Keep on. Moving

Promoting physical activity during hospital stay and enhance recovery - focused on patients with cancer

UMC Utrecht Brain Center

Petra Bor

KEEP ON MOVING

Promoting physical activity during hospital stay and enhance recovery - focused on patients with cancer

Petra Bor

KEEP ON MOVING
Promoting physical activity during hospital stay and enhance recovery - focused on patients with cancer

Author: Petra Bor
ISBN: 978-94-6469-644-8
Cover design: Simone Golob – Illustratieve vormgeving
Lay-out: ProefschirftMaken
Print: ProefschriftMaken

The printing of this thesis was financially supported by the Scientific College Physical Therapy (WCF) of the Royal Dutch Society for Physical Therapy (KNGF), Pam bv (developer of the PAM AM400 activity tracker), Peercode bv (developer of Atris software)

Keep on moving

Promoting physical activity during hospital stay and enhance recovery- focused on patients with cancer

Blijf in beweging

Het verbeteren van fysieke activiteit tijdens ziekenhuisopname om herstel te bevorderen – gericht op patiënten met kanker

(met een samenvatting in het Nederlands)

Proefschrift

ter verkrijging van de graad van doctor aan de Universiteit Utrecht op gezag van de rector magnificus, prof.dr. H.R.B.M. Kummeling, ingevolge het besluit van het college voor promoties in het openbaar te verdedigen op woensdag 20 december 2023 des middags te 12:15 uur

door

Petra Bor

geboren op 10 februari 1990
te IJsselham

Promotoren:

Prof. dr. C. Veenhof
Prof. dr. R. van Hillegersberg

Copromotor:

Dr. K. Valkenet

Beoordelingscommissie:

Prof. dr. I.H.M. Borel Rinkes
Dr. J.F. Homans
Prof. dr. A.F. Lenssen
Prof. dr. A.M. May (voorzitter)
Prof. dr. L. Schoonhoven

TABLE OF CONTENTS

Chapter 1

General introduction

GENERAL INTRODUCTION

Cancer treatment and side effects

Yearly worldwide around 19 million new patients are diagnosed with cancer and 9 million people die due to cancer.(1) The risk of death from cancer decreases continuously since 1991 due to reduction of smoking and the introduction of multimodality treatment of solid tumors using surgery combined with (neo)adjuvant chemotherapy.(2) Additionally, treatment against cancer accelerates due to improvements of minimally invasive surgical techniques.(2) Due to the 'success' of cancer therapies, cancer survivors live longer and experience new issues including physical and physiological side effects of treatment.(3) Counteracting the side-effects seems of high importance to optimize recovery after cancer treatment, especially since physical functioning decline during treatment without returning to baseline levels.(Figure 1) An example which helps to counteract the side-effects and improve recovery of physical functioning, is physical activity. Higher levels of physical activity lowers the risk of complications and could improve survival.(4-6) However, patients with cancer show to have low levels of physical activity during and after treatment.(7)

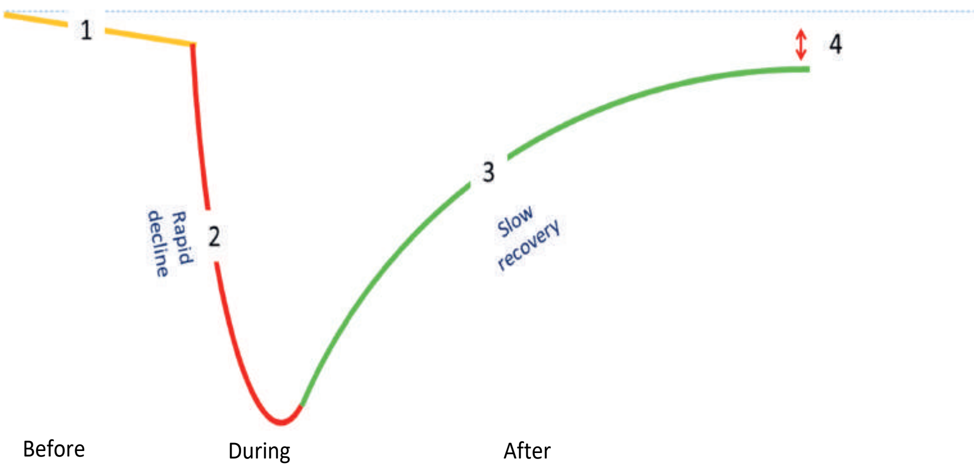


Figure 1. Trajectory of physical functioning before, during and after treatment, like surgery

Culture of inactivity in the hospital

Patients who undergo treatment for cancer like surgery or chemotherapy are frequently admitted to the hospital. In the hospital the bed is assumed as the basis for all treatment.(8) Likewise, the size of a hospital is expressed in number of beds and patients are reflectively put into pyjamas and transferred into bed.(9) Even though most patients are able to walk into the hospital and did not yet receive any treatment, they are in bed once admitted to the hospital ward. This reflects how sedentary behaviour is deeply rooted in the hospital culture and how this environment discourages the patient to be physically active.(9-12) As already discussed in 1947, physical inactivity is associated with complications such as pneumonia, urinary tract infection, deep venous thrombosis and pressure ulcers, which can result in prolonged hospital stay, higher mortality and increased hospital costs.(8) Furthermore, the downside of physical inactivity is the risk of functional decline and the development of new disabilities in activities of daily living (ADL) after discharge.(8, 13-16) Functional decline is described as the loss of ability to complete one of the basic ADL needed to live independently without assistance (e.g. bathing, dressing, rising from a bed or a chair, using the toilet, eating, or walking across a room).(17) This functional decline is labeled as hospitalization-associated disability (HAD) and described in literature as both preventable and iatrogenic. HAD can therefore be considered as collateral damage of the treatment in a hospital in which healthcare professionals and policy makers have the responsibility to resolve this problem.(18) Physical inactivity is associated with this functional decline.(17) During hospital stay, patients spend around 50-80% of their time in bed, whereas the adverse effects of bed rest and inactivity is well known for a long time.(13, 14, 19, 20) Furthermore, this problem of inactivity is a problem of all wards within the hospital. Patients admitted to the oncological wards are no exception.(20) Therefore, fundamental changes to the current thinking and practice to patient mobility within the whole organization, including all disciplines, are needed to change the culture of physical activity during hospital stay.(21)

"beneath the comfort of the blanket there lurks a host of formidable dangers"
Asher, 1947

Interventions promoting inpatients' physical activity

Nevertheless, the optimal content and effectiveness of interventions to change the culture of inactivity and to stimulate inpatients' physical activity is unclear. Recent studies targeting inactivity during hospitalization demonstrated that physical activity is a modifiable factor.(22-24) However, most of these studies investigated the effect of single interventions on patients' function or medical outcomes instead of physical activity itself. Furthermore, to change the immobility culture in the hospital, previous studies suggest that interventions should be multidimensional.(25, 26) Inpatient physical activity is a complex phenomenon with interactions at the level of the patient, healthcare professional, environment, but also within the organization.(27) This is in line with the Social Ecological Model which provides a visual representation of the dynamic relationship among the individual and several levels of the organization. Long-term attention to all levels of the Social Ecological Model (SEM) might help to create change and synergy which might be needed to support sustainable improvements in health care.(28) Figure 2 shows the influence of several levels of the SEM on inpatient physical activity, centralized around the individual (i.e. patient or healthcare professional). The micro- and mesosystem reflect the influence of interpersonal interaction with family, loved ones and healthcare professionals. The exosystem reflects the indirect influence of the mission, vision and communications within the hospital. Therefore, to change the culture of inactivity, this model could be a useful tool to understand and identify targets within the whole organization.(28, 29)

For example within the unit/ward, nowadays the environment is not stimulating to get physically active. Patient care is organized around the bed and food and drinks are typically put within the patients' reach. Therefore, for patients there is no need to get out of bed. Even so, most patients are not aware of the downsides of lying in bed and have limited knowledge about what they are allowed to do. Therefore, interventions should focus on both education and adjustments to the built environment.(12, 30-32) Additionally, healthcare professionals report that they are willing to improve physical activity levels during hospital stay, however it often ends at the bottom of the priority list. Multiple barriers are mentioned like a lack of knowledge, resources, time and workload and their responsibility and expectations within the multidisciplinary team regarding the stimulation of physical activity.(29-31) However, to change the culture of immobility, engagement of the entire team is required. Therefore, it is important that a multidisciplinary team is involved within the development and evaluation of interventions aiming to stimulate inpatients physical activity.(21, 29, 33)

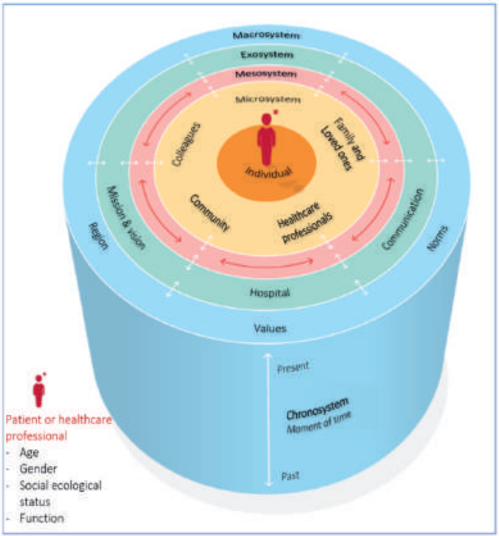


Figure 2. Inpatients' physical activity and the interaction on several levels of the Social Ecological Model(34)

Another promising and upcoming technology to stimulate inpatients' physical activity is the use of activity trackers.(35-38) Activity trackers can deliver continuous gathered physical activity data which can provide insight in actual levels of physical activity. Furthermore, continuous gathered data can be useful to monitoring patterns, identifying patients at risk and to personalize care.(39, 40) Despite the opportunity, the optimal content of interventions using activity trackers to stimulate inpatients' physical activity remain unclear. Furthermore, structural use in daily hospital care is limited by several barriers like making sense of continuous data, patient engagement, integrating sensor in electronic health systems and clinical workflows.(39)

Development, evaluation and implementation

There is a need for development, evaluation and implementation of suitable and multidimensional interventions, involving a multidisciplinary team.(21, 29, 33, 41) However, the process from development to the implementation of complex interventions may take a wide range of different actions and is stated as a cyclic process.(42) It is important that the intervention is tailored to the context, to bridge the gap between the potential contribution of interventions and the site-specific requirements.(43) In literature several intervention development models are described. In general, a flexible and dynamic approach is recommended and it is important that the models addresses the specific requirements.(43, 44) To create sustainable change in the healthcare system, next to the intervention development, the implementation is important.(42, 45) Structured and theoretically driven implementation might contribute to counteract the research-practice gap. Therefore, it is recommended to use an evidence based model to guide the implementation process to enhance the uptake of effective interventions in daily practice.(46)

When interventions are implemented in usual care it is important to evaluate how the intervention works in every day practice, especially in complex interventions. To understand the whole range of effects and the interaction during the implementation, it is important to understand the underlying implementation processes and the active ingredients of the intervention.(42, 43) Therefore, next to the evaluation of the effectiveness, process evaluations are needed to understand the factors of influence on the implementation of interventions.(47) The Medical Research Council developed a framework for the process evaluation of complex interventions.(47) This framework consists of three key functions, including the implementation, mechanisms of impact and the context. Insight in these key functions might help to understand the underlying mechanisms. Providing a process evaluation is important to evaluate the feasibility and implementation of interventions changing physical activity in the hospital. These insights can help to enhance the intervention and implementation processes in the future.

Another way to systematically describe, develop and evaluate active ingredients within the intervention is to identify behaviour change techniques (BCT). A BCT is defined as an "observational, replicable and reproducible component of an intervention designed to alter or redirect causal processes that regulate behaviour".(48) The BCT taxonomy is a method for specifying, evaluating, and implementing behaviour change interventions that can be applied to many different types of interventions and has multidisciplinary and international acceptance and use.(48) Therefore, identifying BCTs withing the interventions stimulating physical activity, provide further insight in the active ingredients to create sustainable change.

Optimizing recovery after major oncological surgery

For patients who underwent major oncological surgery, the hospital admission is only a part of the entire patient journey. For example in patient with esophageal cancer, curative treatment exists of neoadjuvant chemoradiotherapy, followed by extensive surgery.(49) However, these patients have a relatively high risk of postoperative complications.(50) Previous literature about the predictive properties based on physical activity or function to identify patients at risk for complications after esophagectomy is contradictive.(51, 52) Therefore, more research is needed to identify the patients at risk, to optimize care in the future.

Nevertheless, for patients who underwent major oncological surgery, not the number of complications, but the return to daily functioning as soon as possible is most important.(53-55) To enhance postoperative recovery of physical functioning, the level of physical activity seems important.(56-58) However, current studies evaluating physical activity after oncological surgery did not measure physical activity as objective outcome measure or did not evaluate physical functioning measures as well.(40, 59, 60) Therefore, it is important to get insight in objective measured physical activity both during and after hospital stay and to evaluate the recovery of physical functioning after major oncological surgery.

Furthermore, not all patients might need the same level of support to achieve full recovery of physical functioning after hospital admission. Some patients need personal guidance for an optimal recovery were others are capable to recover well without personal support. The decision of what a patient need in daily practice is mostly based on clinical experience. However, from literature it is known that personalized and tailored care leads to increased patient engagement, which accelerates more effective and efficient care.(61-63) Therefore, there is a need for practical guidance on how to personalize and tailor care.(64) One possible way to tailor care is segmentation. Segmentation divides patients into different personas, whereby for each persona intervention programs can be tailored to a person's need.(64) However, it is unknown if the identification of different personas is a useful tool to tailor care in patients who underwent major oncological surgery.

In summary

There is a need for interventions changing the culture of inactivity during hospital stay to prevent unwanted events like complications and functional decline. Therefore, the aim of this thesis is to develop, evaluate and implement interventions to increase physical activity during hospital stay. Next to change the immobility culture during hospital stay, the aim of this thesis is to gain insight in physical activity and functioning in the perioperative period in patients who underwent major oncological surgery, to optimize care in the entire patient journey.

OUTLINE OF THIS THESIS

This thesis focusses on the improvement of physical activity and physical functioning levels during and after hospitalization, with a special focus on patients with cancer. **Part I** develops, evaluates and implements interventions which aim to promote physical activity during hospital stay. **Part II** describes the role of physical activity and functioning around major oncological surgery and provides insight in a potential way to tailor care.

Part I Interventions to promote inpatients' physical activity

Chapter 2 describes the study protocol for the implementation and evaluation of Hospital in Motion, a multidimensional and multidisciplinary implementation project to improve patients' physical behaviour during hospital stay. In **chapter 3**, the effectiveness of the project Hospital in Motion on patients physical behaviour and medical outcomes is evaluated. In **chapter 4** the process evaluation is described by providing insight in the experienced factors of influence after the implementation of Hospital in Motion.

Chapter 5 contains a systematic review, evaluating the effectiveness of physical activity interventions using activity trackers on the level of physical activity and physical functioning during or after an inpatients period like hospital stay in a broad population. Before the conduction of chapter 6, a tailored intervention using activity trackers is developed guided by the intervention mapping approach, aiming to increase inpatients physical activity. **Chapter 6** evaluates the effectiveness of an intervention using activity trackers on inpatients physical activity.

Part II Optimizing care around major oncological surgery

Chapter 7 evaluates whether changes in physical fitness, weight and Fat Free Mass Index during neoadjuvant chemoradiotherapy can predict the risk of postoperative pneumonia in patients undergoing esophagectomy. In **chapter 8** the recovery of physical functioning from preoperative until 3 months after discharge in patients undergoing major oncological surgery is investigated. Additionally, the role of objectively measured physical activity levels during and after hospital stay on the recovery of physical functioning is described. In **chapter 9** it is explored whether segmentation of patients into different personas based on patients' subjective believed health, can be applied in patients who underwent major oncological surgery, to tailor care. Hereby subjective health experience is measured during the perioperative period and differences in physical and mental functioning between the personas are evaluated.

