENS appears to be an effective adjunct in the regaining of motor functions and improving ADL in hemiplegic patients, but the accidental inbalance in severity of disability at entry makes interpretation uncertain	5 failure at the questions: 3,4,5,6,9
Sonde et al. 1998	RCT	44 (26/18) with paretic arm and FMA<50	mean: 71.8y + 5y	type: ? chronic: mean 8.8 mo after stroke + 2.2 mo	No	Low-TENS (1,7Hz) + PT vs PT without TENS E:5x/week; 60 minutes TENS for 3 months; stimulus frequency of 1.7 Hz in pulse trains (8 pulses with interval of 14 ms.; electrodes on wrist extensors and in 21 of 26 persons also over elbow extensors or shoulder abductors and 2x/wk PT C: 2x/week PT	FMA, MAS, VAS (pain) and BI, measured at 3 months	Stimulation using low –TENS could be a valuable complement in the usual training of arm and hand function for rehabilitation of stroke patients. Patients with less severely affected arms showed greatest improvements. The low-TENS did not decrease either pain or spasticity	4 failure at the questions: 3,5,6,7,8,9
Sonde et al. 2000	RCT	28 (18/10)	mean: 71y + 5,2 y	chronic: mean 47 mo, range 42-56 mo	No	Follow-up: 3 years after initial treatment was completed	FMA, MAS and BI, Measured 3 years after intervention	Low TENS stimulation started 6-12 months after stroke may not have a specific effect on arm motor function years after completion of treatment	3 failure at the questions: 3,4,5,6,7,8,9

RCTs investigating EMG-biofeedback for the paretic arm (EMG-BF)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Armagan et al 2003	7	27 (14/13)	Age: 57.00±10.53 yr Type: first isch/hem Time since onset: 4.43±1.09 mos Inclusion: stable health status, modified Brunnstrom's stage 2-3; no visual or auditory defect, MAS >3, Brunnstrom's stage 1, deformities upper limb	Comparison: EMG biofeedback (BF) vs. control (C) EMG-BF: Two-channel device with surface electrodes on m. extensor carpi radialis and extensor digitorum communis. With wrist in flexion position and forearm pronated, try to extend wrist until myoelectric potentials were coverted into a visual or auditory signal. Sensitivity 2 µV to 2 mV. In addition to exercise program (see below). C: EMG-BF as above, with device switched on but turned away so no visual or auditory feedback was given. In addition to exercise program according to Brunnstrom's approach (45 min/d, 5 d/wk, during 4 wk). Intensity: EMG-BF: 20 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	AROM wrist extension, complex movement performance, Brunnstrom's stages Measured at baseline and	Our study demonstrates the potential benefits of EMG biofeedback in conjunction with neurophysiologic rehabilitation techniqarm to maximize the hand function in hemiplegic patients.
Doğan-Aslan et al 2010	5	61 (30/31)	Age: 57.90±13.32 yr Type: isch/hem Time since onset: 199.30±222.22 d Inclusion: none concerning upper extremity functioning	Comparison: EMG biofeedback (BF) + conventional vs. conventional (C) EMG-BF + conventional: Spasticity treatment involving NDT methods, conventional methods, and verbal encouragement to 'relax' spastic wrist flexor muscles. EMG biofeedback applied on spastic wrist muscles hemiplegic upper extremity, muscle activity shown on computer monitor as auditory and visual signs. C: Passive and active movements and mobilization, PNF, stretching affected upper extremity. Intensity: EMG-BF: 20 min/d, 5 d/wk, during 3 wk. Treatment contrast: 300 min.	MAS, FMA arm, upper extremity function test, AROM wrist extension, BI Measured at baseline and 3 wk	Statistically significant greater improvements in FMA arm and BI in EMG-BF group compared to conventional therapy.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Smith 1979	RCT	11 (6 / 5) with an upper limb with moderate to severe paresis and poor functional movements	mean: 52.4 y., range 22-67y.	type: all chronic: mean 18 mo after stroke, range 6-69 mo	No	Intervention: comparing EMG-BF with conventional PT for UE E: EMG-BF limited to 3 or 4 muscle groups (finger – and wrist muscles) in seated position C: conventional methods based on Bobath- and Brunnström-techniques EMG/BF-characteristics: visual and auditory signals Electrodes: at wrist and at the active muscle belly Intensity: 1 hrs, 2 d/wk for 6 wk (= 12 sessions)	BFM stages, muscle tone, function and coordination measured at 6 wk	Greater benefits in EMG-BF group in most fields of testing and the patients in this group had a greater degree of control over patterns of movement in upper limb and the relaxation of spastic groups	3 failure at the questions: 3,4,5,6,9,10, 11

Hurd et al. 1980	RCT	24 (12 / 12)	mean: 57.6 y + 18.7y	type: ? post-acute: mean 77d. + 56d. after stroke	Yes	Intervention: actual EMG/BF vs simulated EMG/BF E: received actual EMG/BF; visual and audio feedback to produce contractions of m. deltoid C: simulated (placebo) EMG/BF (same conditions) EMG/BF-characteristics: audio feedback was given in the form of a constant pitched tone. Visual feedback in the form of a voltmeter whose scale of deflection could be adjusted to correspond to the range of the patients responses. Intensity: 5d/wk; 10-15 trials in each 20 min session during 2 wk	AROM and muscle activity measured at 2 wk after start treatment	No significant differences was found between actual EMG/BF and simulated EMG/BF in AROM, measured in degrees, and muscle activity, measured in microvolts.	6 failure at the questions: 3,5,6,9
Williams 1982	RCT, cross over design	20 (10 / 10) with painful hemiparetic shoulder	mean: 63.5 y. + 11.8, range 37-81y.	type: first stroke post-acute: mean 7 wk after stroke	Yes	Intervention:comparing EMG-BF vs relaxation-therapy E: 0.5 hrs on 5 consecutive days EMG-BF C: 0.5 hrs on 2 consecutive days relaxation therapy (RIP) based on Jacobson method (sitting position with involved arm supported on pillow) EMG/BF-characteristics: audio- and light feedback Electrodes: mm. latissimus dorsi and teres major Intensity: 1 wk BF and 1 wk relaxation; changing after 1 week	MPQ and range of movement measured at 1 and 2 wk	No statistically significant differences were found between the two interventions.	5 failure at the questions: 3,4,5,6,9
Basmajian et al. 1982	RCT	37 (19 / 18) with residual defect in upper limb function	mean: 64 y. range 40-79y.	type: ? post-acute: mean 3.2 mo after stroke, range 2-6 mo	Yes	Intervention: regular PT with addition of EMG-BF vs regular PT E: additional EMG-BF C: regular PT using a neurophysiological approach EMG/BF-characteristics: EMG-BF for both muscle recruitment and inhibition Electrodes: ? Intensity: 40 min 3 d/wk for 5 wk	UEFT, NHPT, grip strength (mmHg) and pinch strength (pounds) measured at the end of treatment	EMG-BF appears to be more effective when upper limb involvement is not severe in a late case or when treatment is started early (within 3 mo post stroke) in a severe case	6 failure at the questions: 3,5,6,9
Inglis et al. 1984	RCT, cross over design	30 (15 / 15) with residual UE impairment	mean: 60.6 y. + 7.8y.	type: ? chronic: mean 18.6 + 19.7 mo after stroke	No	Intervention: EMG-BF and PT vs PT alone in treatment of hemiparetic upper limb in stroke patients E: EMG-BF to relax, contract and to increase strength in UE C: neuromuscular facilitation techniques to relax, contract and to increase strength in UE EMG/BF-characteristics: visual and/or auditory signal, which enabled patient to monitor relaxation or tension in particular muscle groups Electrodes: relevant muscles of affected UE (deltoids, biceps, triceps, wrist flexors and extensors and intrinsic muscles of hand) Intensity: 20 sessions of 60 min., 3 d/wk ; after these sessions changing the groups for another 20 sessions	Oxford scale (muscle strength), AROM of UE, FMA and picture goniometry measured at 4 and 8 wk	Both the experimental and the control groups benefited from their treatment, but EMG-BF was shown to have an additional (not statistically significant) effect, both in the experimental patients and in the control patients when they switched over the experimental treatment condition	3 failure at the questions: 3,5,6,7,8,9, 11
Basmajian et al. 1987	RCT	29 (13 / 16) with some ability to extend the wrist and fingers	mean: 62 + 10 y., range 39-79y.	type: first stroke post-acute: mean 16+9.2 wk after stroke, range 4-44wk	Yes	Intervention:integrated behavioral PT vs traditional PT E: cognitive behavioral model. During sklill acquisition EMG feedback gaols are learned C: traditional PT based on Bobath exercises EMG/BF-characteristics: EMG output of lights+sounds Electrodes: many of main muscle groups of the UE Intensity: 45 min at 3 d/wk for 5 wk	UEFT and finger oscillation test measured at 5 wk and after 9 mo (follow up)	No statistically significant superiority of one therapy over the other	5 failure at the questions: 3,5,6,8,9

Crow et al. 1989	RCT	42 (21 / 21) had some arm function, i.e. at least flicker of activity around shoulder girdle 40 completed the study (5% drop outs); 39 completed follow up	mean: 67.7 y. + 10y. range 43-89y.	type: all post-acute: mean ? (between 2-8wk) after stroke	Yes	Intervention: evaluate EMG-BF vs EMG with placebo feedback; both incorporated in regular PT E: EMF-BF to normalize muscle tone, gain active movement and the aim for functional goals C: placebo EMG-BF; therapy directed to same goals EMG/BF-characteristics auditory and visual feedback (for C switched off) Electrodes: trapezius, pectoral or deltoid muscles Intensity: 18 sessions over a 6 wk-period	ARAT and FMA measured at 6 and 12 wk	There were no significant differences between the groups before treatment or at follow-up, but at the end of treatment those who received EMG-BF scored significantly higher on test of arm function. Patients with severe impairment were shown to benefit most from EMG-BF.	7 failure at the questions: 5,6,9
Bate et al. 1992	RCT	16 (8 / 8) could perform at least 30 degrees active elbow flexion and extension across gravity	mean: ?? y. .	type: first stroke ??: mean ?? after stroke	Yes	Intervention: evaluation of transfer of effects of feedback to performance of 2 tasks that were considered highly similar vs no EMG-feedback E: received EMG feedback from the spastic elbow flexor muscles during tracking of targets moving at different velocities and amplitudes. C: did not receive EMG feedback EMG/BF-characteristics: visual targets Electrodes: triceps, brachialis and biceps and brachioradialis Intensity: 16 sixty seconds trials	3 active and passive tracking tasks to measure muscle activity (EMG) and tracking error measured before and after training	Transfer tests failed to demonstrate effects of feedback on accuracy of tracking or on EMG activity during performance of the practised task without feedback. Moreover, the group that was trained with EMG feedback exhibited negative transfer on variant of the practised task: tracking faster or less predictable targets	2 failure at the questions: 3,4,5,6,7,8,9,11

RCTs investigating strength training of the paretic arm (paragraaf G.1.12)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Lippert-Grüner et al 1999	2	20 (??/??)	Age: ?? Type: isch/hem Time since onset: 4-6 wk Inclusion: central arm paresis	Comparison: Strength training (E) vs. control (C) E: Training with hand-finger dynamometer of isometric maximal muscle power training of handflexion and handextension, with frequency 5 sec contraction, 5 sec relaxation. In addition to normal rehabilitation. C: Normal rehabilitation. Intensity: 5 min/d, 10 d, during 2 wk. Treatment contrast: 50 min.	Muscle strength Measured at baseline and 2 wk	Additional isometric muscle power training in patients with centrally caused arm paresis can be made efficiently, adding a useful part to therapeutical spectrum.
Carr et al 2003	2	40 (??/??)	Age: 30-82 yr Type: ?? Time since onset: >6 mos post stroke Inclusion: >6 mos post stroke; no history of abnormal heart conditions, uncontrolled elevated blood pressure	Comparison: Aerobic and strength training (A&ST) vs. aerobic training (C) A&ST: Aerobic training (see below). Eight strength-training exercises, including chest press, seated row, leg press, leg extension, leg curl, triceps press down, biceps curl, shoulder front raise, with free weigths and isokinetic machines. Increase strength 5% of original load at wk 6, increase 10% original load at wk 11. Finish exercise protocol with flexibility exercises. C: Aerobic training on upper and lower body ergometer. Wk 1-5: 40-50% original test Watt for 20 min; Wk 6-10: 50-60% original Watt for 30 min; Wk 11-16: 60-70% original Watt for 40 min. Finish exercise protocol with flexibility exercises. Intensity: 3 d/wk, during 16 wk. Treatment contrast: ??	VO_2max, peak torque, cholesterol, high-density lipoprotein Measured at baseline and 16 wk	Both groups demonstrated significant changes in functional strength, but the A&ST group experienced larger increases.
Thielman et al 2004	4	12 (6/6)	Age: 72.8±9.1 yr Type: isch/hem Time since onset: 9.3±4.6 mos Inclusion: discharge from rehabilitation, 5-8 mos post stroke, no receptive aphasia/ apraxia/ cognitive deficits, no left-sided neglect, no orthopedic/ sensory/ perceptual problems, some upper-extremity movement ability	Comparison: Progressive resistive exercise (PRE) vs. control (C) PRE: Progressive resistive exercise involving whole-arm pulling against resistive therapeutic tubing in planes and distances similar to that in C: forward, contralateral, ipsilateral to impaired side. Progression by increasing resistance. C: Training at home, sit in armless chair with trunk unrestrained of reaching with affected arm at preferred speed to contact or grasp to objects that differed in size, shape and weight placed across the workspace, i.e. tabletop, floor, adjacent chair, tabletop shelf. Minimizing compensatory movements, progression by increasing speed. Intensity: 35 min/d, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	Kinematics, MAS*, RMI arm Measured at baseline and 4 wk	Training benefits appear to depend on initial level of functioning. Although compensatory trunk use was evident, low-level subjects seemed to benefit most from TR. High-level subjects, whose kinematics showed fairly normal movement organization, demonstrated less compensatory movement after progressive resistive exercises.
Winstein et al 2004	6	64 (21/22/21)	Age: <35 yr n=0, 35-75 yr: n=19, ≥75: n=1 Type: first/rec isch/hem/SAB Time since onset: 16.1±7.7 d Inclusion: ??	Comparison: Strength training (ST) vs. Functional task practice (FTP) vs. control (C) ST: Resistance to available arm motion to increase strength of shoulder, elbow, wrist and hand motions, using eccentric, concentric and isometric muscle contractions. Progressed to repetitions against resistance using free weights, Theraband or grip devices for fingers. In addition to standard dose PT and OT. FTP: Systematic and repetitive practice of tasks that could be performed within the level of available voluntary motion. Progressively arranged to account for proximal-to-distal recovery patterns of reaching and grasping actions. Principles of motor learning by provision of knowledge of results and progressed task difficulty. In addition to standard dose PT and OT. C: Muscle facilitation exercises emphasizing NDT, NMS primarily for shoulder subluxation, stretching exercises, ADL including self-care where upper limb was used as assist if appropriate, caregiver training. Intensity: 1 h/d, 5 d/wk, during 4 wk. Treatment contrast: FTP vs. ST: 0 h. FTP/ST vs. C: 20 h.	FIM mobility, FIM self-care, FMA arm FMA ROM, FMA pain, FMA sensory, FTHUE, isometric torque, grasp and pinch force Measured at baseline, 4 wk and 6 and 9 mos (follow-up)	Task specificity and stroke severity are important factors for rehabilitation of arm use in acute stroke. Twenty hours of upper extremity-specific therapy over 4-6 weeks significantly affected functional outcomes. The immediate benefits of a functional task approach were similar to those of resistance-strength approach, however, the former was more beneficial in the long-term.

Sullivan et al 2007	7	80 (20/20/20/20)	Age: 60.6±13.7 yr Type: isch/hem Time since onset: 27.5±16.1 mos Inclusion: ambulate ≥14 m, FAC ≥2, self-selected walking speed ≤1.0 m/s; no health condition which intervenes with safe participation or exercise program, serious medical conditions, resting systolic blood pressure >180 mmHg, resting diastolic blood pressure >110 mmHg, resting heart rate >100 bpm	Comparison: Four combinations of: Body-weight-supported treadmill training (BWSTT), limb-loaded resistive leg cycling (CYCLE), lower extremity muscle-specified progressive-resistive exercises (LE-EX), upper-extremity ergometry (UE-EX) with intensity ≤80% of age-predicted maximum heart rate. BWSTT/LE-EX: - BWSTT: walk on treadmill with harness for four 5-minute training bouts, speed range 1.5-2.5 mph to achieve 20 accumulated min of walking over 1-hour session. Gait instruction in an overground setting over a 15 m distance. - LE-EX: Isotonically exercise the affected leg using external resistance (e.g. gravity, resistive tubing, cuff weights) following exercise algorithm accounted for strength and movement synergy level to determine a 10RM for 6 groups (hip flexors, hip extensors, knee flexors, knee extensors, ankle dorsiflexors, ankle plantar flexors). Each muscle group exercised for 3 sets of 10 repetitions at 80% of the 10RM. BWSTT/UE-EX: - BWSTT: see above. - UE-EX: cycle with arms on Endorphin EN-300 Hand Cycle, with resistance to level to complete 10 sets of 20RM. Forward and backward cycling alternated, assistance with hemiparetic limb by PT if necessary. BWSTT/CYCLE: - BWSTT: see above. - CYCLE: cycle on modified Biodex semi-recumbent cycle with releasable seat enabling to slide along a linear track where 10-lb bungee cords can be attached to produce extensor muscle resistance similar to a leg press machine, with goal to pedal while keeping the sliding seat from moving out of the target 'exercise region.' 10 sets of 15-20 revolutions in each session, ≥2 minutes rest between sets. Intensity: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: 0 h.	10MWT comf, 10MWT max, 6MWT Measured at baseline, 3 and 6 wk and 6 mos (follow-up)	After chronic stroke, task-specific training during treadmill walking with body-weight support is more effective in improving walking speed and maintaining these gains at 6 months than resisted leg cycling alone.
Thielman et al 2008	5	11 (5/6)	Age: 69.33±10.69 yr Type: ?? Time since onset: 22.67±12.29 mos Inclusion: FMA arm 18-44; no ataxia, rigidity, bradykinesia, left-sided neglect, sensory or perceptual problems, orthopedic, cardiac or pulmonary conditions limiting exercise	Comparison: Trunk restraint (TR) + resistive exercise (RT) vs. TR + task-related training (TRT) TR + RE: Task-related training affected upper extremity sitting at table. Trunk restrained to chair's back with 2 padded shoulder straps. 200 repetitions per session, moved at preferred speed and encouraged to increase speed. Repetitive arm movements that required proximal and distal arm muscles against resistance of Theraband with range from 3.78-13.22 N resistance. Whole-arm pulling movements with paretic limb: forwards, backwards, contralateral across body, ipsilateral away from impaired side. For each movement: upward toward the shoulder, at waist height, downward toward the floor. Increase resistance if session lasted <35 min. TR + TRT: Task-related training affected upper extremity sitting at table. Trunk restrained to chair's back with 2 padded shoulder straps. 200 repetitions per session, moved at preferred speed and encouraged to increase speed. Reached to contact or grasp objects variably placed to require arm movements of different amplitudes across all quadrants of the table. Objects varied in size, shape and weight. Also included sliding arm across tabletop with objects in hand and reaching to grasp/transport objects. Increasing complexity tasks if session lasted <35 min. Intensity: 40-45 min, 2-3 d/wk, total 12 sessions. Treatment contrast: 0 h.	FMA arm, WMFT, AROM, kinematics Measured at baseline and post intervention	Training that restricted compensatory truncal motion during task-related training improved the precision of reaching more than during resistive exercise.
Donaldson et al 2009	7	30 (10/10/10)	Age: 72.8±11.9 yr Type: isch Time since onset: 21.7±16.8 d Inclusion: ARAT >4, unable to complete NHPT in 50 seconds	Comparison: Conventional + functional strength (CPT+FST) vs. conventional + conventional (CPT+CPT) vs. conventional (CPT) CPT+FST: Standardized treatment schedule (see below). In addition functional strength training with prominence to: directing subject's attention to exercise/activity being performed, appropriate verbal feedback on performance, repetition, goal-directed functional activity (hands-off). Based on normal upper limb function, with focus on improving power shoulder/elbow muscles to enable appropriate placing the hand and then using it to manipulate objects. Initial level of resistance maximum load still permitting 5 repetitions through available range	ARAT, NHPT, upper limb strength, isometric force Measured at baseline, 6 and 12 wk (follow-up)	This exploratory phase II trial found a trend for enhanced motor recovery for the CPT+FST group for all measures except hand grip force. The improvements found achieved set clinical importance for ATAT, NHPT, and isometric elbow flexion force.