REFERENCES

1. The Global Cancer Observatory [updated December, 2020. Available from: https://gco.iarc.fr/today/data/factsheets/cancers/39-All-cancers-fact-sheet.pdf.
2. Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer statistics, 2022. CA: a cancer journal for clinicians. 2022;72(1):7-33.
3. Gusani NJ, Schubart JR, Wise J, Farace E, Green MJ, Jiang Y, et al. Cancer survivorship: a new challenge for surgical and medical oncologists. J Gen Intern Med. 2009;24 Suppl 2(Suppl 2):S456-8.
4. McTiernan A, Friedenreich CM, Katzmarzyk PT, Powell KE, Macko R, Buchner D, et al. Physical Activity in Cancer Prevention and Survival: A Systematic Review. Med Sci Sports Exerc. 2019;51(6):1252-61.
5. Cormie P, Zopf EM, Zhang X, Schmitz KH. The Impact of Exercise on Cancer Mortality, Recurrence, and Treatment-Related Adverse Effects. Epidemiologic Reviews. 2017;39(1):71-92.
6. Fransen LFC, Luyer MDP. Effects of improving outcomes after esophagectomy on the short- and long-term: a review of literature. J Thorac Dis. 2019;11(Suppl 5):S845-s50.
7. Littman AJ, Tang MT, Rossing MA. Longitudinal study of recreational physical activity in breast cancer survivors. Journal of cancer survivorship : research and practice. 2010;4(2):119-27.
8. Asher RAJ. Dangers of Going to Bed. British Medical Journal. 1947;2(4536):967-8.
9. Oliver D. David Oliver: Fighting pyjama paralysis in hospital wards. Bmj. 2017;357:j2096.
10. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. J Hosp Med. 2007;2(5):305-13.
11. Koenders N, van Oorsouw R, Seeger JPH, Nijhuis-van der Sanden MWG, van de Glind I, Hoogeboom TJ. "I'm not going to walk, just for the sake of walking…": a qualitative, phenomenological study on physical activity during hospital stay. Disabil Rehabil. 2020;42(1):78-85.
12. Koenders N, van Oorsouw R, Seeger JPH, Nijhuis-van der Sanden MWG, van de Glind I, Hoogeboom TJ. "I'm not going to walk, just for the sake of walking...": a qualitative, phenomenological study on physical activity during hospital stay. Disabil Rehabil. 2018:1-8.
13. Mudge AM, McRae P, McHugh K, Griffin L, Hitchen A, Walker J, et al. Poor mobility in hospitalized adults of all ages. J Hosp Med. 2016;11(4):289-91.
14. Brown CJ, Redden DT, Flood KL, Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc. 2009;57(9):1660-5.
15. Ostir GV, Berges IM, Kuo YF, Goodwin JS, Fisher SR, Guralnik JM. Mobility activity and its value as a prognostic indicator of survival in hospitalized older adults. J Am Geriatr Soc. 2013;61(4):551-7.

16. Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. J Am Geriatr Soc. 2015;63(1):55-62.

17. Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E, Admi H. Low mobility during hospitalization and functional decline in older adults. J Am Geriatr Soc. 2011;59(2):266-73.

18. Covinsky KE, Pierluissi E, Johnston CB. Hospitalization-associated disability: "She was probably able to ambulate, but I'm not sure". Jama. 2011;306(16):1782-93.

19. Pedersen MM, Bodilsen AC, Petersen J, Beyer N, Andersen O, Lawson-Smith L, et al. Twenty-four-hour mobility during acute hospitalization in older medical patients. J Gerontol A Biol Sci Med Sci. 2013;68(3):331-7.

20. Valkenet K, McRae P, Reijneveld E, Jans M, Bor P, van Delft L, et al. Inpatient physical activity across a large university city hospital: a behavioral mapping study. Physiother Theory Pract. 2022:1-8.

21. Czaplijski T, Marshburn D, Hobbs T, Bankard S, Bennett W. Creating a culture of mobility: an interdisciplinary approach for hospitalized patients. Hosp Top. 2014;92(3):74-9.

22. Hoyer EH, Friedman M, Lavezza A, Wagner-Kosmakos K, Lewis-Cherry R, Skolnik JL, et al. Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. J Hosp Med. 2016;11(5):341-7.

23. van der Leeden M, Huijsmans R, Geleijn E, de Lange-de Klerk ES, Dekker J, Bonjer HJ, et al. Early enforced mobilisation following surgery for gastrointestinal cancer: feasibility and outcomes. Physiotherapy. 2016;102(1):103-10.

24. van de Port IG, Valkenet K, Schuurmans M, Visser-Meily JM. How to increase activity level in the acute phase after stroke. J Clin Nurs. 2012;21(23-24):3574-8.

25. Koenders N, Potkamp-Kloppers S, Geurts Y, Akkermans R, Nijhuis-van der Sanden MWG, Hoogeboom TJ. Ban Bedcentricity: A Multifaceted Innovation to Reduce Sedentary Behavior of Patients During the Hospital Stay. Physical Therapy. 2021;101(7).

26. Squires JE, Sullivan K, Eccles MP, Worswick J, Grimshaw JM. Are multifaceted interventions more effective than single-component interventions in changing health-care professionals' behaviours? An overview of systematic reviews. Implement Sci. 2014;9:152.

27. Koenders N, Marcellis L, Nijhuis-van der Sanden MW, Satink T, Hoogeboom TJ. Multifaceted interventions are required to improve physical activity behaviour in hospital care: a meta-ethnographic synthesis of qualitative research. J Physiother. 2021;67(2):115-23.

28. Golden SD, Earp JA. Social ecological approaches to individuals and their contexts: twenty years of health education & behavior health promotion interventions. Health Educ Behav. 2012;39(3):364-72.

29. Stutzbach J, Jones J, Taber A, Recicar J, Burke RE, Stevens-Lapsley J. Systems Approach Is Needed for In-Hospital Mobility: A Qualitative Metasynthesis of Patient and Clinician Perspectives. Arch Phys Med Rehabil. 2021;102(5):984-98.

30. Geelen SJG, Giele BM, Engelbert RHH, de Moree S, Veenhof C, Nollet F, et al. Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals. Disabil Rehabil. 2022;44(15):4004-13.

31. De Klein K, Valkenet K, Veenhof C. Perspectives of patients and health-care professionals on physical activity of hospitalized patients. Physiother Theory Pract. 2019:1-8.

32. van Dijk-Huisman HC, Raeven-Eijkenboom PH, Magdelijns FJH, Sieben JM, de Bie RA, Lenssen AF. Barriers and enablers to physical activity behaviour in older adults during hospital stay: a qualitative study guided by the theoretical domains framework. BMC Geriatr. 2022;22(1):314.

33. Mudge AM, McRae P, Cruickshank M. Eat walk engage: an interdisciplinary collaborative model to improve care of hospitalized elders. Am J Med Qual. 2015;30(1):5-13.

34. KNGF-Standpunt Beweegziekenhuizen. Amersfoort KNGF

35. Baldwin C, van Kessel G, Phillips A, Johnston K. Accelerometry Shows Inpatients With Acute Medical or Surgical Conditions Spend Little Time Upright and Are Highly Sedentary: Systematic Review. Physical Therapy. 2017;97(11):1044-65.

36. Wells CI, Xu W, Penfold JA, Keane C, Gharibans AA, Bissett IP, et al. Wearable devices to monitor recovery after abdominal surgery: scoping review. BJS Open. 2022;6(2).

37. Amin T, Mobbs RJ, Mostafa N, Sy LW, Choy WJ. Wearable devices for patient monitoring in the early postoperative period: a literature review. Mhealth. 2021;7:50.

38. Smart DA, Dermody G, Coronado ME, Wilson M. Mobility Programs for the Hospitalized Older Adult: A Scoping Review. Gerontol Geriatr Med. 2018;4:2333721418808146.

39. Low CA. Harnessing consumer smartphone and wearable sensors for clinical cancer research. NPJ Digit Med. 2020;3:140.

40. Carmichael H, Overbey DM, Hosokawa P, Goode CM, Jones TS, Barnett CC, Jr., et al. Wearable Technology-A Pilot Study to Define "Normal" Postoperative Recovery Trajectories. J Surg Res. 2019;244:368-73.

41. Skivington K, Matthews L, Simpson SA, Craig P, Baird J, Blazeby JM, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. Bmj. 2021;374:n2061.

42. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. Bmj. 2008;337:a1655.

43. Zisberg A, Agmon M, Gur-Yaish N, Rand D, Hayat Y, Gil E. No one size fits all-the development of a theory-driven intervention to increase in-hospital mobility: the "WALK-FOR" study. BMC Geriatr. 2018;18(1):91.

44. O'Cathain A, Croot L, Sworn K, Duncan E, Rousseau N, Turner K, et al. Taxonomy of approaches to developing interventions to improve health: a systematic methods overview. Pilot Feasibility Stud. 2019;5:41.

45. Prior M, Guerin M, Grimmer-Somers K. The effectiveness of clinical guideline implementation strategies--a synthesis of systematic review findings. J Eval Clin Pract. 2008;14(5):888-97.

46. Nilsen P. Making sense of implementation theories, models and frameworks. Implementation Science. 2015;10(1):53.

47. Moore GF, Audrey S, Barker M, Bond L, Bonell C, Hardeman W, et al. Process evaluation of complex interventions: Medical Research Council guidance. Bmj. 2015;350:h1258.

48. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1):81-95.

49. Shapiro J, van Lanschot JJB, Hulshof M, van Hagen P, van Berge Henegouwen MI, Wijnhoven BPL, et al. Neoadjuvant chemoradiotherapy plus surgery versus surgery alone for oesophageal or junctional cancer (CROSS): long-term results of a randomised controlled trial. The Lancet Oncology. 2015;16(9):1090-8.

50. Park DP, Welch CA, Harrison DA, Palser TR, Cromwell DA, Gao F, et al. Outcomes following oesophagectomy in patients with oesophageal cancer: a secondary analysis of the ICNARC Case Mix Programme Database. Critical care (London, England). 2009;13 Suppl 2:S1.

51. Tatematsu N, Park M, Tanaka E, Sakai Y, Tsuboyama T. Association between physical activity and postoperative complications after esophagectomy for cancer: a prospective observational study. Asian Pac J Cancer Prev. 2013;14(1):47-51.

52. van Egmond MA, van der Schaaf M, Klinkenbijl JH, Engelbert RH, van Berge Henegouwen MI. Preoperative functional status is not associated with postoperative surgical complications in low risk patients undergoing esophagectomy. Diseases of the esophagus : official journal of the International Society for Diseases of the Esophagus. 2017;30(1):1-7.

53. Miller TE, Mythen M. Successful recovery after major surgery: moving beyond length of stay. Perioper Med (Lond). 2014;3:4.

54. Lee L, Tran T, Mayo NE, Carli F, Feldman LS. What does it really mean to "recover" from an operation? Surgery. 2014;155(2):211-6.

55. Rajabiyazdi F, Alam R, Pal A, Montanez J, Law S, Pecorelli N, et al. Understanding the Meaning of Recovery to Patients Undergoing Abdominal Surgery. JAMA Surgery. 2021;156(8):758-65.

56. Abeles A, Kwasnicki RM, Pettengell C, Murphy J, Darzi A. The relationship between physical activity and post-operative length of hospital stay: A systematic review. Int J Surg. 2017;44:295-302.

57. Castelino T, Fiore JF, Jr., Niculiseanu P, Landry T, Augustin B, Feldman LS. The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. Surgery. 2016;159(4):991-1003.

58. Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg. 2004;199(5):762-72.

59. Jonker LT, Hendriks S, Lahr MM, van Munster BC, de Bock GH, van Leeuwen BL. Postoperative recovery of accelerometer-based physical activity in older cancer patients. European journal of surgical oncology : the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology. 2020.

60. van Zutphen M, Winkels RM, van Duijnhoven FJ, van Harten-Gerritsen SA, Kok DE, van Duijvendijk P, et al. An increase in physical activity after colorectal cancer surgery is

associated with improved recovery of physical functioning: a prospective cohort study. BMC Cancer. 2017;17(1):74.

61. Hibbard JH, Greene J. What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs. Health Aff (Millwood). 2013;32(2):207-14.

62. Lee DJ, Avulova S, Conwill R, Barocas DA. Patient engagement in the design and execution of urologic oncology research. Urol Oncol. 2017;35(9):552-8.

63. Fournier B, Delrieu L, Russo C, Terret C, Fervers B, Pérol O. Interest and preferences for physical activity programming and counselling among cancer patients aged over 70 years receiving oncological treatments. Eur J Cancer Care (Engl). 2022;31(1):e13527.

64. Vuik SI, Mayer EK, Darzi A. Patient Segmentation Analysis Offers Significant Benefits For Integrated Care And Support. Health Aff (Millwood). 2016;35(5):769-75.

Part I

Interventions to promote inpatients' physical activity

Chapter 2

Hospital in Motion, a Multidimensional Implementation Project to Improve Patients' Physical Behavior During Hospitalization: Protocol for a Mixed-Methods Study

Lotte M.M. van Delft*
Petra Bor*
Karin Valkenet
Cindy Veenhof

*These authors contributed equally

Published in JMIR Research Protocols 2019

ABSTRACT

Background: Despite the evidence of the adverse consequences of immobility during hospitalization, patients spend most of the time in bed. Although physical activity is a modifiable factor that can prevent in-hospital functional decline, bed rest is deeply rooted in the hospital culture. To attack this, a multidimensional approach is needed. Therefore, Hospital in Motion, a multidimensional implementation project, was designed to improve physical behavior during hospitalization.

Objective: The primary objective of this study is to investigate the effectiveness of Hospital in Motion on inpatient physical behavior. Secondary objectives are to investigate the effectiveness on length of hospital stay and immobility-related complications of patients during hospitalization and to monitor the implementation process.

Methods: For this study, Hospital in Motion will be implemented within 4 wards (cardiology, cardiothoracic surgery, medical oncology, and hematology) in a Dutch University Medical Center. Per ward, multidisciplinary teams will be composed who follow a step-by-step multidimensional implementation approach including the development and implementation of tailored action plans with multiple interventions to stimulate physical activity in daily care. A prepost observational study design will be used to evaluate the difference in physical behavior before and 1 year after the start of the project, including 40 patients per timepoint per ward (160 patients in total). The primary outcome measure is the percentage of time spent lying, measured with the behavioral mapping method. In addition, a process evaluation will be performed per ward using caregivers' and patient surveys and semistructured interviews with patients and caregivers.

Results: This study is ongoing. The first participant was enrolled in October 2017 for the premeasurement. The postmeasurements are planned for the end of 2018. The first results are expected to be submitted for publication in autumn 2019.

Conclusion: This study will provide information about the effectiveness of the Hospital in Motion project on physical behavior and about the procedures of the followed implementation process aimed to incorporate physical activity in usual care. These insights will be useful for others interested in changing physical behavior during hospitalization.

BACKGROUND

More than 2 million patients are admitted to Dutch hospitals yearly, with a mean admission time of 7 days [1]. Although hospital admissions are necessary to diagnose or treat patients for health issues, hospital admissions also have downsides. Diverse studies show that hospitalized patients spend most of the time lying in bed, whereas in the last 20 years, a growing body of evidence is established showing the adverse consequences of bed rest [2,3]. Restricted physical activity and immobilization can increase hospital-related complications [3,4], and many studies have proven that inactivity is associated with reduced muscle mass and strength [5]. In addition, bed rest results in an increased risk of diverse medical complications [6-8]. Moreover, lower levels of physical activity are associated with a functional decline and new disability in activities of daily living (ADL) after discharge [3,4,10-13]. This functional decline is labeled as a hospitalization-associated disability (HAD), and HADs have profound implications for patients as it leads to long-term care in nursing homes, readmissions, and even death [12]. In research reports, HADs are described as both preventable and iatrogenic and as a direct result from the actions of a health care provider or institution. HADs can, therefore, be considered as collateral damage of the treatment in a hospital in which health care professionals and policy makers have a responsibility in resolving this problem [14]. Especially, as early mobilization and higher levels of physical activity during hospitalization have proven to decrease the risk of complications and length of stay (LOS) [9].