				of muscle length. Progression using repetition, altering size and weight of items, and using heavier weights. Divided in: muscle group-specific, upper limb gross movement patterns, hand reaching/retrieval activity, hand grip activities, hand manipulation involving entire everyday activities. CPT+CPT: Standardized treatment schedule (see below), double time. CPT: Standardized treatment schedule, i.e. soft tissue mobilization, facilitation of muscle activity/movement, positioning, education patient/carer. Therapist hands-on, to provide sensory input to optimize joint alignment in preparation of voluntary movement. Intensity: Plus therapy: 1 h/d, 4 d/wk, during 6 wk. Treatment contrast: CPT+FST/CPT+CPT vs. CPT: 24 h. CPT+FST vs. CPT+CPT: 0 h.		
Sims et al 2009	6	45 (23/22)	Age: 67.95±14.76 yr Type: ?? Time since onset: 13.2±4.95 mos Inclusion: >6 mos post stroke, walk ≥20 m independently; no PHQ-9 <5, depression with psychotic features, other psychiatric disorders or uncontrolled heart diseases	Comparison: Progressive resistance training (PRT) vs. control (C) PRT: Train in small groups with core PRT program entailed moderate intensity, i.e. 3 sets of 8-10 reps, resistance 80% of 1RM, using machine weights for major upper and lower limb muscle. Resistance increased when patient was able to complete 3 sets of 10 reps. C: Usual care. Intensity: ??, 2 d/wk, during 10 wk. Treatment contrast: ??	CES-D, AQoL, SF-12, SIS, SWLS, SSS, LOT-R, generalised dispositinal optimism, Self-esteem scale, RLOC Measured at baseline and 10 wk and 6 mos (follow-up)	The intervention appeared to be feasible within a community-based setting. To optimized stroke recovery and improve the quality of life of stroke survivors, heath professionals should continue to focus on helping survivors' mental health recovery as well their physical rehabilitation.

RCTs investigating trunk restraint (TR) (paragraaf G.1.3)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Michaelsen et al 2004	5	28 (14/14)	Age: 54±17 yr Type: first Time since onset: 36±28 mos Inclusion: arm paresis	Comparison: Trunk restraint (TR) vs. control (C) TR: Reaching and grasping cylinder in response to auditory signal with trunk restraint by an electromagnet in a 60-trial session. Instructed not to move the trunk and to use as much elbow extension as possible. A 2 to 5 minute rest period was permitted after every 10 trials. C: Reaching and grasping cylinder in response to auditory signal without activated electromagnet for trunk restraint in a 60-trial session. Instructed not to move the trunk and to use as much elbow extension as possible. A 2 to 5 minute rest period was permitted after every 10 trials. Intensity: 1 session. Treatment contrast: 0 h.	Kinematics Measured at baseline, after trial and 24 h (follow-up)	Restriction of compensatory trunk movements during practice may lead to greater improvements in reach-to-grasp movements in patients with chronic stroke than practice alone, and longer-term effects of this intervention should be evaluated.
Michaelsen et al 2006	8	30 (15/15)	Age: 69±10 yr Type: first/rec Time since onset: 17±10 mos Inclusion: CMMSA stage ≥3	Comparison: Trunk restraint (TR) vs. control (C) TR: Therapist-supervised home programme based on motor learning concepts with object-related reach-to-grasp training, with trunk movements prevented by body and shoulder belts attached to the chair back, scapular elevation/ protraction was not prevented. Repetitive uni- and bilateral practice of meaningful tasks that motivated patient, enhanced feedback on summary schedule and progressive. Repetition in 10-minute blocks, with 1-2 minute rest periods between blocks of permitted. Instructed not to move the trunk. C: Therapist-supervised home programme based on motor learning concepts with object-related reach-to-grasp training. Repetitive uni- and bilateral practice of meaningful tasks that motivated patient, enhanced feedback on summary schedule and progressive. Repetition in 10-minute blocks, with 1-2 minute rest periods between blocks of permitted. Instructed not to move the trunk. Intensity: 1 h/d, 3 d/wk, 5 wk. Treatment contrast: 0 h.	FMA arm, TEMPA, BBT, isometric force Measured at baseline, 5 wk and 1 mos (follow-up)	Limitation of compensatory trunk movement may be an essential element to include during task-related training of reaching and grasping, particularly for chronic patients with moderate-to-severe arm hemiparesis.
Thielman et al 2008	5	11 (5/6)	Age: 69.33±10.69 yr Type: ?? Time since onset: 22.67±12.29 mos Inclusion: FMA arm 18-44; no ataxia, rigidity, bradykinesia, left-sided neglect, sensory or perceptual problems, orthopedic, cardiac or pulmonary conditions limiting exercise	Comparison: Trunk restraint (TR) + task-related training (TRT) vs. TR + resistive exercise (RT) TR + TRT: Task-related training affected upper extremity sitting at table. Trunk restrained to chair's back with 2 padded shoulder straps. 200 repetitions per session, moved at preferred speed and encouraged to increase speed. Reached to contact or grasp objects variably placed to require arm movements of different amplitudes across all quadrants of the table. Objects varied in size, shape and weight. Also included sliding arm across tabletop with objects in hand and reaching to grasp/transport objects. Increasing complexity tasks if session lasted <35 min. TR + RE: Task-related training affected upper extremity sitting at table. Trunk restrained to chair's back with 2 padded shoulder straps. 200 repetitions per session, moved at preferred speed and encouraged to increase speed. Repetitive arm movements that required proximal and distal arm muscles against resistance of Theraband with range from 3.78-13.22 N resistance. Whole-arm pulling movements with paretic limb: forwards, backwards, contralateral across body, ipsilateral away from impaired side. For each movement: upward toward the shoulder, at waist height, downward toward the floor. Increase resistance if session lasted <35 min. Intensity: 40-45 min, 2-3 d/wk, total 12 sessions. Treatment contrast: 0 h.	FMA arm, WMFT, AROM, kinematics Measured at baseline and post-intervention	Training that restricted compensatory truncal motion during task-related training improved the precision of reaching more than during resistive exercise.
Woodbury et al 2009	5	12 (6/6)	Age: 60.0±8.6 yr Type: ??	Comparison: mCIMT + trunk restraint (TR) vs. mCIMT mCIMT + TR: Supervised functional task practice using affected upper extremity,	FMA arm, WMFT, MAL, kinematics	Intensive task practice structured to prevent compensatory trunk movements

			Time since onset: 36.3±35.3 mos Inclusion: active extend wrist, 2 fingers and thumb 10^{o}	including feedback and progression in difficulty. No provision of structured shaping like original CIMT. Padded shield provided afferent arm to attempt a reaching strategy that did not include the trunk. Mitt unaffected hand 90% waking hours. <u>mCIMT</u>: Like CIMT + TR but without trunk restraint or trunk-shoulder-elbow coordination strategies. <u>Intensity</u>: 6 h/d, 5 d/wk, during 2 wk. <u>Treatment contrast</u>: 0 h.	Measured at baseline and 2 wk	and promote shoulder flexion-elbow extension coordination may reinforce development of 'normal' reaching kinematics.
Thielman et al 2010	4	16 (8/8)	Age: 62.9±6.5 yr Type: ?? Time since onset: 25.6 (range 11-36) mos Inclusion: >6 mos post stroke, FMA arm 20-44; no receptive aphasia, apraxia, MAS arm and hand <4 upper arm and <1 hand, sensory or perceptual or orthopedic problems, cardiac or pulmonary conditions	<u>Comparison</u>: Sensor vs. Stabilizer <u>Sensor</u>: Task-related training affected upper extremity sitting at table, 150-200 repetitions per session at preferred speed including faded feedback protocol. Keep back against sensor adhered to cushion of chair back, connected to signal for extrinsic auditory feedback when trunk moved forward. <u>Stabilizer</u>: Task-related training affected upper extremity sitting at table, 150-200 repetitions per session at preferred speed including faded feedback protocol Trunk motion restrained by chest harness for intrinsic tactile feedback. <u>Intensity</u>: 40-45 min, 2-3 d/wk, total 12 sessions. <u>Treatment contrast</u>: 0 h.	FMA arm, RPS, WMFT, shoulder flexion, MAL, grip strength, elbow AROM, Measured at baseline and post-intervention	Significant between-group difference on RPS-near target in favour of Sensor group.