Nevertheless, patients are reflexively put into pajamas, transferred into bed [15], and spend less than 6% of the day being active [2-4,10]. Lack of knowledge and time is often mentioned by caregivers as a barrier to promote physical activity [16,17]. This lack of time results in nurses prioritizing their medical tasks above assisting with patient mobilization and stimulating physical activity in patients with the ability to perform their own ADL tasks [16,17]. Studies targeting sedentary behavior during hospitalization have shown that physical activity is a modifiable factor that can prevent in-hospital functional decline [9,18-20]. These studies mostly focused on single interventions, whereas sedentary behavior is deeply rooted in the hospital culture. A multidimensional project focusing on environment, caregivers, and patients using multiple interventions may possibly be even more effective [21]. Even so, literature suggests that a comprehensive and flexible framework may help create sustainable interventions, leading to significant changes in clinical practice [22]. However, projects or studies to improve physical behavior focusing on the whole system, integrating physical activity in all levels of daily hospital care, are not common. Moreover, these studies focused mainly on elderly, whereas low mobility is of all ages [19,22]. Therefore, Hospital in Motion, a multidimensional project to improve patients' physical behavior during hospitalization, has been developed.

Objectives

- The primary objective of this study is to investigate the effectiveness of Hospital in Motion on physical behavior within 4 wards (cardiology, cardiothoracic surgery, medical oncology, and hematology).
- Secondary objectives are to investigate the effectiveness on length of hospital stay and immobility-related complications of patients during hospitalization and to monitor the implementation process.

METHODS

Context

In November 2015, the project Hospital in Motion was started at the University Medical Center Utrecht (UMC Utrecht). Hospital in Motion is a complex multidimensional project primarily designed to improve physical behavior during hospital stay, defined as a decrease in patients' sedentary behavior (lying) and increase in physical activity (ie, standing, walking, and exercising). This project follows 2 approaches. The first approach focusses on creating a hospital-wide awareness of the high amount of sedentary behavior during the hospital stay and the known associated adverse effects, and the necessity to incorporate physical activity in usual care. The second approach includes the development and implementation of tailored action plans for each clinical ward. In 2016 and 2017, a pilot study was performed on the geriatric department. Preliminary results and gained experiences during this pilot form the basis of this study protocol.

Setting

This study will be conducted within 4 wards (cardiology, cardiothoracic surgery, medical oncology, and hematology) of the UMC Utrecht, the Netherlands. Per ward, a tailored action plan will be implemented. The study protocol was assessed and approved by the medical ethics committee of the UMC Utrecht (study protocol number 16-250). Verbally informed consent was obtained from all patients.

Study Design

An observational study with a prepost design will be used to evaluate the effectiveness of Hospital in Motion on physical behavior. In addition, the implementation process will be evaluated by using a qualitative approach. Data will be collected before and after implementation. The duration of the implementation project is planned for 10 months, starting in January 2018 (Figure 1).

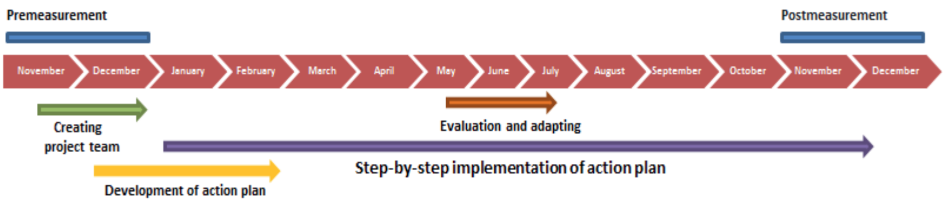


Figure 1. Time line of the implementation project Hospital in Motion.

Implementation Approach and Interventions

Hospital in Motion will be implemented following the step-by-step model of Wensing and Grol (Figure 2) [23]. Steps 1 to 3 include the development of proposal for change, analysis of actual performance, and problem analysis. Step 4 includes the selection of strategies and measures to change practice, which will be identified by a multidisciplinary project team per ward. During step 5, an action plan consisting of multiple interventions will be developed, tested, and executed at each ward. This plan will consist of 6 general topics:

1. Education: Education is an important cornerstone for increasing awareness on the importance of physical activity [17,24], for example, education for the staff members about the dangers of bed rest and posters and leaflets for patients about the importance of staying active during hospital stay.
2. Physical activity as part of usual care: For successful implementation, physical activity needs to be incorporated in usual care and all caregivers with direct patient contact need to be involved [17,25], for example, integrating questions on the physical activity level in the anamneses of nurses and physicians, standardized reporting of daily mobility levels in the patient records, and discussing the patients mobility during multidisciplinary meetings.
3. Involving third parties: Involving the social environment (ie, family, friends, or volunteers) to improve inpatient physical behavior, for example, family and visit leaflets with information about the importance of physical activity during hospitalization and tips to improve patients' physical activity [26,27].
4. Stimulating environment: Currently, hospital wards are not stimulating environments for performing physical activity [28]. Changes in the environment are conditional for stimulating physical activity, for example, by adjustments of the accommodation inpatient areas, introducing shared lunching, and visualizing walking routes.
5. Mobilization milestones: Daily mobilization goals are successful in increasing walking distance, ADL activities, and number of mobilization moments out of bed [9]. The use of a mobility scale or activity trackers are examples of interventions, which could be used to set personal mobility goals.
6. Technology support: Implementing technological applications such as cycle ergometers with interactive screens, activity trackers, or mobile apps to support, stimulate, and measure physical activity [29].

Outcome Evaluation

In total, 160 patients will be included during a period of 2 months (40 patients per ward). Each patient admitted in the specific ward is eligible to participate in this study. Exclusion criteria for participating in this study were delirium and other cognitive impairments, whereby patients who were not able to provide informed consent were excluded. Patients receiving terminal care were also excluded.

Primary Outcome

Physical behavior will be measured with the behavioral mapping method [30] and will be assessed before and after the implementation period (Figure 1). Patients will be observed on a random weekday of their stay in a fixed order every 10 min for 1 min. During this minute, the patients' location, body position, daily activity, and direct contact will be registered [30]. A maximum of 8 patients per ward per day can be observed, and observations take place from 9 am until 4 pm.

Physical behavior is defined as the percentage of the total observed time that a patient spent in a specific body position. A distinction will be made between lying, sitting (bedside or chair), and moving (standing, transferring, walking, and cycling). The primary outcome in this study is the percentage of time spent lying.

Secondary Outcomes

Secondary outcomes are the percentages of time spent sitting and moving, LOS, and the incidence of immobility-related complications (ie, pneumonia, aspiration, chest infection, pulmonary embolism, deep-vein thrombosis, urinary tract infection, and pressure sores) [31]. LOS and immobility-related complications will be retrospectively retrieved out of the electronic patient file.

Patient Characteristics

Demographic characteristics that will be documented are gender, age, admission reason, specialism, the use of mobilization tools (ie, rollator, walker, crutches, or stick), urine catheter (yes/no), infusion (yes/no), and main perceived limitations during physical activity (eg, pain and exhaustion). In addition, the health perception and physical functioning of patients will be assessed.

The subjective believed health questionnaire is used to obtain the health perception, defined as "individual's experience of physical and mental functioning while living his life the way he wants to, within the actual constraints and limitations of individual existence" [32]. The questionnaire consists of 8 questions; question 1 and 2 focus on subjective health, scored on a ladder-type scale from 0 to 10. Question 3 to 8 focus on perceived control and acceptance, scored between 1 (completely disagree) and 7 (totally agree) [33].

The Activity Measure for Post-Acute Care (AM-PAC) is a validated measurement instrument based on the activity limitation domain of the International Classification of Functioning, Disability and Health. In this study, the AM-PAC "6-Clicks" measures of basic mobility and daily activity in acute care will be used. These short forms have shown to be valid for assessing patients' activity limitations in acute care settings [34,35]. Handgrip strength can indicate the overall strength of an individual and can provide insight into the level of physical function [36,37]. Handgrip strength will be measured with the Jamar hydraulic hand dynamometer, which is an isometric, hydraulic, and easily accessible tool with excellent test-retest reliability ($r>0.80$) and interrater reliability ($r=0.98$) [36,37]. The 30 seconds chair stand test (30-s CST) is a reliable and valid measurement method for lower extremity strength assessment and a good indicator for a person's level of physical function [38].

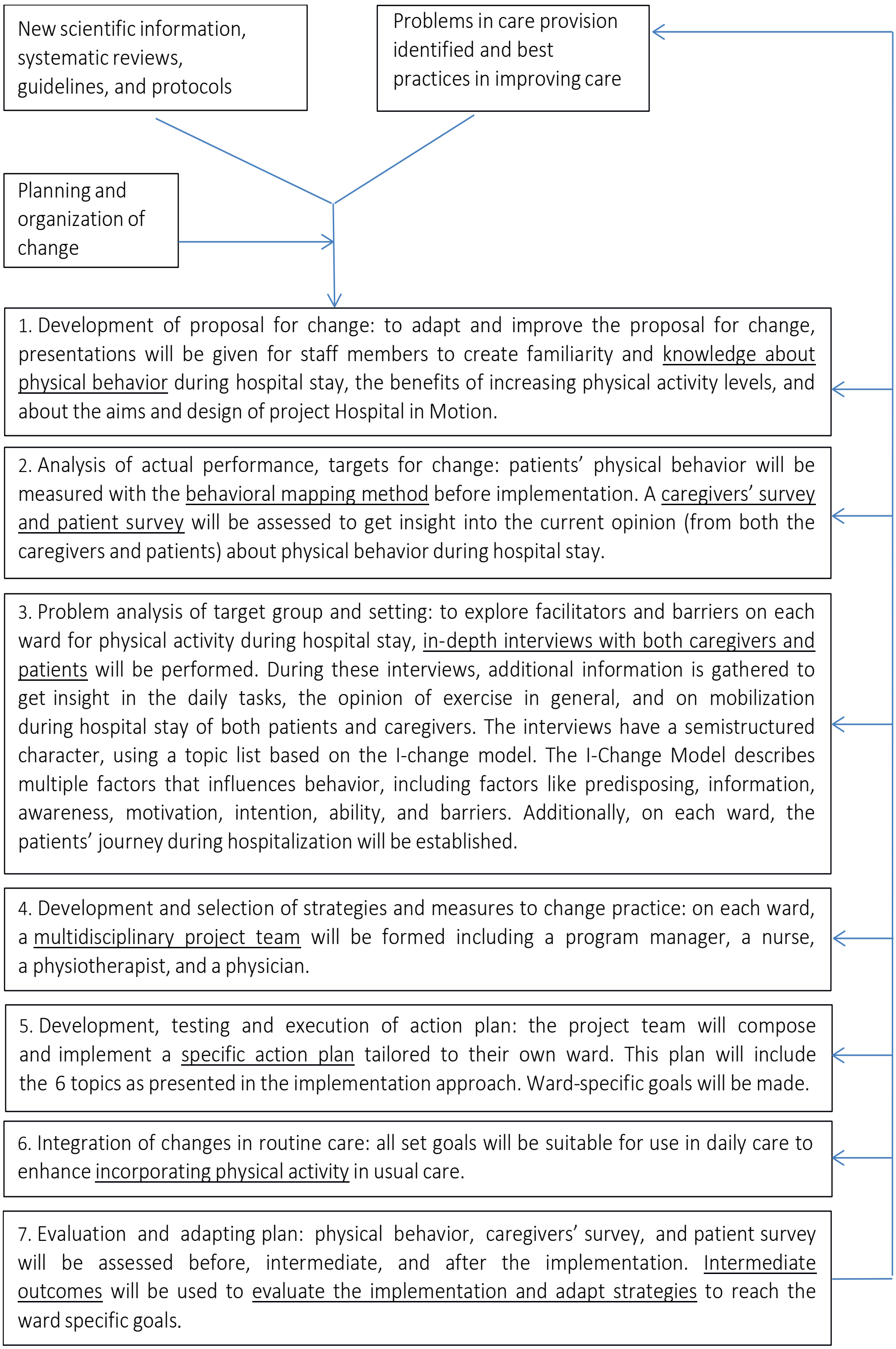


Figure 2. Implementation model based on the study by Wensing and Grol.

Sample Size Calculation

In this study, per ward 40 patients will be included per time point. This number is based on earlier studies evaluating physical behavior with the behavioral mapping method [39]. Patients will be included on 4 wards, leading to a total study population of 160 patients. To check if this number is adequate for powered effectiveness analyses, a sample size calculation was performed. For the sample size calculation, unpublished observation data from the UMC Utrecht in 2016 were used, in which 80 patients across the hospital were observed according to the behavioral mapping method. These data demonstrated that patients spent 56.01% of the time lying, with an SD of 32.53. On the basis of an earlier study evaluating the implementation of a multidimensional intervention to improve patients' physical behavior, a decrease of 15% in the time spent in bed is expected to be feasible [18]. According to the sample size calculation, including a power of 80% and a P value of .05, a sample size of 74 patients would be needed. This confirms that the proposed sample size of 160 patients is more than adequate to evaluate the effectiveness of Hospital in Motion.

Process Evaluation

Process evaluations are advised to monitor implementation processes of complex interventions and to evaluate factors of influence on the implementation. In this study, the framework of the medical research council guideline 2008 is followed to guide the process evaluation [40]. The 3 key functions of this framework include implementation, mechanisms of impact, and context. Implementation contains the goals and interventions that have been delivered by the project, including the adaptations, dose and reach, and how this delivery is achieved. The mechanisms of impact include the response (of caregivers and patients) to the interventions, the mediators, and all unexpected pathways and consequences. Context includes all other factors that may affect the implementation, interventions, and outcomes, such as barriers (eg, openness to changes, motivation, workload, and money) and facilitators [40]. For the process evaluation of the Hospital in Motion study on the different wards, a caregivers' survey, a patient survey, and semistructured interviews with patients and caregivers are developed, which contain items of the 3 key functions of a process evaluation. The caregivers' survey and the patient survey will be conducted before and after the implementation period. The semistructured interviews will be conducted at the end of the implementation period (Figure 3).

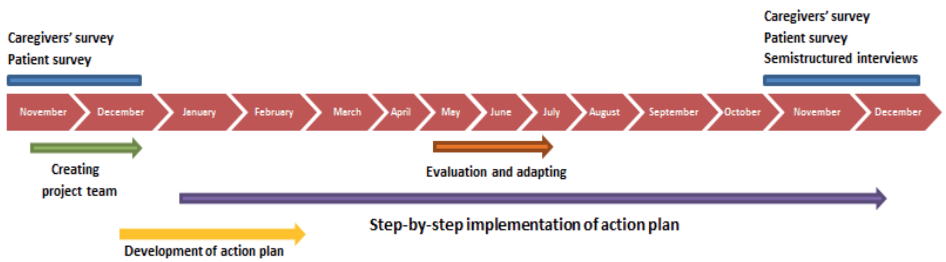


Figure 3. Time line of process evaluation.

For the caregivers' survey, questions are formulated focusing on the willingness to change and motivation of the caregivers to help improve patients' physical behavior. In addition, questions are included to investigate the current state of the 6 topics of the action plan. The scoring of the questions is based on the visual analog scale; a score between 0% and 100% agreement can be given per question. The survey will be sent to all caregivers of the included wards before and after the implementation period.

For the patient survey, the level of encouragement patients perceived from care providers and the environment to be physically active in the past 2 days will be investigated using 6 statements with a 5-point scale. This patient survey will be performed before and after the implementation period. After the implementation, the survey will be supplemented with questions to investigate the success of the implementation of the action plans per ward.

Semistructured interviews with patients and caregivers: After the implementation, semistructured interviews with both patients and caregivers will be undertaken. The interviews will be guided with a topic list based on the 3 key functions of process evaluation as described before [40].

Statistical Analysis

All statistical analyses will be conducted using IBM SPSS statistics software 25. All outcome variables will be tested on normality with the Kolmogorov-Smirnov test. Patients' characteristics will be described using descriptive statistics and tested with the Chi-square test, Mann Whitney test, or independent samples t test. Physical behavior is defined as the percentages of the total observed time that a patient spent lying, sitting, and moving. For both the primary outcome (the percentage of time spent lying) and the secondary outcomes (percentage of time sitting and moving), the changes in percentages after implementation will be analyzed. In addition, between-group analyses will be performed per ward. The differences between pre- and postmeasurements will be analyzed with an analysis of covariance, whereby the covariate(s) include baseline variables that may differ between pre- and postmeasurements. If data are not normally distributed, log transformation will be executed before testing.

The process evaluation will be based on the caregivers' survey, patient survey, and semistructured interviews. Categorical data will be analyzed using Chi-square test and continuous data by using the Mann Whitney test or independent sample *t* test. To correct for multiple testing, a post hoc multiple comparison test will be performed. The semistructured interviews will be audio recorded and transcribed. Data analysis will follow 3 steps: coding, categorizing, and selecting themes, which will be performed in NVivo 11.

RESULTS

This study is ongoing. The first participant was enrolled in October 2017 for the premeasurement. The postmeasurements are planned for the end of 2018. The first results are expected to be submitted for publication in autumn 2019.

DISCUSSION

Despite the evidence about the negative consequences of low levels of physical activity, patients still spend most of the day in bed, leading to unnecessary functional decline and new disabilities in ADL [2,3]. Previous studies demonstrated that increased amounts of physical activity during hospitalization may prevent this functional decline [41]. Furthermore, 3 recent studies reported the results of the implementation of a single intervention to improve physical mobility during hospital stays [9,20,42]. The first study implemented a mobility scale and demonstrated an improved level of physical functioning on a general medicine unit [9]. The second study implemented an enforced mobilization protocol in patients following gastrointestinal cancer surgery and found a reduced number of postoperative pulmonary complications [20]. The third study is a large-scale study in which the implementation of specific mobilization goals (mobilization within 24 hours, mobilization 3 times a day, and progressive and scaled mobility) showed a 10% increase in the frequency of mobilization out of bed [42]. However, to integrate physical activity in usual care, multidimensional approaches with multiple interventions focusing on the whole system are suggested to be more successful [16]. The Eat Walk Engage program of Mudge et al is a good example of a multidimensional approach using multiple interventions, which demonstrated a reduced LOS after the implementation [19]. However, it still remains unclear if physical activity is a modifiable factor during hospital stay.

The Hospital in Motion study has the strength that it contains multiple interventions tailored per ward, developed by a multidisciplinary project team. In addition, it is one of the first known large projects using a multidimensional approach, focusing on the physical environment, caregivers, and patients, instead of only 1 element, to improve physical behavior during hospitalization. Another strength of the Hospital in Motion study is the primary outcome of physical activity. As previous studies mostly included medical outcomes (eg, LOS, remissions, and mortality), levels of physical functioning or frequency of mobilization and the actual amount and change of physical activity have not been evaluated [9,19,20,42]. To get more information about patients' physical behavior, it is important to assess and evaluate the physical activity levels of patients during hospitalization. For this purpose, the behavioral mapping method is used. This method provides insight into the actual activity level of patients during an average hospital day and also assesses environmental factors such as the people in direct contact with the patient and the patients' daily activity. This enables detailed evaluation of inpatient physical behavior and differences per ward.

Diverse factors could influence the success of the implementation of Hospital in Motion. The action plan is a multidimensional package of interventions aimed to improve physical behavior. It contains multiple interventions aimed to incorporate physical activity in usual care procedures, targeting the whole care system. This strength is a challenge at the same time. Many factors may affect the implementation process, such as the functioning of the project team, caregivers' motivation and willingness to change, available time, and perceived workload. The appropriate study design has been discussed extensively within the research team because of the possible influence of confounding factors. As this study primarily aims to integrate physical activity in daily hospital care, more classic research designs (ie, RCT) are less suitable. By following a step-by-step implementation process and by performing a process evaluation, the authors will provide useful insights into the changes in usual care and the successful and unsuccessful elements of the implementation process.

REFERENCES

1. CBS StateLine. http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71859NED&D1=0&D2=a&D3=0-21&D4=0&D5=l&HDR=G2&STB=G3,G1,T,G4&VW=T. Accessed 06 June 2014.
2. Brown CJ, Redden DT, Flood KL, Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc. 2009;57(9):1660-5.
3. Pedersen MM, Bodilsen AC, Petersen J, Beyer N, Andersen O, Lawson-Smith L, et al. Twenty-four-hour mobility during acute hospitalization in older medical patients. J Gerontol A Biol Sci Med Sci. 2013;68(3):331-7.
4. Ostir GV, Berges IM, Kuo YF, Goodwin JS, Fisher SR, Guralnik JM. Mobility activity and its value as a prognostic indicator of survival in hospitalized older adults. J Am Geriatr Soc. 2013;61(4):551-7.
5. Ferrando AA LH, Stuart CA, et al. Prolonged bed rest decreases skeletal muscle and whole body protein synthesis. . Am J Physiol. 1996;270:627–33.
6. Cameron S BI, Cepinskas G, Choong K, Doherty TJ, Ellis CG, Martin CM, Mele TS, Sharpe M, Shoemaker JK, Fraser DD. Early mobilization in the critical care unit: A review of adult and pediatric literature. Journal of Critical Care. 2015;30(4):664-72.
7. Knight J NY, Jones A. Effects of bedrest 1: cardiovascular, respiratory and haematological systems. Nurs Times. 2009;105(21):16-20.
8. Knight J NY, Jones A. Effects of bedrest 2: gastrointestinal, endocrine, renal, reproductive and nervous systems. Nurs Times. 2009;105(22):24-7.
9. Knight J NY, Jones A. Effects of bedrest 3: musculoskeletal and immune systems, skin and self-perception. Nurs Times. 2009;105(23):18-22.
10. Adler J MD. Early Mobilization in the Intensive Care Unit: A Systematic Review. . Cardiopulmonary Physical Therapy Journal. 2012;23(1):5-13.
11. Hoyer EH, Friedman M, Lavezza A, Wagner-Kosmakos K, Lewis-Cherry R, Skolnik JL, et al. Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. J Hosp Med. 2016;11(5):341-7.
12. Villumsen M JM, Andreasen J, Rathleff MS, Mølgaard CM. Very Low Levels of Physical Activity in Older Patients During Hospitalization at an Acute Geriatric Ward: A Prospective Cohort Study. Journal of Aging and Physical Activity. 2015;23(4):542-9.
13. Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. J Am Geriatr Soc. 2015;63(1):55-62.
14. Brown CJ FR, Inouye SK. Prevalence and outcomes of low mobility in hospitalized older patients. Journal of the American Geriatrics Society. 2004;52(8):1263-70.
15. Covinsky KE PE, Johnston CB. Hospitalization-associated disability: "She was probably able to ambulate, but I'm not sure". JAMA. 2011;306(16):1782-93.
16. Maayan AZ, Gil E, Rand D, Gur-Yaish N, Azriel M. Association Between 900 Steps a Day and Functional Decline in Older Hospitalized Patients. JAMA Intern Med. 2917;177(2):272–4.

17. Sourdet S, Lafont C, Rolland Y, Nourhashemi F, Andrieu S, Vellas B. Preventable Iatrogenic Disability in Elderly Patients During Hospitalization. J Am Med Dir Assoc. 2015;16(8):674-81.

18. Oliver D. David Oliver: Fighting pyjama paralysis in hospital wards. BMJ. 2017;357:2096.

19. Lafreniere S, Folch N, Dubois S, Bedard L, Ducharme F. Strategies Used by Older Patients to Prevent Functional Decline During Hospitalization. Clin Nurs Res. 2017;26(1):6-26.

20. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. J Hosp Med. 2007;2(5):305-13.

21. Kneafsey R, Clifford C, Greenfield S. What is the nursing team involvement in maintaining and promoting the mobility of older adults in hospital? A grounded theory study. Int J Nurs Stud. 2013;50(12):1617-

22. van de Port IG, Valkenet K, Schuurmans M, Visser-Meily JM. How to increase activity level in the acute phase after stroke. J Clin Nurs. 2012;21(23-24):3574-8.

23. Mudge AM, McRae P, Cruickshank M. Eat walk engage: an interdisciplinary collaborative model to improve care of hospitalized elders. Am J Med Qual. 2015;30(1):5-13.

24. van der Leeden M, Huijsmans R, Geleijn E, de Lange-de Klerk ES, Dekker J, Bonjer HJ, et al. Early enforced mobilisation following surgery for gastrointestinal cancer: feasibility and outcomes. Physiotherapy. 2016;102(1):103-10.

25. Prior M, Guerin M, Grimmer-Somers K. The effectiveness of clinical guideline implementation strategies a synthesis of systematic review findings. J Eval Clin Pract. 2008;14(5):888-97.

26. Grol R, Wensink W. Implementatie - effectieve verbetering van patientenzorg. 6th ed. Springer Media B.V.; 2006.

27. Scott A. Managing anxiety in ICU patients: the role of pre-operative information provision. Nursing in Critical Care. 2004;9:2.

28. Buttery AK, Martin FC. Knowledge, attitudes and intentions about participation in physical activity of older post-acute hospital inpatients. Physiotherapy. 2009;95(3):192-8.

29. Oyeyemi AY, Usman RB, Oyeyemi AL. A survey of disposition of physicians towards physical activity promotion at two tertiary hospitals in north-eastern Nigeria Ann Ibd Pg Med. 2016;14, (No.2):74-80.

30. Prakash V, Shah MA, Hariohm K. Family's presence associated with increased physical activity in patients with acute stroke: an observational study. Brazilian Journal of Physical Therapy. 2016;20(4):306-11.

31. Steunenberg B, van der Mast R, Strijbos MJ, Inouye SK, Schuurmans MJ. How trained volunteers can improve the quality of hospital care for older patients. A qualitative evaluation within the Hospital Elder Life Program (HELP). Geriatr Nurs. 2016;37(6):458-63.

32. Kahn PEB, Ramsey LT, Brownson RC, Heath GW, Howze EHS, Powell KE, Stone EJ, Rajab MW, Corso P. The effectiveness of interventions to increase physical activity A Systematic Review. Am J Prev Med. 2002;22:73–107.

33. Huisman ERCM, Morales E, van Hoof J, Kort HSM. Healing environment: A review of the impact of physical environmental factors on users. Building and Environment. 2012;58:70-80.

34. Janssen H, Bernhardt J, Collier JM, Sena ES, McElduff P, Attia J, et al. An enriched environment improves sensorimotor function post-ischemic stroke. Neurorehabil Neural Repair. 2010;24(9):802-13.

35. Hoyer E, Friedman M. Johns Hopkins Highest Level of Mobility (JH-HLM) Scale.

https://www.hopkinsmedicine.org/pulmonary/research/outcomes_after_critical_illness_surgery/ExcelFiles/Highest%20Level%20of%20Mobility%20doc%207_3_2014%20FINAL-dmn2.pdf Accessed 3 July 2014.

36. Comstock J. 21 clinical trials that are using Fitbit activity trackers right now 2016. http://www.mobihealthnews.com/content/21-clinical-trials-are-using-fitbit-activity-trackers-right-now. Accessed 16 March 2016.

37. Bernhardt J, Dewey H, Thrift A, Donnan G. Inactive and alone: physical activity within the first 14 days of acute stroke unit care. Stroke. 2004;35(4):1005-9.

38. Bernhardt J. Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial. The Lancet. 2015;386(9988):46-55.

39. Craig LE BJ, Langhorne P, Wu O. Early Mobilization After Stroke. An Example of an Individual Patient Data Meta-Analysis of a Complex Intervention. Stroke. 2010;41(11):2632-6.

40. Bloem S, Stalpers J. Subjective experienced health as a driver of health care behavior. In: Nyenrode research paper series. 2012. http://repository.nyenrode.nl/search?identifier=11552. Accessed July 2012.

41. Stalpers J. Psychological determinants of subjective health: In: PhD dissertation Nyenrode Business Universiteit. 2009. http://repository.nyenrode.nl/search?identifier=8552. Accessed 23 October 2009.

42. Diane U. Jette MS, Vinoth K. Ranganathan, Sandra D. Passek,, Frederick S. Frost AMJ. Validity of the AM-PAC 6-clicks inpatients daily activity and basic mobility short forms. Phys Ther. 2014:379–91.

43. Peolsson A, Hedlund, R and Oberg, B. Intra- and inter-tester reliability and reference values for hand strength. J Rehab Med 2001;33:36–41.

44. Macfarlane DJ, Chou KL, Cheng YH, Chi I. Validity and normative data for thirty-second chair stand test in elderly community-dwelling Hong Kong Chinese. Am J Hum Biol. 2006;18(3):418-21.

45. Yamada T. Effectiveness of Sit-to-stand Tests for Evaluating Physical Functioning and Fall Risk in Community-dwelling Elderly. Human Performance Measurement 2015;12:1-7.

46. Moore GF, Audrey S, Barker M, Bond L, Bonell C, Hardeman W, et al. Process evaluation of complex interventions: Medical Research Council guidance. BMJ. 2015;350:1258.

47. Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E, Admi H. Low mobility during hospitalization and functional decline in older adults. J Am Geriatr Soc. 2011;59(2):266-73.

48. Liu B MJ, Almaawiy U, Chan WH, Khan S, Ewusie J, Hamid JS, Straus SE; MOVE ON Collaboration. Outcomes of Mobilisation of Vulnerable Elders in Ontario (MOVE ON): a

multisite interrupted time series evaluation of an implementation intervention to increase patient mobilisation. Age Ageing. 2018;47(1):112-9.

49. de Vries H, Mudde A, Leijs I et al. The european smoking prevention framework approach (EFSA) an example of integral prevention. Health education research. 2003;18:5.

Chapter 3

The effectiveness of Hospital in Motion, a multidimensional implementation project to improve patients' movement behavior during hospitalization

Lotte M.M. van Delft
Petra Bor
Karin Valkenet
Arjen J.C. Slooter
Cindy Veenhof

Published in Physical Therapy 2020

ABSTRACT

Background: Hospital in Motion is a multidimensional implementation project aiming to improve movement behavior during hospitalization.

Objective: To investigate the effectiveness of Hospital in Motion on movement behavior.

Design: Prospective, pre-post design.

Methods: Hospital in Motion was conducted at four wards of an Academic Hospital in the Netherlands. Per ward, multidisciplinary teams followed a ten month step-by-step approach including the development and implementation of an ward-specific action plan with multiple interventions to improve movement behavior. Inpatients movement behavior was assessed before the start of the project and one year later, using the behavioral mapping method, where patients were observed between 9AM and 4PM. The primary outcome was the percentage of time spent lying. In addition, sitting and moving, immobility-related complications, length of stay, discharge destination home, discharge destination rehabilitation setting, mortality and 30-days readmissions were investigated. Differences between before and after implementation were analyzed using the chi-square test for dichotomized variables, the Mann Whitney test for non-normal distributed data, or independent samples t-test for normally distributed data.

Results: Patient-observations demonstrated that the primary outcome, the time spent lying, changed from 60.1% to 52.2% (p=0.01). Concerning the secondary outcomes, the time sitting increased from 31.6% to 38.3% (p=0.01) and discharges to a rehabilitation setting reduced from 6 (4.4%) to 1 (0.7%) (p=0.04). No statistical differences were found in the other secondary outcome measures.

Conclusion: The implementation of the multidimensional project Hospital in Motion was associated with improved movement behavior.