RCTs investigating somatosensory training for the paretic arm (paragraaf G.1.14)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Feys et al 1998, 2004	4	100 (50/50)	Age: 65.62±11.81 yr Type: isch/hem Time since onset: 21.40±5.94 d Inclusion: FMA arm <46, ability to sit independently or with minimum of support	Comparison: Sensorimotor vs. control (C) Sensorimotor: Sensorimotor stimulation, by performing rocking movements in a rocking chair pushing with the heels and/or hemiplegic arm. Inflatable splint used to support affected arm, shoulder in 80° flexion and slight abduction, elbow extension, wrist dorsiflexion. Chair balanced such a way that during movement the patient fell slightly forward and had to actively push backwards, encouraged to use hemiplegic arm. In addition to usual rehabilitation procedures. C: Positioned in a rocking chair, but with arm rested on a cushion on the patient's lap, no additional stimulation was given. Fake short wave therapy on the shoulder during the rocking. In addition to usual rehabilitation procedures. Intensity: 30 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, ARAT, BI, MAS Measured at baseline, 3, 6 wk and 6 and 12 mos and 5 yr (follow-up)	Adding a specific intervention during the acute phase after stroke improved motor recovery, which was apparent 1 year later.
Sonde et al 1998, 2000	3, 4	44 (26/18) 28 (18/10)	Age: 71±6.0 yr Type: first Time since onset: 9.1±2.2 mos Inclusion: FMA arm 0-50	Comparison: Transcutaneous electric nerve stimulation (TENS) vs. control (C) TENS: Out-patient PT 2d/wk. In addition, low frequency (1.7 Hz) TENS with surface electrodes on wrist extensors of affected arm, and elbow extensors or shoulder abductors, initiated by physical therapist and after 3rd occasion treatments performed by patients themselves at home. C: Outpatient PT, 2 d/wk. Intensity: 60 min/d, 5 d/wk, during 3 mos. Treatment contrast: 60 h.	FMA arm, MAS, VAS, BI, AROM, PROM, deep and superficial sensibility Measured at baseline and 3 mos	Stimulation by means of Low-TENS could be a valuable complement to the usual training of arm and hand function in the rehabilitation of stroke patients. Low-TENS started 6-12 months after stroke may not have a specific effect on arm motor function years after completion of treatment.
Heldmann et al 2000 [single-session RCT]	4	14 (7/7)	Age: 53.0±10.4 yr Type: isch/hem right Time since onset: 9.5±5.0 mos Inclusion: sensitivity to identify different materials	Comparison: Repetitive peripheral magnetic stimulation (RPMS) vs. control (C) RPMS: Controlled muscle contraction by RPMS of left dorsal palm, with high power magnetic stimulator (maximum 1500 J) with figure-of-eight coil, and closed-loop control which generates position-controlled movement of the forearm and fingers. Verbal cueing of attention by encouraging the patient to report the quality of the contralesional stimulus before that of the ipsilesional stimulus. C: No therapy. Intensity: 1d. Treatment contrast: ??	QET Measured at baseline and after the experiment	RPMS improved selectively the contralesional tactile extinctions in the experimental group without affecting ipsilesional tactile performance significantly. In contrast, left-sided attentional cueing had no effect on contralesional extinctions, but increased the number of ipsilesional errors significantly.
Byl et al 2003	4	18 (8/10)	Age: 69.0±5.1 yr Type: first/rec Time since onset: chronic Inclusion: walk >100 ft independent, elevate arm ≥60°, flex elbow 40°-65° against gravity, initiate partial opening/ closing of the hand	Comparison: Sensory training (ST) vs. control (C) ST: Sensory discriminative training, including 1) using stress-free hand strategies in all functional activities, e.g. use hand in functional position, let sensation of objects open hand, hold objects with least force possible and feel everything with different fingers, perform activities with eyes closed, thread fingers together and facilitate maintenance of carpal and obliqarm arches of the hand; 2) improve sensory discrimination, e.g. watch videotape demonstrating sensory activities, play games with eyes closed, read Braille books, place coarse and unusual surfaces on objects to help control excessive feedback, place hand into box filled with objects; 3) quiet the nervous system, e.g. facilitate normal motor movements following light sensory stimuli, keep arm close to trunk, wrap up in blanket and rock in a rocker, positioning, tape skin; 4) reinforce learning with mental rehearsal and mirror. Activities matched to abilities, required attention and repetition, feedback on performance, progressed in difficulty. At home wear garden glove unaffected hand 7 h/d, practice specific functional activities ≥15 min to ≥90 min/d. Videotape demonstrating how to perform variety	Graphesthesia, kinesthesia, Byl-Cheney-Boczai Test for stereognosis, digital reaction time, PPT, MMT, ROM, WMFT, CFE, gait speed comf Measured at baseline, 4 wk and 8 wk	This study provides evidence documenting significant improvement in function in the late poststroke recovery period following 12 hours of supervised learning based sensory motor training.

				of tasks emphasizing sensory discrimination and fine motor activities, each task ≥5 min. Keep log. C: Fine motor training. Intensity: Total 12 h, 1.5 h/d during 4 wk. Treatment contrast: 0 h.		
Cambier et al 2003	5	23 (11/12)	Age: 63.9±11.2 yr Type: first Time since onset: 114.1±92.6 d Inclusion: impairment of sensory function in upper limb	Comparison: Pneumatic compression vs. control (C) E: Lying supine, with inflatable splint on affected upper limb connected to an intermittent pneumatic compression machine, with a pattern of 2 minutes with 90 seconds inflation and 90 seconds deflation duty cycle. Inflation peak 40 mmHg. In addition to conventional therapy based on NDT. C: Sham short-wave therapy with device switched off on the hemiplegic shoulder for 30 minutes, in same supine position. In addition to conventional therapy based on NDT. Intensity: 30 min/d, 5 d/wk, during 4 wk. Treatment contrast: 0 h.	NSA, FMA arm, MAS, VAS Measured at baseline, 2 and 4 wk	The use of intermittent pneumatic compression in the rehabilitation of stroke patients may be of clinical importance for the restoration of sensory function.
Mann et al 2005	6	22 (11/11)	Age: 68 (range 57-86) yr Type: isch/hem Time since onset: 5.7 (range 1-12) mos Inclusion: able to take hemiplegic hand to the mouth, sensory impairment	Comparison: NMS vs. control (C) NMS: 2-channel stimulator with self-adhesive electrodes placed on elbow extensors and wrist and finger extensors. Stimulation 8 seconds on, 8 seconds off, ramped over 2 seconds, frequency 20 Hz, to give full extension without discomfort. C: Passive stretching exercises of elbow, wrist and fingers. Intensity: 2x 10-30 min/d during 1st wk, then 30 min/d, during 11 wk. Treatment contrast: 0 h.	ARAT, sensation Measured at baseline and 12 wk	A significant treatment effect of electrical stimulation over passive exercise has been demonstrated.
Chen et al 2005	6	29 (15/14)	Age: 58.5±12.9 yr Type: first isch/hem Time since onset: 14.3±6.8 d Inclusion: FMA arm stage <4, no diabetic history or sensory impairment attributable to peripheral vascular disease or neuropathy	Comparison: Thermal stimulation (TS) vs. control (C) TS: Thermal stimulation, with thermal agent placed on region of hand and wrist, with thermal couple placed between hand and agent. Heating agent (≈75 C°) placed on nonparetic hand and wrist, feel change of skin temperature and learn to move hand from agent when unpleasantness developed. Heating agent on paretic hand 10 times up to 15 seconds, interleaved with≥30 seconds pause. Move paretic hand away if it felt uncomfortable, or accept 15 second stimulation. Identical procedure for 30 second cooling agent (<0 C°). In addition to standard therapy. C: Standard therapy. Visit of PT to discuss progress in rehabilitation. Intensity: TS: 30 min/d, 5 d/wk, during 6 wk. CT: 15-20 min/d, ≥3 d/wk, during 6 wk. Treatment contrast: 540 min.	FMA arm, modified motor assessment scale, ROM wrist, gripstrength, Semmes-Weinstein monofilament Measured at baseline, weekly till 6 wk	TS on the paretic hand significantly enhances the recovery of several aspects of sensory and motor functions in hemiplegic stroke patients.
Byl et al 2008	4	45 (18/19/8)	Age: 61.1±13.3 yr Type: isch/hem Time since onset: 2.4±2.1 yr Inclusion: partially open and close involved hand, elevate arm ≥45° against gravity, flex elbow 90° against gravity, able to walk independently ≥100 ft with or without assistive device	Comparison: Learning-based sensorimotor training (LBSMT) of different doses (3 groups) LBSMT I: Tasks with attended, repeated, purposeful and progressed in difficulty with performance accuracy positively reward. Emphasis on improving sensory discrimination of cutaneous, muscle and joint receptors by performing matching tasks with the eyes closed. Integrate sensory and motor function by manipulating objects with varying weights, shapes and surface textures. Attention to normal sensory, sensorimotor, graded and quality of fine motor movements. Also mental practice and mirror practice. In addition to supervised physical therapy. LBSMT II: LBSMT, in addition body-weight supported treadmill training, with therapist manually facilitation quality of stepping and pelvis stabilization as needed, up to 40% of body weight and progressively decreased over 6 wk, total time walking 30 min with rest breaks from 2-10 minutes. Encouraged to talk, spell, and count during training, practice overground walking 5-10 minutes. LBSMT III: LBSMT. Intensity: Group I: 1.5 h/d, 1 d/wk, during 6-8 wk. Group II: LBSMT 45 min/d, 3 d/wk, during 6-8 wk; BWSTT 45 min/d, 3 d/wk, during 6-8 wk. Group III: 3 h/d, 4 d/wk, during 6-8 wk. Treatment contrast: group I vs. group II: 21 h. Group I vs. group III: 73.5 h.	WMFT, sensory discrimination, digital reaction time, grip and pinch strength Measured at baseline and 8 wk	Learning-based sensorimotor training based on the principles of neuroplasticity was associated with improved function in patients stable poststroke. The gains were dose specific with the greatest change measured in subjects participating in the high-intensity treatment group.