INTRODUCTION

Although there is extensive literature describing the detrimental effects of immobility , bedrest and inactivity is still deeply rooted in the hospital culture [1]; hospitalized patients spend 49% to 98% of their time in bed [2-6]. Immobility during hospital-stay is associated with complications like pneumonia, urinary-tract infection, deep venous thrombosis and pressure ulcers, which can result in prolonged hospital stays, more readmissions, higher mortality and increased hospital costs [7-9]. In addition, lower levels of physical activity leads to functional decline and new disabilities in activities of daily living after discharge [10-13]. This functional decline is labelled as hospitalization-associated disability, and lead to long-term care in nursing homes, readmissions or even death [12, 14].

Promoting inpatient mobilization can be challenging since the traditional hospital culture seems to discourage patients to be physically active [15-17]. Care is usually organized around the inactivating hospital bed, with food and drinks supplied within reach. In addition, patients often feel dependent on health care providers (HCPs) for instructions and manual support in mobilizing, even when they are able to move independently. This feeling of dependency on HCPs might be a result of nurses automatically supporting patients in washing, clothing, and eating [17]. All together this has resulted in a culture where many patients are spending most of the time in bed. Recent studies targeting inactivity during hospitalization demonstrated that mobilization and physical activity is a modifiable factor that can prevent in-hospital functional decline [2, 18, 19]. Most of these studies investigated the effect of single interventions on patients' physical function or medical outcomes, instead of on movement behavior itself, which is a crucial first step in the pathway towards improving patient outcomes. The evaluation of movement behavior is important to provide useful information about the successful and unsuccessful elements of interventions.

However, sedentary behavior is deeply rooted in the hospital culture. To overcome this culture and create more sustainable changes, there is a need for effective interventions that integrate physical activity in usual tailored care [17, 20-23]. Multi-component interventions are preferred above single interventions as they have proven to be more effective [24]. Additionally, in line with the social ecological model, multidimensional interventions focusing on the patients, on HCPs and on the built environment, may be more effective [20, 21, 24, 25]. Programs or studies aiming to improve movement behavior focusing on the whole system, by implementing multidisciplinary and multi-component interventions tailored to local context, are still rare. Existing multi-component studies mainly focused on elderly [21-23], or focused only on HCPs [23]. Since our aim is to implement physical activity throughout the hospital within current daily care procedures, Hospital in Motion, a multidimensional and multidisciplinary implementation project was developed. The purpose of this study was to investigate the effectiveness of the Hospital in Motion project on inpatients movement behavior. Furthermore, we assessed the effectiveness on length of hospital stay, discharge destination home, discharge destination rehabilitation setting, 30-days readmission, mortality and immobility-related complications of patients during hospitalization.

METHODS

Study design

A pre-post design was used to evaluate the effectiveness of Hospital in Motion. The project started in January 2018 and ended 10 months later (November 2018). Baseline measurements were performed two months before the start of the project, and the post-implementation measurement one year later, in November and December 2018. For more detailed information about the design and timeline we refer to our published study protocol [26].

Setting

This study was conducted within four participating wards of the University Medical Center Utrecht, the Netherlands; Cardiology, Cardiothoracic Surgery, Medical Oncology, and Hematology. The study protocol was assessed and approved by the local Medical Ethics Committee (study protocol number 16-250). Verbal informed consent was obtained from all included patients.

Study population

Patients admitted to one of the four participating wards were eligible to be included for the evaluation of Hospital in Motion. Exclusion criteria were cognitive impairments like delirium (defined as an acute disorder of attention and cognition, estimated by the medical and nursing staff) and language restrictions making a patient unable to provide informed consent. In addition, patients receiving terminal care were excluded. The day before the observations PB, LvD or KV discussed with the coordinating nurse of the ward which of the admitted patients were eligible to participate. Eligible patients were asked in random order and inclusion stopped when 8 patients wanted to participate, or when no more eligible patients were available [26].

Hospital in Motion

Hospital in Motion is a multidisciplinary and multidimensional implementation project designed to improve patients movement behavior during hospitalization. Per ward a multidisciplinary project team was formed, including a project manager (LvD or PB, both PhD student and physical therapist), a unit-manager, physical therapist(s), nurse(s) and physician(s). The Implementation of Change Model, developed by Grol and Wensing, was followed [27]. This model is developed especially for the implementation of change in clinical practices and contains seven steps. Steps one to three include the development of proposal for change, analysis of actual performance and problem analysis. During these steps, on each ward the opinion of patients about perceived promotion to be physically active was assessed using short statements, surveys were performed among HCPs and in depth interviews per performed with HCPs and patients. Furthermore, the baseline measurement of the movement behavior of patients was performed. Step four of the model includes the selection of strategies and measures to change practice, and step five focusses on the development, testing and execution of the implementation plan. During step four and five, each project team identified multiple interventions to be implemented to stimulate inpatient physical activity in usual care and developed an action plan with this interventions for their ward. Interventions were focusing on three levels of the social ecological model, a conceptual framework depicting spheres of influence over human behavior, namely individual, interpersonal and organizational [25]. In 2016 and 2017, a pilot study was performed on the geriatric department. Preliminary results and gained experiences during this pilot formed the six topics for the action plan, focusing on patients, HCPs and environment: education of staff and patients, physical activity as part of daily usual care, involvement of third parties such as family members or volunteers, creation of a stimulating environment and mobilization milestones and technology support. Step six and seven contain the integration of changes in routine care, and the evaluation of the implementation plan. In these steps the patient statements and the survey among HCPs were repeated. Furthermore, the follow-up measurement of the movement behavior of patients was performed and in depth interviews were performed with HCPs from within and outside the project team. For more detailed information about the interventions and the followed approach see Appendices 1 and 2, and our published study protocol [26].

Patient involvement

In this study patients were involved in the development and implementation of the interventions (action plan). Before the start of the project patients' opinions were investigated using semi-structured interviews. At the end of the implementation period, patients were interviewed for the process evaluation [26].

Outcome evaluation

Patient characteristics

Demographic and clinical characteristics including the use of a walking aid (i.e. rollator, walker, crutches, or stick) and urine catheter were recorded. In addition, physical functioning was assessed using the Activity Measure for Post-Acute Care Basic Mobility "6-Clicks" (AM-PAC) and by measuring handgrip strength. The AM-PAC includes six items: turning over in bed, sitting down on and standing up from a chair with arms, moving from lying on the back to sitting on the side of the bed, moving to and from a bed to a chair, walking in a hospital room and climbing 3-5 steps with a railing. All activities were scored on a scale of 1 (unable to do/total assistance required) to 4 (no assistance required). The sum of the scores ranges from 6 (indicating total assistance or 'cannot do at all') to 24 (indicating completely independent functioning). The AM-PAC demonstrated to be reliable and valid for assessing patients' basic mobility in acute care settings [28, 29]. Handgrip strength was measured to get insight into the overall muscle strength and level of physical function. Handgrip strength was measured with the Jamar hydraulic hand dynamometer, which is an easily accessible tool with excellent psychometric characteristics [30, 31].

Movement behavior

Movement behavior was assessed two months before and after implementation, using the behavioral mapping method [26, 32, 33]. Behavioral mapping is a structured method where participants are intermittently observed at set intervals. It has a good to excellent inter-rater reliability and analyses showed that the level of agreement with accelerometers was strong for identifying physical activity [2, 31, 32]. For this study, a maximum of 8 patients per ward per day were observed on a random weekday. The observations took place from 9 am until 4 pm, in a fixed order every 10 minutes, during 1 minute. During this minute, the patients' location, body position, daily activity, and direct contact was noted. Patients could be included in the observations more than once during the same hospital admission because the observations are a reflection of the patient population at that moment. For this study movement behavior was defined as the percentage of the total observed time that a patient spent in a specific body position. A distinction was made between lying (in bed), sitting (bedside or chair), and moving (standing, transferring, walking, and cycling) [26, 33]. The percentage of time spent lying in bed was studied as primary outcome. Sitting and moving were included as secondary outcomes [26]. The physical function measurements (AM-PAC and handgrip strength) and the observations (behavioral mapping) were performed following a strict protocol by trained physiotherapy students who were not involved during the implementation phase.

Medical outcomes

Furthermore, length of stay (LOS), discharge destination home, discharge destination rehabilitation setting, mortality, 30-day readmission rate and the incidence of immobility-related complications (i.e. pneumonia, pulmonary embolism, deep-venous thrombosis, urinary tract infection, and pressure sores [34]) were included as secondary outcomes. Data on these outcomes were retrospectively retrieved from the electronic patient files by data managers and a trained independent research assistant of the patients who were included for the observations.

Sample size and data analyses

The calculation of the required sample size was based on a statistical power of 80%, a P value of .05, and an decrease of 15% of the time lying in bed [2, 26]. This calculation gave a sample size of at least 74 patient-observations for both the baseline period and the post-implementation period [26]. All continuous variables were tested for normality with the Kolmogorov-Smirnov test. Patient characteristics were described using descriptive statistics and tested with the Chi-square test, Mann Whitney test or independent samples t test, where appropriate. For the movement behavior data, first, the time spent per category of movement behavior (i.e. lying, sitting and moving) was calculated per participant. Second, the percentage of observed time in a specific category was calculated per participant. Subsequently, for both periods (baseline and post-implementation), the mean percentages of observed time per category of movement behavior were calculated. Differences in movement behavior and medical outcomes between the two periods were tested using the Chi-square test, Mann Whitney test or the independent samples t test, where appropriate. In addition to overall analyses, we stratified per ward [26]. Statistical analyses were conducted using IBM SPSS statistics software 25.

RESULTS

A total of 171 patient-observations on 138 patients were performed during the baseline period. After the implementation period, 163 patient-observations on 150 patients were performed. Characteristics of the total study population are presented in table 1. The majority of the participants were male, with a mean age of 59.5 years (16.1SD). Around 80% of the patients were able to transfer to chair and walk without assistance. There were no significant differences observed in the characteristics of the population before and after implementation ($p>0.05$). Baseline characteristics and context per ward are demonstrated in table 2.

Throughout the implementation period diverse interventions were developed. In total 15 interventions were implemented within the actions plans. See Table 3 for an overview of the final delivered interventions per ward. A detailed description of these interventions can be found in Appendix 2.

Table 1. Characteristics of observed patients

	Baseline	Post-implementation	P-value
Age (years); mean (SD)	60.6 (15.8)	58.3 (16.3)	0.356
Male; N (%)	109 (63.7)	114 (69.9)	0.230
Surgery; N (%)	59 (35.5)	51 (31.5)	0.436
Physical Functioning (AM-PAC 6-click BM); mean (SD)	22.2 (4.1)	22.4 (3.1)	0.245
- Mobilizing independently in room; N (%)**	143 (83.6)	127 (77.9)	0.185
Handgrip strength (kg); mean (SD)	28.5 (12.1)	30.1 (12.5)	0.280
Mobilizing without walking aid; N (%)	130 (76.9)	134 (82.7)	0.394
Urinary Catheter; N (%)	8 (4.7)	7 (4.5)	0.915

* significant p<0.05 ** AMPAC-BM 1 to 5 without assistance required

During the baseline period, patients were lying in bed 60.1% (28.9SD) of the time between 9 AM and 4 PM. This percentage decreased after implementation to 52.2% (28.6SD) (p=0.010). The percentage sitting increased from 31.6% (25.5SD) to 38.3% (25.3SD) (p=0.012). The percentage moving did not significantly improve after implementation, it changed from 8.3% (7.8SD) to 9.6% (7.9SD) (p=0.308). See table 4.

Analyses per ward show comparable changes in percentages lying, sitting and moving after implementation (see table 5). The time moving increased most on the cardiothoracic surgery ward from 8.2% to 12.7% of the day (p=0.019), which is in contrast to the medical oncology ward, where the percentage moving decreased from 8.4% to 5.4% (p=0.022).

Concerning the medical outcomes, the number patients who were discharged to a rehabilitation center significantly decreased from 6 (4.4%) to 1 (0.7%) (p=0.044). No statistical differences were found in the other secondary outcome measures (see table 6).

Table 2. Characteristics and baseline context per ward

	Cardiology	**Cardiothoracic surgery**	**Medical Oncology**	**Hematology**
Population	Medical	Surgical	Medical	Medical
Number of admission places	32	22	14	20
Baseline characteristics of included patients	N=41	N=45	N=42	N=43
➢ Length of Stay; mean (SD)	14 (14)	15 (15)	8 (6)	32 (24)
➢ Age; mean (SD)	64 (16)	60 (16)	60 (16)	58 (15)
➢ AMPAC score; mean (SD)	23 (2)	22 (4)	21 (6)	23 (3)
➢ Mobilizing independently in room;%*	88%	82%	79%	93%
Baseline statements patients **	N=40	N=41	N=36	N=42
➢ I find the environment stimulating *(% agrees or strongly agrees)*	30%	44%	33%	21%
➢ I received information about the importance of mobilization and physical activity during hospitalization *(% agrees or strongly agrees)*	60%	66%	50%	74%
➢ The nurse stimulated me to be physically activity *(% agrees or strongly agrees)*	50%	76%	61%	67%
Baseline surveys HCPs (nurses & physicians)	N=28	N=24	N=13	N=20
➢ In what percentage of the new admissions do you provide information about the importance of physical activity during hospitalization to your patients?	39%	75%	55%	56%
➢ Mobilization of my patients is high on my priority list, also during busy days. *(rank from 0 to 10)*	4	7	6	6
➢ I am willing to actively involve myself in promoting mobilization and physical activity of patients. *(rank from 0 to 10)*	7	8	8	7
Project team	Project manager (LvD) Nurses (n=2) Physical therapist Cardiologist Unit manager	Project manager (LvD) Nurses (n=2) Physical therapist Unit manager	Project manager (PB) Nurses (n=2) Physical therapist Unit manager	Project manager (PB) Nurses (n=2) Physical therapist Unit manager

* AMPAC-BM 1 to 5 without assistance required ** Based on a 5-poin Likert scale from totally not agree to totally agree

Table 3. Overview of implemented interventions per ward, displayed per topic of the action plan

Intervention	Cardiology	Cardiothoracic surgery	Medical Oncology	Hematology
Education:				
- Patient information brochure	X	X	X	X
- Patient information poster	X	X	X	
- Education to staff	X	X	X	X
- Pre-admission information		X		X
Physical activity as part of usual care:				
- Joint lunch for patients (in living room)	X	X	X	X
- Eating out of bed	X	X	X	X
- Exercise guides & 7 minutes workout videos with exercises (lying, sitting and standing)	X		X	X
Stimulating environment:				
- Improving the patient living room	X	X		
- Exercise material and walking aids available	X	X		
- QR-code walking route	X	X	X	X
- Department map with all facilities	X	X	X	X
Involving third parties:				
- Stimulating visitors to go walking or do the exercises from the guides with the patient			X	X
- Mobility icons	X			
Mobilization milestones & technology:				
- Daily activity schedule per patient		X		
- Highest level of mobility card per patient			X	

Table 4. Differences in movement behavior pre and post-implementation

	Baseline (N=171)	P-value
Percentage lying; mean (SD)	60.1 (28.9)	0.010*
Percentage sitting; mean (SD)	31.6 (25.5)	0.012*
Percentage moving; mean (SD)	8.3 (7.8)	0.308

* significant p<0.05

Table 5. Differences in movement behavior per ward

	Baseline	Post-implementation	Δ	P-value
Cardiology; mean (SD)	N=41	N=39		
- Percentage lying	51.0 (29.6)	41.6 (24.1)	9	0.136
- Percentage sitting	38.9 (24.8)	45.9 (20.8)	7	0.146
- Percentage moving	10.2 (9.8)	12.4 (10.1)	2	0.335
Cardiothoracic surgery; mean (SD)	N=45	N=40		
- Percentage lying	54.5 (29.7)	46.7 (21.2)	8	0.208
- Percentage sitting	37.3 (26.4)	40.7 (18.9)	3	0.484
- Percentage moving	8.2 (7.8)	12.7 (9.2)	5	0.019*
Medical oncology; mean (SD)	N=42	N=43		
- Percentage lying	69.3 (24.8)	62.0 (30.2)	7	0.349
- Percentage sitting	22.3 (21.0)	32.6 (28.1)	10	0.096
- Percentage moving	8.4 (7.0)	5.4 (6.8)	-3	0.022*
Hematology; mean (SD)	N=43	N=41		
- Percentage lying	65.5 (28.1)	57.2 (33.1)	9	0.336
- Percentage sitting	27.9 (26.6)	34.7 (29.7)	7	0.418
- Percentage moving	6.6 (6.3)	8.1 (6.7)	2	0.268

* significant $p<0.05$

Table 6. Differences in medical outcomes before and after Hospital in Motion

	Baseline (N=136)	Post-implementation (N=146)	P-value
Patients with one or more immobility related complication(s) total; N (%)	24 (17.6)	16 (11.0)	0.108
Length of stay, in days; mean (SD)	16.9 (17.6)	15.8 (13.6)	0.727
Mortality during hospital stay; N(%)	4 (3.0)	1 (0.7)	0.149
Discharged to rehabilitation setting; N(%)	6 (4.4)	1 (0.7)	0.043*
Discharged home; N (%)	108 (80.0)	126 (86.3)	0.157
Readmission within 30 days; N (%)	21 (15.6)	20 (13.7)	0.660

* significant p<0.05

3

DISCUSSION

In summary, the multidimensional and multidisciplinary Hospital in Motion project was associated with an overall decline in the time spent lying in bed (-7.9%). Additionally, the time spent sitting up (+6.7%) increased and the amount of patients' discharged to a rehabilitation center decreased.

An important strength of the Hospital in Motion study is the use of a ward-specific, multidisciplinary and multidimensional approach [26]. Since patient populations and daily care processes can differ greatly per ward, implementation projects need to be the tailored per ward to fulfil specific requirements. Changing the culture regarding physical activity requires fundamental changes to current thinking and practice to patient mobility within the whole organization, including all disciplines [20]. Therefore, the project teams were multidisciplinary including physical therapists, nurses, physicians and unit-managers. Single initiatives might not be enough to ensure success for change in behavior or for creating sustainable and continual improvement of processes [20, 21]. Integrating physical activity in usual care by multidimensional approaches including interventions aiming at several social ecological levels are more likely to be successful [17, 21, 25]. Another strength of this study is the primary outcome of movement behavior, measured with the behavioral mapping method, as improving movement behavior is the crucial step in the pathway towards improving patient outcomes. This provided insight into the actual physical activity level of patients as well as insight into the context in which the physical activity or bedrest takes place. This enables detailed evaluation of movement behavior and provides insight in ward-specific opportunities to develop targeted interventions [26]. A limitation of this study is the pre-post design to evaluate the action plan, whereby external factors that may have influenced the outcomes of Hospital in Motion could not be ruled out. In addition, this study investigated the effect of implementing an action plan with multiple interventions, resulting that only statements can be made about the impact of the entire action plan and not the individual interventions. A limitation concerning the behavior mapping method is the fact that the behavior of patients or HCPs may have been influenced by the observers' presence during the day. However, a recent study show a high level of agreement between the behavioral mapping method and an accelerometer [33].

Studies improving movement behavior in usual care, by implementing multidisciplinary and multi-component interventions tailored to local context, are still rare. To our knowledge one previous study investigated the effect of multi- component interventions on movement behavior itself [2]. Van de Port et. al, investigated the implementation of multi-component interventions at a neurology department to increase physical activity of stroke patients and also used the behavioral mapping method. After implementing a daily therapy group, a brochure with exercises and HCPs education, patients spent less time lying (-20%)[2]. Additionally, three previous studies implemented multi-component interventions to promote physical activity and found positive results on physical and medical outcomes [21-23]. Their implementation models are comparable with the Implementation of Change Model used in this study [27]. However, these programs focused mainly on elderly, whereas low mobility during hospitalization is of all ages. In addition, Liu et al. implemented interventions only focusing on HCPs [23]. The study of Mudge et al. contained interventions using newly contracted and paid staff, instead of changing current usual care, which was one of our main aims for creating sustainable and continual improvement [22]. In addition to the diverse approaches used, it is not possible to compare their effect sizes with our study due to the differences in outcome measures.

Before the start of the project the mean percentage of lying in bed was 60%, which is consistent with previous observational studies reporting percentages of lying in bed between 49% to 70% of the daytime [2, 3, 6]. After the implementation the percentage of lying was reduced to 52%, and the time sitting increased from 32% to 38%, which means patients on average spent 33 minutes more out of bed between 9 AM and 4 PM. The percentage moving did not increase significantly. Based on these results, it cannot be stated that patients moved from sedentary (<1.5 METs) to physical active (>1.5 METs) [35]. However, it is also clinically relevant to decrease the time spent lying in bed as research shows that this can decrease complications [36-38]. Currently, no data is known about how much change of time spent in bed is clinically relevant. However, we did not achieve the 15% reduction of time lying in bed which we aimed for a priori as we found a decrease of 8% in time lying in bed. Although, the clinical relevance of this decrease is unclear, these results may be a promising first step in changing the hospital culture regarding movement behavior.

The decreases in time spent lying are comparable at the four included wards (range 7.3% - 9.4%). Remarkably, the time spent moving only increased at the cardiothoracic surgery ward, from 8.2% to 12.7%. This was the only surgical ward included in this study and majority of admissions was elective. One of the interventions characteristic for this ward was that information was sent home to all patients about the importance of and schedule for mobilization after the operation before their admission. Therefore, patients might have been prepared better at getting physically active during their hospital stay. The highest percentage of lying in bed is found at the medical oncology ward (before and after the project), and the time spent moving decreased at this ward after implementation. Reasons for this are unclear.

We have chosen to identify six topics a priori in which interventions could be created by the project teams. Although the aim of Hospital in Motion was to form tailored action plans per ward, the final four action plans included very similar interventions, which might have been the result of the predefined topics. However, the final interventions might not be equally implemented and effective at all four wards. Most interventions within the action plans primarily focused on emphasizing the importance of getting out of bed instead of getting physically active more. This might explain our finding that patients did not move more after the implementation, but mostly exchanges time lying for time sitting up. To provide more insight into the reach, adaptations and impact of the implemented interventions within the action plans, the successful and unsuccessful elements of the implementation approach of Hospital in Motion and the maintenance in daily care, a process evaluation is crucial. Therefore, a detailed process evaluation was performed per ward alongside the effectiveness measurements, following the Medical Research Council (MRC) guidance of Moore et al. 2015 [26, 39]. Aspects like the reach and adoption per intervention, and barriers and facilitators during the implementation were evaluated. The results of the process evaluation will be reported in two separate studies. These results will hopefully help others to develop and implement effective interventions to improve inpatient physical activity. Since this is one of the first studies showing the results of multi-component interventions on movement behavior on different wards of a hospital, more studies are needed investigating interventions designed to change movement behavior during hospitalization. We recommend that future studies investigate interventions that specifically focus on improving time spent moving by patients, in addition to decreasing time spend lying and sitting.

CLINICAL MESSAGES

- The time spent lying by patients can be decreased by implementing a multidimensional action plan.
- An in depth process evaluation is needed to give more insight in the successful and unsuccessful elements of Hospital in Motion.

REFERENCES

1. Asher, R.A.J., Dangers of Going to Bed. BMJ, 1947. 2(4536): p. 967-968.
2. van de Port, I.G., et al., How to increase activity level in the acute phase after stroke. J Clin Nurs, 2012. 21(23-24): p. 3574-8.
3. Mudge AM, M.P., McHugh K, Griffin L, Hitchen A, Walker J, Cruickshank M, Morris NR, Kuys S. J. , Poor Hospital Mobility. J. Hosp. Med. , 2016. 4: p. 289-291.
4. Brown, C.J., et al., The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc, 2009. 57(9): p. 1660-5.
5. Pedersen, M.M., et al., Twenty-four-hour mobility during acute hospitalization in older medical patients. J Gerontol A Biol Sci Med Sci, 2013. 68(3): p. 331-7.
6. Kuys SS, D.U., Guard A. , Activity level of hospital medical inpatients: an observational study. . Arch.Gerontol.Geriatr. , 2012(55): p. 417-21.
7. Knight J, N.Y., Jones A., Effects of bedrest 1: cardiovascular, respiratory and haematological systems. Nurs Times, 2009. 105(21): p. 16-20.
8. Knight J, N.Y., Jones A., Effects of bedrest 2: gastrointestinal, endocrine, renal, reproductive and nervous systems. Nurs Times, 2009. 105(22): p. 24-7.
9. Knight J, N.Y., Jones A., Effects of bedrest 3: musculoskeletal and immune systems, skin and self-perception. Nurs Times, 2009. 105(23): p. 18-22.
10. Zisberg, A., et al., Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. J Am Geriatr Soc, 2015. 63(1): p. 55-62.
11. Maayan Agmon, A.Z., Efrat Gil, Debbie Rand, Nurit Gur-Yaish, Mary Azriel, Association Between 900 Steps a Day and Functional Decline in Older Hospitalized Patients. . JAMA Intern Med, 2017. 177(2): p. 272–274.
12. Ostir, G.V., et al., Mobility activity and its value as a prognostic indicator of survival in hospitalized older adults. J Am Geriatr Soc, 2013. 61(4): p. 551-7.
13. Villumsen M, J.M., Andreasen J, Rathleff MS, Mølgaard CM, Very Low Levels of Physical Activity in Older Patients During Hospitalization at an Acute Geriatric Ward: A Prospective Cohort Study. Journal of Aging and Physical Activity, 2015. 23(4): p. 542-549.
14. Covinsky KE, P.E., Johnston CB, Hospitalization-associated disability: "She was probably able to ambulate, but I'm not sure". JAMA, 2011. 306(16): p. 1782-1793.
15. Brown, C.J., et al., Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. J Hosp Med, 2007. 2(5): p. 305-13.
16. Oliver, D., David Oliver: Fighting pyjama paralysis in hospital wards. BMJ, 2017. 357: p. j2096.
17. Koenders, N. et al, “I’m not going to walk, just for the sake of walking…”: a qualitative, phenomenological study on physical activity during hospital stay. Disability and Rehabilitation, 2018.
18. Hoyer, E.H., et al., Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. J Hosp Med, 2016. 11(5): p. 341-7.

19. van der Leeden, M., et al., Early enforced mobilisation following surgery for gastrointestinal cancer: feasibility and outcomes. Physiotherapy, 2016. 102(1): p. 103-10.

20. Czaplijski, et al., Creating a Culture of Mobility: An Interdisciplinary Approach for Hospitalized Patients. Hospital Topics, 2014. 92(3): p. 74-79.

21. Zisberg, A.M., Gur-Yaish N, Rand D, Hayat Y, Gil E; WALK-FOR team., No one size fits all-the development of a theory-driven intervention to increase in-hospital mobility: the "WALK-FOR" study. BMC Geriatr, 2018. 18(1): p. 91.

22. Mudge, A.M., P. McRae, and M. Cruickshank, Eat walk engage: an interdisciplinary collaborative model to improve care of hospitalized elders. Am J Med Qual, 2015. 30(1): p. 5-13.

23. Liu B, M.J., Almaawiy U, Chan WH, Khan S, Ewusie J, Hamid JS, Straus SE; MOVE ON Collaboration, Outcomes of Mobilisation of Vulnerable Elders in Ontario (MOVE ON): a multisite interrupted time series evaluation of an implementation intervention to increase patient mobilisation. Age Ageing, 2018. 47(1): p. 112-119.

24. Prior, M., M. Guerin, and K. Grimmer-Somers, The effectiveness of clinical guideline implementation strategies--a synthesis of systematic review findings. J Eval Clin Pract, 2008. 14(5): p. 888-97.

25. Golden, S.D. and J.A. Earp, Social ecological approaches to individuals and their contexts: twenty years of health education & behavior health promotion interventions. Health Educ Behav, 2012. 39(3): p. 364-72.

26. Delft van, L.M.M. et al. Hospital in Motion, a Multidimensional Implementation Project to Improve Patients’ Physical Behavior During Hospitalization: Protocol for a Mixed-Methods Study. JMIR Res Protoc, 2019. 8(4).

27. Grol R, W.M., Improving patient care. The implementation of change in clinical practice, ed. n. ed. 2013: Chichester: Wiley, BMJ Books.

28. Doetsch PW, H.D., Haseltine WA, Mechanism of action of a mammalian DNA repair endonuclease. Biochemistry, 1986. 25(8): p. 2212–20.

29. Geelen SJ, V.K., Veenhof C., Construct validity and inter-rater reliability of the Dutch activity measure for post-acute care. Disabil Rehabil, 2018: p. 1-7.

30. Peolsson, A., Hedlund, R and Oberg, B, Intra- and inter-tester reliability and reference values for hand strength. J Rehab Med 2001. 33: p. 36–41.

31. Bohannon, R., Muscle strength: clinical and prognostic value of hand-grip dynamometry. Curr Opin Clin Nutr Metab Care, 2015. 18(5): p. 465-70.

32. Bernhardt, J., et al., Inactive and alone: physical activity within the first 14 days of acute stroke unit care. Stroke, 2004. 35(4): p. 1005-9.

33. Valkenet, K., Measuring physical activity levels in hospitalized patients: a comparison between behavioural mapping and data from an accelerometer. Clinical Rehabilitation, 2019. 33(7): p. 1233- 1240.

34. The AVERT Trial Collaboration group., Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial. Lancet, 2015. 386(9988): p. 46–55.

35. Tremblay, et al. Terminology Consensus Project: process and outcome. Sedentary Behavior Research Network (SBRN) - International Journal of Behavioral Nutrition and Physical Activity 2017. 14(75).

36. Epstein, N.E., A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures. Surg Neurol Int, 2014. 5(Suppl 3): p. S66-73.

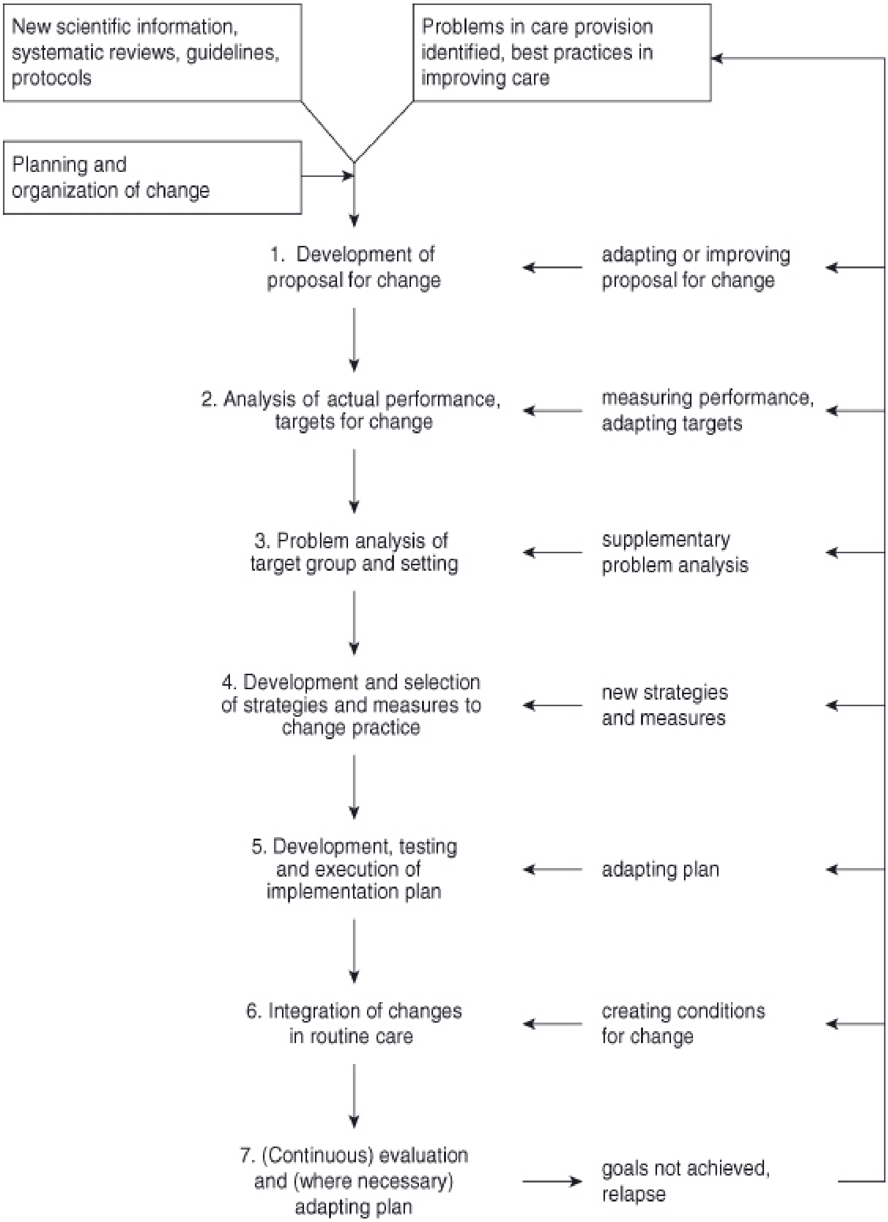
37. Ramos Dos Santos, P.M., et al., Effects of early mobilisation in patients after cardiac surgery: a systematic review. Physiotherapy, 2017. 103(1): p. 1-12.