				Group II vs. group III: 52.5 h.		
Wolny et al 2010	6	96 (32/32/32)	Age: 61.47±12.53 yr Type: isch/hem Time since onset: 1.78± 0.75 yr Inclusion: no severe contraindications for physical loading	Comparison: Traditional + PNF (E1) vs. Traditional + PNF + Butler's (E2) vs. control (C) E1: Traditional therapy plus individual therapy based on PNF method. Kinesiotherapy in which PNF was individualized and basic principles were respected: passive exercises 20-30 repetitions, self-assisted exercises for shoulder joint (10 minutes), active exercises and active synergistic exercises (10 minutes), locomotion and balance (15 minutes), manipulative function of the hand (10 minutes). Physical therapy modalities: 1) diadynamic current 10 minutes, 10 sessions every second day; 2) interferential current: 10 sessions, every day; 3) ultrasound: 6-8 sessions, every day or every second day; 4) cryotherapy: 3 minutes, 15 sessions, every day. E2: Traditional therapy plus individual therapy based on PNF method plus Butler's neuromobilizations of n. medianus, n. radialis, n. ulnaris. C: Traditional therapy without PNF principles. Intensity: 18 sessions, 45 min/d, 6 d/wk, during 3 wk. Treatment contrast: 0 h.	2-point discriminatory sense, stereognosia, thermaesthesia Measured at baseline and 3 wk	In our subjects, application of Butler's neuromobilizations combined with proprioceptive neuromuscular facilitation showed greater effectiveness in reducing sensory deficits than proprioceptive neuromuscular facilitation or traditional therapy alone.
Wu et al 2010	7	23 (12/11)	Age: 59.9±11.4 yr Type: first isch/hem Time since onset: 10.0±7.3 mos Inclusion: Move upper limb independently	Comparison: outpatient rehabilitation + thermal stimulation arm (E) vs. outpatient rehabilitation + thermal stimulation leg (C) E: PT and OT. Additional thermal stimulation arm, with two thermal stimulators and two therapeutic pads: hot pad 46°C-47°C, cold-pad 7°C-8°C. Hot pad on paretic hand 10 times for 15 sec, interleaved with 30 sec pauses. Patients had to withdraw or move hand from pad when discomfort occurred or after 15 sec of stimulation. During pause perform voluntary paretic wrist and elbow extensions. Then 10 times 30 sec cold pad stimulations. 2 alternate cycles of heat and cold stimulation. C: PT and OT. Additional thermal stimulation lower extremity. Intensity: Physical therapy 1 h 3d/wk; occupational therapy 1 h 3 d/wk; thermal stimulation 30 min/d 3 d/wk, during 8 wk. Treatment contrast: 0 h.	arm-STREAM, ARAT MAS, leg-STREAM, BI Measured at baseline, 8 wk and 1 mos (follow-up)	Additional arm thermal stimulation could provide further improvement in motor function of arm than those in control group.
Carey et al 2011	9	50 (25/25)	Age: 61.02±12.75 yr Type: first isch/hem Time since onset: median 48.14 (IQR 2218-130.86) wk Inclusion: impaired texture discrimination, limb position sense, and/or tactile object recognition	Comparison: Sensory vs. control (C) Sensory: Perceptual-learning based sensory discrimination program, including per session in random order: texture discrimination (graded stimuli with varying surface characteristics), limb position sense (wide range of limb positions), and tactile object recognition (discrimination of shape, size, etc using range of multidimensional graded objects; each lasting 15-20 minutes. Employed a variety of stimuli within each sensory dimension trained, graded progression of discriminations, attentive exploration, anticipation trials, cross-model calibration via vision, feedback on sensation and method of exploration, intermittent feedback and self-checking of accuracy, feedback on ability to identify distinctive features in novel stimuli, tuition of training principle, summary feedback. C: Non-specific exposure to sensory stimuli via passive movements of the limb and grasping of common objects. Intensity: 10 sessions, 1 h/d, 3 d/wk. Treatment contrast: 0 h.	Index of functional somatosensory discrimination capacity Measured at baseline and post intervention	Sensory discrimination training can achieve significant improvements in functional sensory discrimination capacity after stroke. The clinically oriented training achieved transfer of training effects to novel stimuli.
Hunter et al 2011	8	76 (18/19/20/19)	Age: 73.3±7.3 yr Type: isch/hem Time since onset: 35.6±23.6 d Inclusion: 8-84 d post stroke, MI arm <61, no diseases affecting upper-limb movement	Comparison: Mobilization and tactile stimulation (MTS) 30 min vs. MTS 60 min vs. MTS 120 min vs. control (C) MTS 30: Tactile and proprioceptive stimulation through actions such as guided sensory exploration, massage, passive joint/soft-tissue mobilization technique, active-assisted movements, active movements. In addition to routine conventional PT (see below). MTS 60: In addition to routine conventional PT (see below). MTS 120: In addition to routine conventional PT (see below). C: Routine conventional PT, i.e. soft tissue mobilization, facilitation of muscle activity/movement, positioning, education patient/carer. Therapist hands-on, to	MI arm, ARAT Measured at baseline and 14 working days	The authors were not able to deliver a maximum dose of 120 minutes of daily therapy each day. The mean daily dose of MTS feasible for subseqarmnt evaluation is between 37 and 66 minutes.

				provide sensory input to optimize joint alignment in preparation of voluntary movement. Intensity: MTS 30: 30 min/d, 5 d/wk, during 14 working days. MTS 60: 60 min/d, 5 d/wk, during 14 working days. MTS 120: 120 min/d, 5 d/wk, during 14 working days. Treatment contrast: MTS 30 vs. C: 420 min. MTS 30 vs. MTS 60: 420 min. MTS 30 vs. MTS 120: 1260 min. MTS 60 vs. MTS 120: 840 min. MTS 60 vs. C: 840 min. MTS 120 vs. C: 1680 min.		

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Yekutiel & Guttman, 1993	CCT	39 (20 / 19) with persisting sensory deficit in the hand	mean: 65.5 y, range 44-81y	type: all chronic: mean 6.2 y after stroke, range 2-18 y	Yes	Intervention: sensory re-education vs no treatment E: sensory re-education, i.e. identification of letters drawn on the arm and hand; “find your (plegic) thumb” blindfolded; discrimination of shape, weight and texture of objects or materials placed in the hand C: no therapy Intensity: 45 min at home; 3x/wk during 6 wk	4 sensory tests: Location of touch; Sense of elbow position; 2-PD and Stereognosis measured at baseline and after 6wk	The treated group showed large and significant gains on all sensory tests. Somatosensory deficit can be alleviated even years after stroke.	4 failure at the questions: *3,5,6,7,9,11*

RCTs investigating shoulder continuous passive motion (CPM) (paragraaf G.2.1)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Lynch et al 2005	5	35 (19/16)	Age: 60.0±3.0 yr Type: first Time since onset: 13±6 d Inclusion: upper extremity muscles MRC <3, FMA shoulder-elbow <20, no poor alignment of shoulder resulting from injuries prior to stroke or history of shoulder surgery	Comparison: Continuos passive motion (CPM) vs. Control (C) CPM: Standard post stroke interdisciplinary therapy with impairment reduction coupled with teaching compensation strategies to perform daily functional activities. In addition, CPM consisting of two phases: 1) elevation shoulder in scapular plane to 90° on the high setting with a 3-s pause at the beginning and end of the movement; 2) external rotation shoulder to 80° with 30° abduction and elevation. C: Supervised self-range of motion exercises. Intensity: 25 min/d, 5 d/wk, during rehabilitation. Treatment contrast: 0 h.	FMA arm, MSS, FIM (self-care and mobility), MAS, FMA arm joint pain index Measured at baseline and discharge	Device-delivered continuous passive range of motion may offer an enhanced benefit for some adverse symptom reduction in the hemiplegic arm after stroke over traditional self-range of motion exercises.

RCTs investigating muscle vibration (paragraaf G.2.2)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Stein et al 2010	10	30 (15/15)	Age: 66.0±9.0 yr Type: first isch/hem Time since onset: 6.8±4.2 yr Inclusion: FMA arm 28-55	Comparison: Stochastic resonance stimulation (SR) + OT vs. OT SR + OT: Task-specific training, if necessary trunk control exercises and awareness of noncompensatory reaching strategies. During training mechanical stimulator on extensors elbow, wrist and fingers at 90% of threshold (subsensory) with maximum of 50 µA root mean square. Home exercises. OT: Task-specific training and home exercises, without SR. Intensity: 1 h introduction session, 1 h, 3 d/wk, during 4 wk. Treatment contrast: 0 h.	FMA arm, WMFT, ARAT, MAS, SIS-16, MAL, RPS Measured at baseline, 4 wk and 1 mos (follow-up)	SR therapy combined with OT was not more effective than OT alone in restoring sensorimotor performance in patients with hemiparetic stroke.

RCTs investigating circuit class training (CCT) (paragraaf G.2.3)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Chu et al 2004	6	12 (7/5)	Age: 61.9±9.4 yr Type: first isch/hem Time since onset: 3±2 yr Inclusion: >1 yr post stroke, independent walking with or without assistive device, medically stable, pedal cycle ergometer ≥60% age predicted HRmax; no previous myocardial infarction	Comparison: Circuit class arm (E) vs. Water-based exercises (C) E: Supervised arm exercises to improve upper extremity function. 6-station circuit while seating: gross upper-limb movement, fine motor movement, muscle strengthening of the shoulder/ elbow/ wrist/ fingers. Cool-down (5 min). 1 PT, 1 exercise physiologist. C: Supervised water-based exercise group training with objective to improve cardiovascular fitness, in chest-level water at local community center swimming pool (temperature 26-28^{o}C), wearing flotation belt or lifejacket. Land-based stretching (10 min), light aerobic warm-up in water (5 min), moderate to high aerobic activities at target HR described for that week (30 min), light cool-down (5 min), gentle stretching in water (10 min). HR wk 1-2: 50-70%, wk 3-5: 75%, wk 6-8: 80% HRR.1 PT, 2 exercise physiologists. Number of participants per group: 6 Intensity: 1 h/d, 3 d/wk, during 8 wk. Treatment contrast: 0 h.	VO_2max, maximal workload, walking speed comf, BBS, muscle strength Measured at baseline and 8 wk	A water-based exercise program undertaken as a group program may be an effective way to promote fitness in people with stroke.
Pang et al 2006	7	63 (31/32)	Age: 64.9±8.5 yr Type: first isch/hem Time since onset: 5.1±3.6 yr Inclusion: independent in ambulation with or without assistive device for at least 10 m, unstable cardiovascular disease	Comparison: Circuit class arm vs. Circuit class leg Arm: Prevent learned non-use, improve upper extremity function through self-directed exercises. Warming-up (5 min) and cool down in which participants performed upper-extremity stretches and active or self-assisted ROM exercises. Rotate through 3 stations: 1) shoulder theraband exercises; 2) ROM, weight bearing activities and elbow/wrist exercises; 3) hand activities and functional training, with FES if necessary. More self-directed as trial progressed. Leg: Rotate through 3 stations: 1) cardiorespiratory fitness and mobility; 2) mobility and balance; 3) lower-extremity muscle strength. More self-directed as trial progressed. Number of participants per group: 9-12 Intensity: 1 h, 3 d/wk, during 19 wk. Treatment contrast: 0 h.	WMFT, FMA arm, gripstrength, MAL Measured at baseline and 19 wk	A community-based exercise program can improve upper-extremity function in persons with chronic stroke.

RCTs investigating passive-active bilateral arm training (paragraaf G.2.4)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Stinear et al 2008	6	32 (16/16)	Age: 52.6 (range 25-73) yr Type: isch/hem Time since onset: 20.2 (range 6-73) mos Inclusion: abbreviated FMA arm 3-25	Comparison: BAT + active passive bilateral training (APBT) vs. unilateral training (C) BAT + APBT: APBT device that allows rhythmic flexion-extension of unaffected wrist, which in turn drives the passive flexion-extension of the affected wrist in a mirror-symmetric pattern. First focus on unaffected wrist, then shift attention to affected wrist. In 3rd week imagine they were actively producing movements affected wrist, bilaterally active movements in wk 4. Self-directed home-based tasks with wooden blocks with affected upper extremity. C: Self-directed home-based tasks with wooden blocks with affected upper extremity. Intensity: BAT 3x 10 min/d, 7 d/wk, during 4 wk. APBT: 3x 10-15 min/d, 7 d/wk, during 4 wk. Treatment contrast: 1050 min.	FMA arm, NIHSS, TMS, grip strength Measured at baseline, 6 week and 1 mos (follow-up)	All patients improved immediately after intervention, only those patients primed with APBT before motor practice showed sustained improvement in arm motor function and had specific neurphysiological changes in motor cortex function.

RCTs investigating mechanical arm training (paragraaf G.2.5)

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Wang et al 2007	6	44 (22/22)	Age: 57±1.6 yr Type: first Time since onset: 7±2.8 wk Inclusion: FMA arm stage <3	Comparison: ULEM vs. control (C) ULEM: Motion operating setting (operating rod, two spring wheels and operating platform for subject to stand or sit on), feedback scanner and computer control system. Grasp rod and move it against resistance with inferior-posterior-superior-anterior sequence in a circle. Visual information feedback. 10-15 encircling motions per unit, 5 units per day. In addition to conventional PT (see below). C: Conventional PT consisting of stretching upper extremity, weight bearing, walking, balance training. Combined with neuromuscular facilitation technique. Intensity: ULEM: 5x/d, 5 d/wk, during 4 wk. PT: 60 min/d, 5 d/wk, during 4 wk. Treatment contrast: ??	FMA arm, BI Measured at baseline and 4 wk	ULEM apparatus can significantly improve integrative motor function of extremities of patients with stroke. It is a safe and effective treatment.
Hesse et al 2008	8	54 (27/27)	Age: 61.1±10.0 yr Type: first isch/hem Time since onset: 4.6±1.0 wk Inclusion: MRC 0-1 of wrist and finger extensors, FMA arm <18, inability to transport block in BBT, absent to moderate elbow/wrist/finger spasticity	Comparison: Mechanical arm trainer (AT) vs. electrical stimulation (ES) AT: Mechanical arm trainer with bilateral movement, with an inductive sensor counting number of repetitions and displays to patient. 100 isolated forward and backward movements in horizontal plane, 100 in inclined position, 100 circles clockwise, 100 circles counter clockwise, then inclined. Metronome to pace movements. Instructed to attempt to assist bilateral movement with paretic arm and to extend paretic elbows as much as possible without electing pain. Increased forward-backward friction over the weeks. At the end of session computer game of choice. Practice without close supervision. In addition to conventional rehabilitation. ES: EMG-initiated ES of wrist extensors (4-7 seconds monophasic exponential pulses). Practice without close supervision. In addition to conventional rehabilitation. Intensity: 20-30 min/d, 5 d/wk, during 6 wk. Treatment contrast: 0 h.	FMA arm, BBT, MRC, MAS Measured at baseline, 6 wk and 3 mos	Arm training did not lead to a superior primary outcome over electrical stimulation training. However, ‘good performers’ on the secondary outcome seemed to benefit more from the arm trainer training.

RCT PEDro-score < 4

RCTs investigating passive movement wrist

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (eg type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Dechaumont-Palacin 2008	3	13 (7/6)	Age: 64±12 yr Type: first Time since onset: 17±8 d Inclusion: supcortical lesion in pyramidal tract	Comparison: Passive wrist movement (E) vs. control (C) E:. Passive proprioceptive extension of the impaired wrist (20 min, 1 Hz, aplitude 60^{o}). Patients were told to relax their arm to ensure a passive movement. Starting position of the paretic wrist was neutral , the hand sustained by the PT, arm along body. Patients were awake but not asked to attend or to focus on the passive movement. Standard rehabilitation according to Bobath's procedure (see below). C: Standard rehabilitation according to Bobath's procedure favoring stimulation of the proximal part of the limbs when the patient had no movement of the distal part. Intensity: 5 d/wk, during 6 wk. Treatment contrast: 0 h.	fMRI, NIHSS, BI, MAS Measured at baseline and 4 wk	We have demonstrated that purely passive proprioceptive training applied for 4 weeks is able to modify brain sensorimotor activity after a stroke.

RCTs 2004

RCTs KNGF-guideline 2004: Active upper extremity therapy

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodological quality**
Logigian et al. 1983	RCT	42 (21 / 21)	mean: 61.6 y + 21 y	type: all chronic: mean 4.8 y + 8.2 y. after stoke, range 6 mo-26 y.	Yes	Intervention: facilitation techniques vs traditional techniques E: based on facilitation approach (Rood and Bobath), treatment techniques include bilateral weight bearing, reflex inhibiting and i.e tactile or vestibular stimulation C: based on traditional approach (Kendall, Clayton and Coulter) treatment techniques include resistive exercises upper limb skateboards and pulleys. Intensity: 1 – 1.5 hrs/day in addition to other program involvements, plus all patients ½ hrs/d ROM-group. Patients remained in treatment until their functional and motor performance stabilized, so weeks of treatment: variable	BI and MMT measured at start and (variable) end	Both facilitation and traditional exercise therapies improved functional and motor performance but there were no significant differences between the approaches.	3 failure at the questions: 3,4,5,6,7,8,9
Jongbloed et al. 1989	RCT	90 (43 / 47) with weakness in UE and LE of affected side	mean: 71.3 y + 9.1y	type: first stroke post-acute: mean 40 d. + 42 d. after stoke	Yes	Intervention: OT sensorimotor integrative treatment approach vs traditional functional OT-approach E: approach based on combination of theories described by Bobath, Rood and Ayres, and emphasizes treating the cause od dysfunction rather than compensating or adapting the problem C: practice of particular tasks, usually ADL subdivided into 2 aspects:compensation + adaptation + splinting. Intensity: both groups for 40 min/d, 5 d/wk for 8 wk	BI, meal preparation and 8 subtests of SITB measured at 4 and 8 weeks after admission	No statistical significant differences between both treatment groups. , OT can on basis of the findings	3 failure at the questions: 3,4,5,6,8,9, 11
Sunderland et al. 1992	RCT	132 (65/67) 137 of 429 patients submitted in study 4% drop-outs, 132 completed the study	median 67.5y, range: 32-92 y	type: SAH and brain stem strokes excluded sub-acute: median 9 d., range 2-35 d.	Yes	Intervention: enhanced therapy vs conventional therapy E: 1) more intensive treatment for the arm, with amount and type of therapy for leg the same as C, and 2) eclectic approach with specific aims: promote more active participation in arm rehabilitation C: expert hands-on treatment based on “Bobath” en “Johnstone”- techniques, without routinely instructions to exercise between therapy sessions Intensity: E more than twice the amount of arm therapy per week, during a longer period	EMI, subtests of Motor Club Assessment, FAT, NHPT and BI measured at 1, 3 and 6 mo after stroke	At six months after stroke the enhanced therapy group showed a small but statistically significant advantage in recovery of strength, range and speed of movement. This effect seemed concentrated amongst those who had a milder initial impairment.	6 failure at the questions: 3,5,6,9
Sunderland et al. 1994	RCT	97 (48/49) of 132 patients completed the follow-up (=27% drop-outs)		chronic: mean: 52 w after stroke, range 39-64 w	Yes	Intervention: follow-up Sunderland et al. 1992	EMI, MCA, FAT, NHPT and BI measured at 1 year after stroke	The advantage seen for some patients with enhanced therapy at six months after stroke had diminished to a non-significant trend by one year.	4 failure at the questions: 3,4,5,6,7,9