38. Hanada, M., et al., Effect of early mobilization on postoperative pulmonary complications in patients undergoing video-assisted thoracoscopic surgery on the esophagus. Esophagus, 2018. 15(2): p. 69-74.

39. Moore, G.F., et al., Process evaluation of complex interventions: Medical Research Council guidance. BMJ, 2015. 350: p. h1258.

APPENDICES

Appendix 1. The Implementation of Change Model, by Grol & Wensing [27]



3

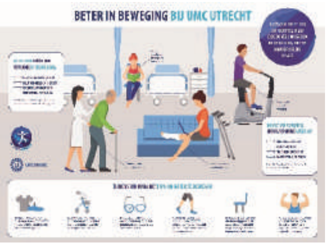
Appendix 2. Detailed description of implemented interventions within the action plan

Patient information brochure on physical activity

A brochure was designed for inpatients with information about the importance of physical activity. Tips were given about what patients can do themselves to avoid unnecessary physical inactivity (like avoiding to wear a pajama during daytime) and to promote physical activity (like eating out of bed and go walking with visitors).

Patient information poster on physical activity

An infographic was designed to visualize the information from the brochure. The infographic was provided to patients on A4 together with the brochure and was placed at the wall in A3 format of the patient rooms and on several places in the hallways of the wards.

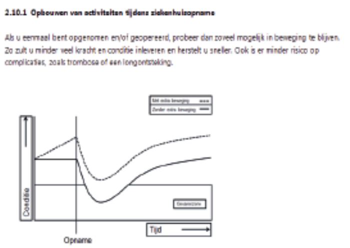


Education to health care professionals (HCPs)

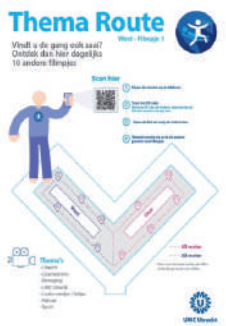
Before the start op the implementation period and every two months during the implemention period, the project managers gave presentations about the importance and impact of movement behavior during hospitalization to HCPs. Furthermore, the implemented interventions were presented and discussed.

Pre-admission patient information

At the hematology ward information about the importance of physical activity during hospitalization was added to the existing pre-admission information folder. At the cardiothoracic surgery ward information about the importance of physical activity during hospitalization, examples of exercises and a schedule for mobilization in the days post-surgery were added to the pre-admission folder.

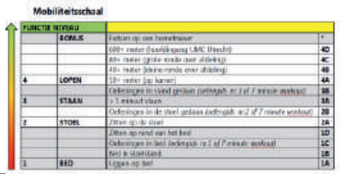


Exercise brochures & 7 minute workouts Three exercise brochures were composed. One with exercises to be performed from lying position, one from sitting position and one from standing position. On average 10 exercises for the upper and lower extremities were included per brochure with a simple instruction about the performance and frequency of the exercise. Additionally, these exercises could be watched on the infotainment system at the bedside of each patient, in the form of three 7-minute workout videos.	 
Joint lunches On one day in the weekend a lunch was organized in a shared space on the wards. Patients were invited to join the lunch. When patients were not able or willing to join, they received their lunch according to usual care in the patient room.	
Eating out of bed Patients were stimulated to eat out of bed (breakfast, lunch, diner). In all presentations for HCPs and in meetings with the food service, the importance of eating out of bed was emphasized. Additionally, it has been the focus of the week several times during the implementation period.	
Improving built environment of the shared areas In the shared areas changes were performed to become more attractive to patients and increase the visibility of exercise opportunities. For example, bicycle ergometers, the exercise folders, weights were placed in sight and books and games were added to the areas.	
Exercise material and walking aids New exercise materials and walking aids were purchaced, such as rollators, weights, steps and walking frames.	

QR- code walking routes A system was developed especially to enable QR codes to link a different (YouTube) video each day. In total 10 posters were designed including a different QR code per poster. This made it possible for patients to walk to one or more posters every day to watch a different video. Per day a theme was chosen for the video's. For example, on wednesday the theme was 'nature' and 10 different nature video's could be watched when a patiënt visited all the posters. The other themes were: physical activity, funny knowlegde facts, sports, UMC Utrecht (the hospital), Utrecht (city) and Earth&History.	
Department map with all facilities At every ward a map was placed in a central area which showed the location of the facilities on the ward like the family room, bicycles and coffee machine. Additionally, these maps show the locations of the QR-code walking posters	
Stimulating visitors to walk of exercise with the patient At the beginning of the ward supportive information was displayed on posters or video screens to stimulate visitors to help the patient getting active.	
Mobility icons The mobility level of a patient was visualized in the patient room at the Cardiology ward to increase insight for staff, volunteers and visitors about the physical ability of the patient and to initiate the conversation about helping a patient the get moving.	
Daily activity schedule At the cardiothoracic surgery ward daily activity schedules were developed and implemented. For the short stay patients (CABG, valve surgery) the daily activity schedule was displayed in the electronic patient file, and in the pre-admission information. For the long stay patients (e.g. assist devices, heart transplantation) tailored day schedules were made and placed in the patient room.	**Globale opbouw van activiteiten en conditie na een open hart operatie** Na de operatie is het heel belangrijk om zo snel mogelijk in beweging te komen. U verliest dan minder spierkracht, u krijgt minder snel rug, nek en schouderklachten en u kunt beter doorademen. U verkleint de kans op complicaties in de longen en in de rest van uw lichaam. Omdat snel in beweging komen zo belangrijk is helpt de verpleegkundige u de dag na de operatie uit bed, zodat u in de stoel kan zitten. Per dag worden uw activiteiten uitgebreid: Dag 0: Operatiedag, nacht ter controle op de Intensive Care Dag 1: Van IC naar de Medium Care: 's middags of 's avonds uit bed Dag 2: 's morgens uit bed op de Medium Care, 's middags lopen op de kamer. Daarnaast 's middags en 's avonds regelmatig in de stoel zitten. Dag 3: Zelfstandig zo vaak mogelijk uit bed, lopen op de kamer en op de gang starten, en mogelijk al deelname oefengroep om 11 uur. Dag 4 : Deelname oefengroep dagelijks om 11 uur, zelfstandig wandelen op de gang uitbreiden min 3x per dag, eventueel al traplopen.

Mobilisation card (highest level of mobility)

A mobilization card displayed the highest level of mobility of the patients was placed in the patientroom at the medical oncology ward. The level of mobility ranged from lying in bed to be able to walk > 600 meters.



Mobiliteitsschaal

FUNCTIE NIVEAU			
	BONUS	Fietsen op een hometrainer	*
		600+ meter (buitenomgang UMC Utrecht)	4D
		80+ meter (grote ronde over afdeling)	4C
		40+ meter (kleine ronde over afdeling)	4B
4	LOPEN	10+ meter (op kamer)	4A
		Oefeningen in stand gedaan [illegible]	3B
3	STAAN	> 1 minuut staan	3A
		Oefeningen in de stoel gedaan [illegible]	2B
2	STOEL	Zitten op de stoel	2A
		Zitten op rand van het bed	1D
		Oefeningen in bed [illegible]	1C
		Bed in stoelstand	1B
1	BED	Liggen op bed	1A

3

Chapter 4

Perceived Factors of Influence on the Implementation of a Multidimensional Project to Improve Patients' Movement Behavior During Hospitalization: A Qualitative Study

Petra Bor
Lotte M.M. van Delft
Karin Valkenet
Cindy Veenhof

Published in Physical Therapy 2022

ABSTRACT

Objective The aim of this study was to explore perceived factors of influence on the implementation of Hospital in Motion, a multidimensional and multidisciplinary implementation project to improve inpatients' movement behavior.

Methods This qualitative study was conducted on 4 wards. Per ward, a tailored action plan was implemented consisting of multiple tools and interventions to stimulate the integration of inpatient physical activity in usual care processes. After implementation, semi-structured interviews were performed with health care professionals and patients to explore perceived factors of influence on the implementation of the Hospital in Motion project. A content analysis was performed using the framework of the Medical Research Council for complex interventions as guidance for the identification of categories and themes.

Results In total, 16 interviews were conducted with health care professionals and 12 with patients. The results were categorized into the 3 key components of the Medical Research Council framework: implementation, mechanisms of impact, and context. An important factor of influence within the theme "implementation" was the iterative and multidisciplinary approach. Within the theme "mechanisms of impact," continuous attention and the interaction of multiple interventions, tailored to the target group and targeting multiple dimensions (individual, inter-professional, community and society), were perceived as important. Within the theme "context", the intrinsic motivation and inter-professional, community and societal culture towards physical activity was perceived to be of influence.

Conclusion Impact can be achieved and maintained by creating continuous attention to inpatient physical activity and by the interaction between different interventions and dimensions during implementation. To maintain enough focus, the amount of activities at one time should be limited.

Impact To improve inpatients' movement behavior, implementation project teams should be multidisciplinary and should implement a small set of tailored interventions that target multiple dimensions. Intermediate evaluation of the implementation process, strategies, and interventions is recommended.

INTRODUCTION

Higher physical activity levels during hospitalization lead to a reduction in diverse complications, functional decline and outplacement to a rehabilitation setting.[1-5] However, promoting physical activity can be challenging since physical inactivity is deeply rooted in the hospital culture.[6-8] It is suggested that, to integrate physical activity in usual care, interventions should be multidimensional (e.g. individual, inter-professional, community and society) and implementation should follow a dynamic approach.[9-13] Although previous studies showed that inpatient physical activity can be improved, the content of the interventions and used implementation approaches vary widely which make studies difficult to compare and translate to other settings.[2, 11, 14]

To understand the whole range of effects, the variety and the interaction during the implementation of complex interventions, it is important to understand the underlying implementation processes. [11, 15, 16] Insight into the perceived barriers and facilitators during the implementation of interventions aiming to promote inpatient physical activity is required to successfully and sustainably change the immobility culture in hospitals around the world.[15]

The Medical Research Counsel developed a framework for the process evaluation of complex interventions.[15, 16] This framework consists of three key components including implementation, mechanisms of impact and context. This framework can be used as guidance during the evaluation of an implementation process.

Therefore, this qualitative study was performed using the Medical Research Counsel as guidance during data analysis. This study was performed after the implementation of the multidisciplinary and multidimensional implementation project Hospital in Motion which aimed to improve inpatient movement behavior[5, 17]. The aim of the current study was to explore the perceived factors of influence on the implementation of interventions to improve patients' movement behavior during hospitalization by health care professionals and patients.

METHODS

Hospital in Motion

The project Hospital in Motion (HiM) aims to improve inpatient movement behavior and was initiated in 2016 at the University Medical Centre Utrecht, the Netherlands, with a pilot study on the geriatrics ward. During this pilot the multidisciplinary project team identified the lack of proper tools and information resources to address the importance of physical activity with patients. Therefore, several tools were developed like an information brochure and video animation on physical activity during hospital stay, 7-minute workout videos and exercise guides with exercises in lying, sitting and standing position, and posters to increase awareness on physical activity during hospitalization. Following, this set of tools was implemented. Furthermore, a 2-weekly movement group session, a daily group lunch and the use of a home trainer with interactive screen were implemented as interventions to promote physical activity. The results on inpatient movement behavior were published in a Dutch journal for gerontology physiotherapists.[18]

After the pilot, between January and November 2018 the project HiM was implemented on four other clinical wards: cardiology, cardiothoracic surgery, medical oncology, and hematology.[17] Per ward, a multidisciplinary project team was formed that composed a tailored action plan. This action plan contained multiple implementation strategies, interventions and tools to promote physical activity which were allocated into one of the five topics of the action plan: 1) education of staff and patients; 2) integration of physical activity in usual care; 3) involvement of third parties such as family members or volunteers; 4) creation of a stimulating environment; 5) mobilization milestones & technological support.[5, 17] An overview of the strategies, interventions and tools per ward can be found in Appendix 1 of chapter 3.

Following, the project teams used the Implementation of Change Model as guideline during implementation.[19] This model is developed especially for clinical practices. The results of the implementation on movement behaviour of patients during hospital stay was investigated using a prospective pre-post design.[5, 17] Patient observations (n=334) demonstrated that the time spent lying decreased from 60.1% to 52.2% (p=0.01) and the time spent sitting increased from 31.6% to 38.3% (p=0.01). The time spent moving did not change (8.3% - 9.6% (p=0.31)).[5]

Setting and design

This single-center study was conducted after the implementation of project HiM on the cardiology, cardiothoracic surgery, medical oncology, and hematology wards in 2018. The study was performed at the University Medical Centre Utrecht, a 800-bed academic teaching hospital in Utrecht, the Netherlands. A qualitative content analysis was performed, using individual semi-structured interviews with open ended questions.[20] For reporting this study, the Standards for Reporting Qualitative Research was used.

Study procedure and participants

Research team members PB (physical therapist and PhD student) and LvD (physical therapist and PhD student) approached potential participants for inclusion. Both HCPs and patients of the four wards of interest were included in the semi-structured interviews to explore factors of influence on the implementation of HiM. HCPs who participated in the HiM project teams as well as HCPs outside the project teams were purposefully sampled based on discipline (nurse, physical therapist, unit manager) and years of work experience. Additionally, patients who were admitted for at least 3 days, did not have strict bed rest orders and were not receiving end-of-life care were eligible to be included. For the inclusion of patients, the head nurse was consulted to create a list of eligible patients. To ensure heterogeneity, patients were also purposefully sampled based on age, gender, ward, level of physical functioning and length of hospital stay. Inclusion of participants ended when theoretical saturation was reached.[17]

PB and LvD were participating in the HiM project teams (PB on the medical oncology and hematology wards, LvD on the cardiology and cardiothoracic surgery wards). To prevent bias as much as possible, the participant inclusion and interviews were carried out on the wards where the researcher was not involved in the project teams. Participants were informed about the reasons for research and the role of the interviewers in the implementation project. Written informed consent was obtained from all participants included in the study. Ethical approval was granted by the Medical Ethics Committee Utrecht (16-316).

Data collection

The semi-structured interviews were guided by a topic list: one for the patients, and one for the HCPs (Table 1). The topics HCPs included 'interventions', 'factors of influence on implementation' , 'evaluation of the design of HiM' and 'sustainability'. The topics for patients included the topics of the action plans and the implemented interventions. For the HCPs who also participated in one of the HiM project teams, supplementary questions were added. All interviews took place face-to-face at one of the four participating hospital wards and were audio-recorded. At the end of each interview, a member check was performed by providing a verbal summary of the findings to the participant.