Gelber et al. 1995	RCT	27 (15 / 12) with pure motor stroke	mean: 71.8 y + 9.1y	type: iCVA sub-acute: mean 13 d + 2 d. after stoke	Yes	Intervention: NDT approach vs traditional functional retraining approach. E:NDT-approach, therapy techniques included tone inhibition and weight-bearing activities and encouraged patients to use the affected side; no resistive exercises and use of abnormal reflexes. C: traditional functional retraining approach, therapy techniques included PROM in anatomic planes, progressive resistive exercises, early use of assistive devices and bracing and allowed patients to use their unaffected side. Intensity: interventions for the duration of inpatient and outpatient rehabilitation.	FIM, BB and NHPT measured at discharge and 6 and 12 mo after stroke	Both treatments are equally efficacious in treating pure motor hemiparetic strokes in terms of functional outcomes, gait measures and upper extremity motor skills.	4 failure at the questions: 3,4,5,6,7,9
Werner et al. 1996	RCT	40 (28/12) 49 (33/16) of 552 patients submitted in study, 29% drop-outs (=14 patients) and 5 patients added; 40 completed the study	mean: 61.1 + 10.2 y	type: MCA chronic: 3 y + 1.8 after stroke	Yes	Intervention: treatment vs no treatment E: intensive outpatient rehabilitation program; functional tasks (transfers, walking, self-care, feeding) and strengthening, stretching, mobilization and muscle retraining/facilitation. C: did not receive any outpatient therapy Intensity: 1 hrs PT and 1 hrs OT, 4 d/wk during 12wk	FIM-MM and SIP measured at 3 and 9 mo	Significant improvement after 3 months in treatment group. The improvement in functional tasks can be attained with therapy during the post-acute period and the gains are maintained for at least 6 months following the intervention.	4 failure at the questions: 3,5,6,8,9,11
Duncan et al. 1998	RCT	20 (10 / 10) with mild to moderate stroke 22 recruited, 2 refused to participate	mean: 67.6 y + 8.4 y	type: iCVA and hCVA post-acute: mean 62 d. + ? after stoke	Yes	Intervention: home-based exercises vs usual care E: PT supervised program: 1) warming-up: stretching/flexibility exercises, 2) assistive-resistive exercises PNF or Theraband, 3) balance exercises, 4) functional activities for affected UE and 5) walking or bicycle ergometer program. C: usual care: highly variable types of exercises without endurance training immobilisation of paretic arm by an inflatable pressure splint with the patient in supine for 30 min/day for 5d/wk Intensity: E: ~1.5 hrs/day, 3x/wk for 8 wk and 4 additional weeks self-continuing and C: variable intensity, frequency and duration	FMA, BI, Jebsen Test of hand function measured at 1, 3 and 6 mo after stroke	Measures of lower extremity (FMA) were significant; no significant differences in the effect of upper extremity dexterity.	7 failure at the questions: 5,6,7
Feys et al. 1998	RCT	100 (50/50); 108 of approximately 1000 patients submitted in study, 7% drop-outs	mean: 64.2 y + 11.9, range 36-88 y	type: iCVA or hCVA (SAH excluded) sub-acute: 23 d. + 6 d	Yes	Intervention: additional sensorimotor stimulation vs treatment standard treatment E: rocking chair + inflatable arm splint (affected arm); arm has to push backwards as reaction on movement of rocking chair. C: rocking chair + no stimulation of affected arm (rested on cushion), but fake short-wave therapy of shoulder did not receive any outpatient therapy Intensity: both groups 30 min., 5 d/wk during 6 wk (total 30 sessions)	FMA, ARAT and BI measured at 6 and 12 mo after stroke	Adding a specific intervention during the acute phase after stroke significantly improved motor recovery of the upper limb (FMA), which was apparent 1 year later, but no differential effect measured with BI and ARAT.	6 failure at the questions: 3,5,6,9

Lincoln et al. 1999	RCT	282 (94/93/95); 282 of 1265 patients submitted in study, with arm impairment 282 completed the study	median 73 y	type: all sub-acute: median 12 d, range 1-5 wk after stroke	Yes	Intervention: additional amount of intensity of PT (affected arm) vs daily routine PT only E: two intervention groups: E1) standard PT (30-45 min/d) and additional treatment by senior research PT (facilitation, specific neuromuscular techniques and functional rehabilitation based on Bobath approach; E2) standard PT(30-45 min/d) and additional treatment by PT-assistant (positioning and care of affected arm; passive, assisted and active movements; and practice of functional activities based on teaching by PT before start of treatment. facilitation, No additional PT by research PT. Intensity: both E-groups received additional 2 hrs/wk during 5 wk PT (= 10hrs) Groups were subdivided according to severity of initial arm impairment	RMA, ARAT, THPT and BI measured at 5 wk and after 3 and 6 mo after stroke	The increase in the amount of PT for arm impairment with a typical British approach given early after stroke did not significantly improve recovery of arm function.	6 failure at the questions: 5,6,8,9
Parry, Lincoln, Vass 1999a	RCT	Post-hoc analysis (Lincoln et al. 1999)	-	-	Yes		-	Benefits of additional treatment were detected in the less-severe patients group; in the more severe patients no benefits were found.	6 failure at the questions: 3,4,5,6
Parry, Lincoln, Appleyard 1999b	RCT	Post-hoc analysis (Lincoln et al. 1999)							
Altschuler et al. 1999	RCT, cross over design	9 (5 / 4) with mild to extremely severe stroke	mean: 58.2 y range 53-73y	type: ? chronic: mean 4.8 y + 8.2 y. after stoke, range 6 mo-26 y.	No	Intervention: moving arms symmetrically using a mirror vs using a transparent sheet . E: moving both hands or arms symmetrically (moving the affected arm as best they could), while watching the unaffected arm in mirror C: moving both hands or arms symmetrically (moving the affected arm as best they could), while watching the unaffected arm through the clear plastic sheet. Intensity: 15 min, twice a day, 6 d/wk, during 8 wk (cross over after 4 wk).	Ratings based on video of movements of UE measured at cross over point (4 w k) and at end treatment (8 wk)	Mirror therapy may be beneficial for at least some patients with hemiparesis following stroke.	4 failure at the questions: 3,5,6,8,9,10
Kwakkel et al. 1999	RCT	101 (33/ 31/37) 101 of 1761 patients submitted in study, with impairment of motor function of the arm, 9% drop-outs 89 completed the study	mean: 65.9 y + 11.5y	type: first stroke, MCA sub-acute: mean 7 d. + 2.7 d. after stoke	Yes	Intervention: additional amount of intensity of PT (affected arm) vs immobilising affected arm with splint E: 30 min (5d/wk) additional arm therapy based on eclectic approach (functional exercises that facilitated forced arm and hand activity such as leaning, punching a bal, grasping and moving objects) C: immobilisation of paretic arm by an inflatable pressure splint with the patient in supine for 30 min/day for 5d/wk Intensity: all groups received basic rehabilitation (15 min/d. leg training; 15 min/d arm training and 1.5 hrs ADL-training) during the first 20 w. after stroke.	BI, FAC and ARAT measured at 6, 12, 20 and 26 w. after stroke	Greater intensity of arm rehabilitation results in small improvements in dexterity.	7 failure at the questions: 5,6,9
Kwakkel et al. 2002	RCT	86 (28/25/33)	-	-	Yes	Follow-up study Kwakkel et al. 1999	BI, FAC and ARAT measured at 6, 9 and 12 mo. after stroke	Unable to demonstrate long-term effects of intensity of treatment on the individual patterns of functional recovery between 6 and 12 months after stroke.	6 failure at the questions: 5,6,7,9

RCTs KNGF-guideline 2004 (Pre-mobilisation phase; oedemateous limb)

Study (reference+ publication year)	**Design**	**N (E/C)**	**Age + SD**	**Type of stroke**	**Ext. val.* yes/no**	**Characteristics of intervention**	**(Primary) Outcome**	**Conclusions (author)**	**Methodo-logical quality****
Roper et al. 1999	RCT	37 (20 / 17)with oedema of he-miparetic hand 60 patients sub-mitted in study; 43 started the study and 37 completed the study (14% drop-outs)	mean: 73.3 y. range 61-85y.	type: first stroke sub-acute: mean 3.7 wk after stroke, range 1-20 wk	Yes	Intervention: standard PT and additional intermittent pressure compression vs standard PT E: intermittent compression machine with hemiplegic limb in full arm-inflatable sleeve; Pressure-characteristics: pressure 50 mmHg with 30 s. inflation and 20 s. deflation duty cycle. C: standard PT based on pragmatic approach, included correct positioning of hemiplegic limbs to prevent spasticity and PROM; (no icing to influence hand volume) Intensity: 2 sessions of 2 hrs/d for 1 month	Hand volume measure and MI measured each week during 4 wk treatment period	No statistical difference between the groups. MI increased for both groups. Intermittent pneumatic compression at the prescribed pressure and duration of this study is not an effective treatment for the oedematous stroke hand	7 failure at the questions: *5,6,9*

Bijlage 1.3 Activities of daily living (ADL)

RCTs investigating ADL: training for apraxia

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Smania et al 2006	5	33 (18/15)	Age: 65.67±9.83 yr Type: first isch/hem Time since onset: 10.39±7.96 mos Inclusion: limb apraxia; no age >80 yr, uncooperativeness, orthopedic or other disabling disorders	Comparison: Apraxia training (E) vs. control (C) E: A behavioural training program for limb apraxia consisting of gesture-production exercises; divided in 3 sections dedicated to the treatment of gestures with or without symbolic value and related or nonrelated to the use of objects. C: Conventional treatment for aphasia. Intensity: 50 min/d, 3d/wk, 30 sessions. Treatment contrast: 0 h.	Limb praxis tests (ideational apraxia, ideomotor apraxia, gesture comprehension), Raven test, Token test, Oral apraxia, constructional apraxia tests Measured at baseline and after treatment and 2 mos (follow-up)	Rehabilitative treatment in patients with limb apraxia after stroke can bring about a significant improvement in performing and recognizing both transitive and intransitive gestures. Moreover, amelioration of praxis functions generalizes to ADL functioning.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Smania et al. 2000	RCT	13 (6 / 7) with the presence of limb apraxia 9 (2 / 7) completed the trainings-protocol of 34 of 35 sesions (31% drop-outs)	mean: 65.7 y., range 48-76y.	type: iCVA and hCVA chronic: mean 13.4mo after stroke, range 2-36 mo	Yes	Intervention: evaluate the effectiveness of a rehabilita-tive training program for patients with limb apraxia. E: a behavioural training program for limb apraxia consisting of gesture-production exercises; divided in 3 sections dedicated to the treatment of gestures with or without symbolic value and related or nonrelated to the use of objects C: conventional treatment for aphasia Intensity: 3d/wk: 35 experimental sessions each lasting 50 min. Treatment stopped after completion of all training sections (max 12 wk)	Limb praxic tests (Idea-tional apraxia, ideomotor apraxia and gesture comprehension), Raven test, Token test, Oral apraxia and construc-tional apraxia tests measured after comple-tion of all 35 training sessions (~12wk)	Specific training program for treatment of limb apraxia showed to be effective. The experimental group achieved a significant improvement of performance in both ideational and ideomotor apraxia tests. A trend toward improvement was found in gesture comprehension test while other outcomes did not show any significant amelioration	4 failure at the questions: 3,5,6,8,9,10

Donkervoort et al. 2001	RCT	113 (56 / 57) with LH stroke and apraxia; staying on a in-patient care unit 90 (42 / 48) completed the study (20% drop-outs) 82 (43/39) completed the follow up (5 mo)	mean: 58+10 yrange 47-69y.	type: left hemisphere (all types) post-acute: mean 102 d. + 67d. after stroke	Yes	Intervention: determine the efficacy of strategy training in left hemisphere patients with apraxia E: strategy training integrated into usual OT; uses of strategies to compensate for apraxic impairment du-ring the performance of ADL. Examples are self-ver-balisation to support performance and writing down or showing pictures of the proper sequence of activities. C: usual OT only; the main focus of the therapy is on (sensory) motor impairments (muscle tone, reflexes, controlled movements, muscle strength, contractures) and disability due to these impairments. And aims at increasing independent functioning in ADL tasks Intensity: mean: 26+ 13 sessions, resulting in (mean) 17+11 hrs of OT during 8 wk	ADL-observations (set standardised observations specially developed for apraxia) and BI, extended ADL based on Rivermead Activities of Daily Living Scale, MI, FMT and Apraxia Test measured at the end of the 8 wk treatment and after 5 mo (follow-up)	Evidence was found for the short-term effectiveness of strategy training in left hemisphere stroke patients with apraxia. Strategy training improved significantly more than patients in the usual treatment group on ADL-observations. With respect to the secondary outcome measures a medium effect was found on the BI. No beneficial effects of strategy training were found after 5 mo (at follow-up)	6 failure at the questions: 5,6,8,9

RCTs investigating ADL: leisure therapy

First author, year of publication	PEDro	N (E/C)	Patient characteristics	Intervention (e.g. type, duration, frequency)	Outcome measure (primary)	Conclusions (author)
Nour et al 2002	5	14 (7/7)	Age: 71.1±9.5 yr Type: isch/hem Time since onset: 64.6±37.7 d active inpatient rehabilitation Inclusion: finished active rehabilitation; no communication problems, major cognitive deficit	Comparison: Leisure education program (E) vs. control (C) E: Leisure education program consisting of 12 steps. See: Desrosiers 2007. C: Placebo "friendly visit." See: Desrosiers 2007. Intensity: Planned: 1 d/wk, during 10 wk. Applied: E: 75 min/d; C: 55 min/d. Treatment contrast: Planned: 0 h. Applied: 200 minutes (in favor of E).	BDI, SIS Measured at baseline and 10 wk	The participants receiveing the home leisure educational program performed significantly better on physical and total quality of life measures than the placebo participants.
Desrosiers et al 2007	7	56 (29/27)	Age: 70.0±10.2 yr Type: first/rec isch/hem Time since onset: 24.5±25.7 mos Inclusion: living in community, self-report of some problems with leisure participation or satisfaction; no cognitive problems, language comprehension problems, severe comorbidities	Comparison: Leisure education program (E) vs. control (C) E: Leisure education program with an emphasis on empowerment devided into 12 steps, with 3 components: leisure awareness, self-awareness, competency development. End of program: 1) participant had gone through all the steps, 2) integrated significant leisure activities in his/her life. Program applied at home and in the community by a recreational therapist who was consulted by an OT. C: Visited by recreational therapist at home, but topics discussed were unrelated to leisure (eg, family, cooking, politics, news, everyday life). Intensity: Intended: 60 min/d, 1 d/wk, during 8-12 wk. Applied: E: 76.9 min/d, 10.1±1.2 sessions; C: 65.8 min/d, 9.5±0.9 sessions. Treatment contrast: Intended: 0 h. Applied: 151.59 min.	Participation in leisure activities, Leisure Satisfaction Scale, Individualized Leisure Profile, General Well-Being Schedule, CES-D, SA-SIP30 Measured at baseline and after treatment (8-12 wk)	The results indicate the effectiveness of the leisure education program for improving participation in leisure activities, improving satisfaction with leisure and reducing depression in people with stroke.

RCTs KNGF-guideline 2004

Study (reference+ publication year)	Design	N (E/C)	Age ± SD	Type of stroke	Ext. val.* yes/no	Characteristics of intervention	(Primary) Outcome	Conclusions (author)	Methodo-logical quality**
Jongbloed & Morgan 1991	RCT	40 (20 / 20) able to follow a one-step command	mean: 68.9 y. + ? range 42-86y.	type: all chronic: mean ? < 15 mo after stroke	Yes	Intervention: OT related to leisure activities vs no intervention E: intervention at home: OT assist the subjects in resuming former leisure activities, to learn to engage in new activities, or both. Leisure activities included individual or social activities carried out in the home or community environment C: visited by an OT and asked questions about leisure activity involvement throughout their life span (i.e. during childhood, working years and the time prior to the stroke) and about the effects of the stroke on their life. No treatment. Intensity: 5 home visits (1 hrs each) over 5 consecutive weeks.	Two subscales of the KAI: 1) level of free-time activities and 2) level of satisfaction with free-time activities and MMSE measured at 5 and 18 wk after initial visit or treatment	No statistically significant differences between the experimental and control groups in activity involvement or satisfaction with that involvement	4 failure at the questions: 3,5,6,8,9,11

Gladman et al. 1993	RCT	327 (162 / 165) patients when plans for discharge were being made; excluded those discharged to residential homes or nursing homes 282 (134 / 148) completed the study (14% drop-outs)	mean: 70 + ?y	type: ? sub-acute: mean 20 d. after stroke	Yes	Intervention: randomisation to receive domiciliary or hospital-based care after discharge. They were allocated to three strata (Health Care of the Elderly, General Medical and Stroke Unit) E: treated at home by PT and OT C no domiciliary rehabilitation but hospital- based rehabilitation according to the usual practices in Nottingham. Intensity: 6 mo	BI, NEADL and NHP measured at 3 and 6 mo after discharge	Overall there was no difference in the effectiveness of the domiciliary and hospital-based services, although younger stroke unit patients appeared to do better with home therapy while some frail elderly patients might have benefited from day hospital attendance. The domiciliary group showed significantly greater performance on Extended ADL household and leisure sub-scores at 6 mo	7 failure at the questions: 5,6,9
Drummond & Walker 1995	RCT	65 (21 / 21 / 23) 60 (20 / 20 /20) completed the study at 6 mo (8% drop-outs)	mean: 66 y. + 9,9y range 29-87y.	type: all sub-acute: mean 28d. + 20d. after stroke, range 4-90d.	Yes	Intervention: evaluate the effectiveness of a leisure rehabilitation programme at home. Subjects were allocated to 3 groups: 1) leisure rehabilitation group, 2) conventional occupational therapy group and 3) control group E1: leisure treatment program for each patient was different reflecting personal preferences and abilities E2: conventional OT (transfers, washing, dressing practice and where appropriate perceptual treatments C: no therapy after discharge from hospital Intensity: 30 min/wk for the first 3 mo following discharge and then 30min/every 2 wk for the next 3 mo	NLQ, TOTL, TLA, RMFS and Rivermead-ADL-scale measured at 3 and 6 mo	There was at 6 months an increase in the leisure scores ((TOTL and TLA) for the leisure rehabilitation group only	7 failure at the questions: 5,6,9
Parker et al. 2001	RCT (multi-centre)	466 (153 / 156/ 157) 374 completed the study at 6 mo (20% drop-outs) 331 completed the follow-up at 12 mo	mean: 72 y.	type: ? post-acute: mean 4.7mo + 4.7 mo after stroke	Yes	Intervention: evaluate the effects of leisure-based therapy or conventional (ADL-based) OT at home vs no OT-treatment at home E: Leisure-group: interventions included practising the leisure tasks as well as any ADL-tasks necessary to achieve the leisure objective E2: ADL-group: improving independence in self-care tasks by practising these tasks (such as preparing a meal, walking outdoors) C: no OT-treatment during the trial Intensity: mean 8.5 sessions in ADL- and Leisure-group and mean duration of sessions was 59 min (leisure) and 52 min (ADL), maximum 6 mo	GHQ (mood), NEADL (ADL) and NLQ (Leisure), also BI, LHS, OHS and IST outcomes questions measured at 6 and 12 mo after hospital discharge	There were no major short- or long-term beneficial effects of the additional leisure or ADL occupational therapy provided in this trial on the mood, ADL ability or leisure participation of stroke patients living in the community.	7 failure at the questions: 5,6,8