To warrant the quality and consistency of the interviews, a third researcher (KV – senior researcher) observed one of the first three interviews of both PB and LvD. KV did not actively participate in the interviews. After the observations by KV, the interview techniques (eg. neutral phrasing of interview questions and consistent use of the topic list) and differences between PB and LvD were discussed to increase homogeneity of the interview styles of PB and LvD.

In addition to the interview data, characteristics of the participants were collected. Collected characteristics of the HCPs were: ward, gender, age, discipline and years of work experience. Characteristics of the patients included: ward, gender, age and the level of physical functioning. Physical functioning was assessed using the Activity Measure of Post-Acute Care Basic Mobility "6-clicks" (AM-PAC BM), which measures the ability of performing basic activities such as turning in bed and climbing 3-5 steps.[21, 22] The sum score ranges from 6 (total assistance or 'cannot do at all') to 24 (completely independent functioning).

Data analysis

All interviews were audio-recorded and transcribed verbatim. Following, the text of the interviews was read and re-read word by word to gain a general understanding of the perceptions of the participants.A conventional content analysis was performed as coding categories were derived directly from the text data.[20] Firstly, the text data was labelled with codes (PB and LvD) to describe the meaning of condensed parts of the text. The first three interviews were independently coded by two researchers (PB and LvD). The subsequent interviews were independently coded by one researcher (HCPs by PB, patients by LvD) and checked and supplemented by the second researcher to create rigor and trustworthiness. Secondly, categories were formed (PB and LvD) by grouping the codes together that were related to each other. The categories were discussed with a third researcher (KV) until consensus was reached. Finally, these codes were allocated into one of the three key components of the MRC framework in a consensus meeting (PB, LvD, KV and CV): implementation, mechanisms of impact and context (Figure 1). [15, 16, 20] NVivo 12 was used for the qualitative analysis.

Table 1. Topic list of the semi-structured interviews of both HCPs and patients

Topic	Subtopic
HCPs	
Interventions	- Opinion - Familiarity - Usage - Adoption - Reaction - Consequences
Factors of influence	- Hospital wide, ward-specific or personal - Why and how was this of influence - Was it preventable or utilized
Evaluation of the design of HiM	- Design and execution of the project - Output of the project
Sustainability	- Changed behaviour
Patients	
Education	- Getting information about the importance of physical activity - who, when and how - Involvement of family - Opinion about the achieved information
Physical activity as part of usual care	- Opinion about environment and implemented interventions - Joint lunch for patients (in living room) - Eating out of bed
Involvement of third parties	- Encouragement of visitors to do exercises, walk or go to the living room - Stimulation from food services to eat while sitting in the chair
Stimulation environment and technology	- Stimulation environment - QR-code walking theme route at the hallway of the wards - Good and sufficient patient seats available - Availability of training material and walking aids at the department - Attractive space to go
Mobilization mile stones	- Mobilization card (familiarity, usage, opinion) - Day schedules
Barriers and enablers of implemented interventions	- Opinion about the implemented interventions - Influence on movement behaviour, how and why - Barriers and facilitators of the usage of the interventions

HCP = Health care professional; HiM = Hospital in Motion

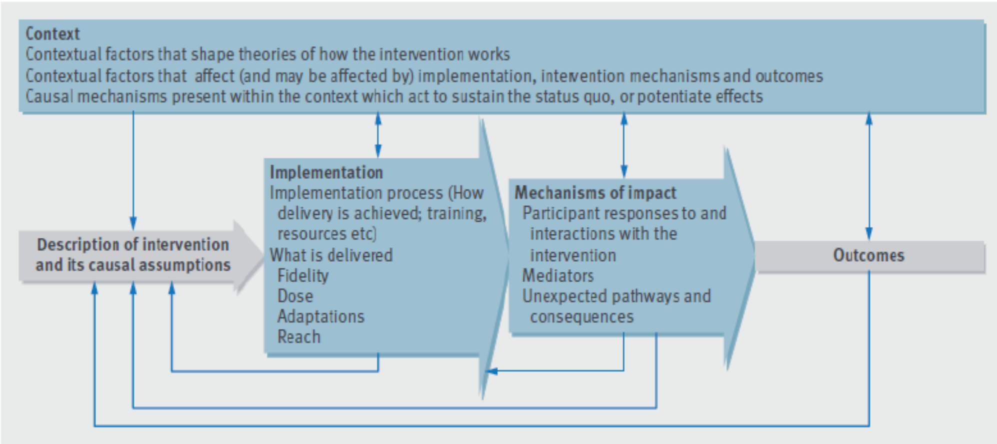


Figure 1. Key components of a process evaluation according to the MRC[15, 16]

RESULTS

Participant characteristics

Participant characteristics are shown in Table 2. Between December 2018 and February 2019 a total of 28 participants were included in the study: 16 HCPs and 12 patients. HCPs were working as nurse (n=9), physical therapist (n=3) or unit manager (n=4) and were mostly female (n= 13). Patients were mostly male (n=11) and admitted on the cardiology (n=3), cardiothoracic surgery (n=2), medical oncology (n=4) or the hematology ward (n=3).

Perceived factors of influence on the implementation of HiM

The results from the interviews are displayed using the framework of the MRC as guidance (Figure 2). Additionally, a narrative synthesis is provided.

Implementation

The theme implementation was divided in two subthemes: the process of the implementation and the implementation of the interventions.

Process

Changing physical behavior during hospitalization in usual care was mentioned as an organic, iterative and multidisciplinary process, since physical inactivity is deeply rooted in the hospital culture. To change this culture of inactivity, the implementation should follow an iterative approach. Progress can be made step-by-step and takes time (HCP3). Additionally, the involvement of different disciplines in the project group was experienced as a positive modifier. Different disciplines have different approaches and perspectives. By working together, this may help to overcome barriers and promote change in daily care (HCP12).

"This is an organic process, step by step you will make more progress"
[HCP3, female, nurse, cardiology]

Table 2. Demographic data of the participants

	HCPs (n=16)	Patients (n=12)
Ward, n(%)		
- Cardiology	4(25)	3(25)
- Cardiothoracic Surgery	4(25)	2(17)
- Medical oncology	4(25)	4(33)
- Haematology	4(25)	3(25)
Male, n(%)	3(5)	11(92)
Age (years), mean±SD	39±13	61±18
Discipline, n(%)		
- Nurse	9(56)	N.A.
- Physical therapist	3(5)	N.A.
- Unit management	4(25)	N.A.
Years of work experience, mean±SD	14±12	N.A.
Physical Functioning (AM-PAC 6-clicks BM), mean±SD	N.A.	23±4
Duration of the interview in minutes, mean±SD	26±5	21±4

HCPs; healthcare professionals, AM-PAC 6-click BM; Activity Measure of Post-Acute Care Basic Mobility “6-clicks”, N.A. = not applicable

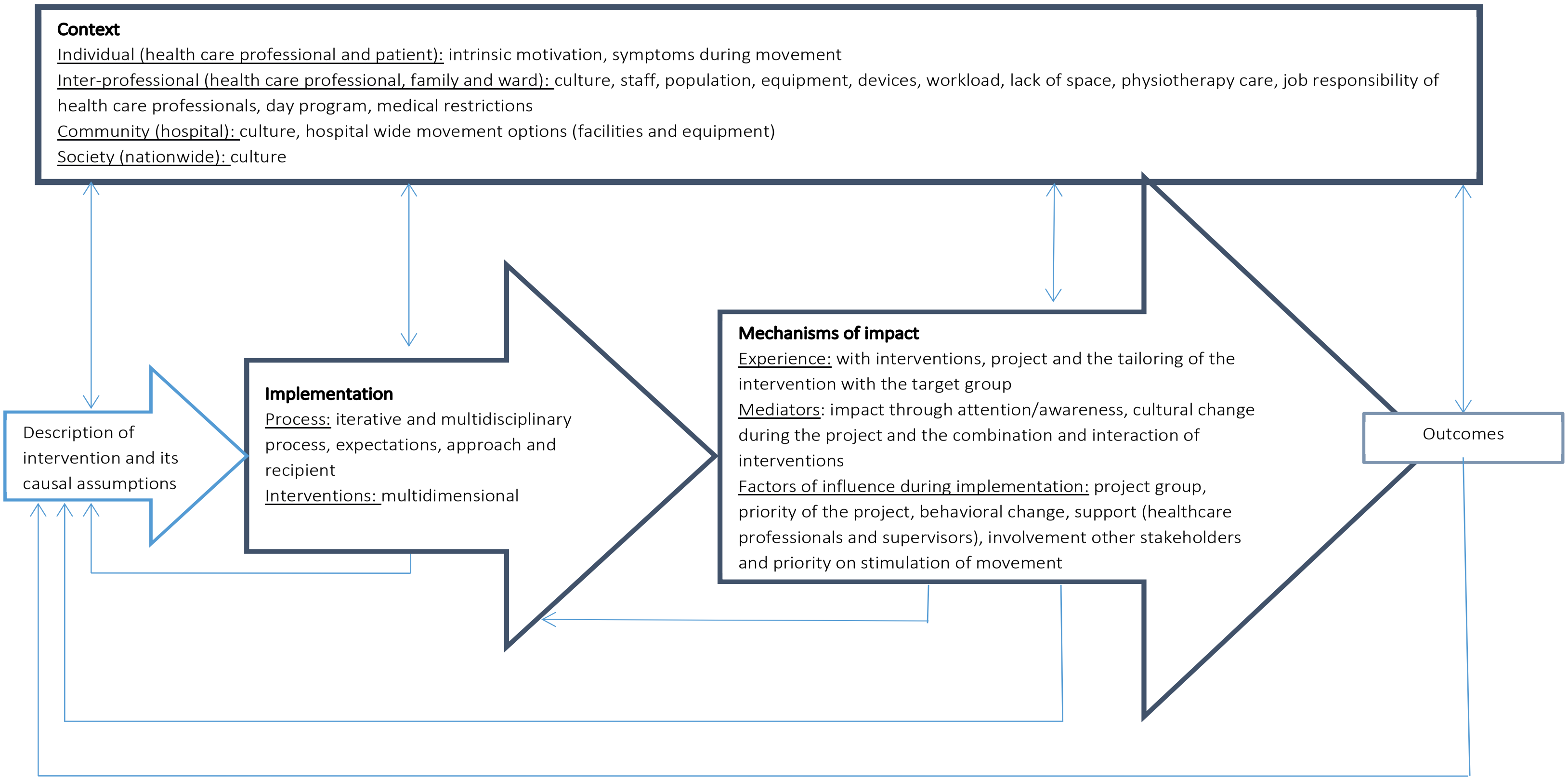


Figure 2. Perceived factors of influence on the success of an implementation project to improve patients' movement behavior during hospitalization categorized in the MRC framework.[15]

The expectations and attitudes of HCPs and the way the ward adopted the project were perceived as factors of influence on the success of the implementation. It could have a stimulating effect if the recipient has a positive attitude towards the aim of the project. However, when expectations and intentions were not clearly specified at the beginning of the project, this was perceived as barrier (HCP8).

"There has been some resistance to the project. There has been a feeling of an increased workload for the nursing staff because the physiotherapist told us to do something with my patient [like education or mobilization]. This was not the purpose of course, but some colleagues might have experienced it like that"
[HCP8, female, nurse, medical oncology]

Interventions

The fact that during the HiM project multiple interventions across multiple dimensions were implemented, had both advantages and disadvantages. Mentioned advantages were that the interventions were implemented on different social ecological levels and thereby interacted with each other. On the other hand, as different interventions were implemented at the same time this diminished the involvement and focus of HCPs (HCP7).

"Now (after implementation) I think, many things are created, but we haven't found the time yet to fully implement the changes which makes it not running smoothly yet. There have been moments where suddenly three or more things had to be done at the same time, which made some of us give up"
[HCP7, female, nurse, hematology]

Mechanisms of impact

The theme mechanisms of impact during and after the implementation of the intervention was categorized in three subthemes: the experience with the interventions and the overall project, mediators (including factors that arose as a consequence of the intervention or project) and factors of influence during the implementation.

Experience

The experience with the different interventions and the overall aim of the implementation project can promote or obstruct the effect on the wanted outcome (HCP3). Additionally, tailoring the intervention to the target group was one of the factors, which was mentioned by the HCPs, that interacted with the outcome and thereby the success of the implementation (HCP8).

"I think this project is fantastic, also because we have a very enthusiastic team and we got some budget, which creates more opportunities"
[HCP3, female, nurse, cardiology]

Mediators

HCPs stated that the impact of the implementation was derived through the attention and awareness of the importance of movement behavior (HCP3 and HCP10). Achieved cultural changes on the participating ward during the implementation period improved the implementation outcomes. For example, if mobilization became more common in daily care and was stimulated more by several disciplines, this positively affected the implementation processes. Or if the implementation of the group lunch was successful, this might have motivated both nurses and catering assistants in a positive way to embrace other interventions as well. Simultaneously, if an intervention was not received well, this might negatively impact further implementation.

“Everything that gets your attention repeatedly, will grow”
[HCP3, female, nurse, cardiology]

Factors of influence during the implementation

During the implementation several factors arose as consequences of the implementation process. First, the way the project group functioned was mentioned as an important factor for successful implementation. If the participants of the project group were the driving force on the ward, they were able to involve the rest of the department more easily (HCP12). On the other hand, it was hard to involve everyone since the participants of the project group were not working every day of the week, or not working on the ward for a longer period of time (HCP7).

“I think that we were in the luxury position of having a few nurses on the ward who were really fanatically involved and really keen to promote the importance of regular movement for patients and as part of a healthy lifestyle. As a ward we have used these colleagues as ambassadors of exercise and an active lifestyle, both for patients and health care professionals”
[HCP12, female, unit manager, cardiology]

“It proves challenging to reach everyone with this message. I was with my colleague, who is not working that many hours and I am only working here for just a year, making it hard to involve everyone, especially the older generation”
[HCP7, female, nurse, hematology]

Furthermore, the openness of the HCP’s on the ward to behavioral change, the priority given to the project (HCP9) and the support from other HCPs and supervisors were important for the involvement on the ward (HCP7 and HCP12). Additionally, the involvement of other stakeholders, all propagating the same message, was considered to be helpful (HCP2).

Context

The theme context includes four subthemes; individual (HCP or patients), inter-professional (HCP, family or ward), community (hospital) and society.

Individual

Individual factors that were mentioned were the intrinsic motivation of HCPs and patients, and the experienced symptoms by patients during movement (PT7). Examples of symptoms to reduce a patient’s likeliness to exercise were fear, nausea, pain and fatigue.

“But exercise, I think everybody knows the importance of exercise. But you have to do it, you need to have the energy. And I guess, that is the hard part. You wake up in the morning, still feeling tired. You really want to sleep all day. So the energy to do it… I can imagine some people were thinking.. oh no.. But I think, I just have to do it, otherwise….I never make any progress. So, let’s do it and it’s done”
[PT7 male, 58 year, hematology]

Inter-professional

Each ward in the hospital has its own culture and patient population, which may both impact the implementation positively or negatively. On some wards, movement is already part of daily care, on other wards movement is seen as one of many extra tasks. On these latter wards, HCPs may struggle with the question who’s responsibility it is to mobilize the patients (HCP4).

”A while ago we got some criticism ‘it is your job to exercise with the patient’. That was unfair as we weren’t talking about exercising, but about delivering care. Supporting someone to wash him/herself independently by just putting him/her in front of a wash basin is a form of exercise as well”
[HCP4 female, physical therapist, medical oncology]

Additionally, workload is a theme which came forward frequently both in the HCPs' and patients' interviews. HCPs stated that they have an extensive range of tasks which should be arranged for the patients, of which mobilization is just one of the many tasks (HCP12). When the workload is high, tasks were prioritized. The high workload of HCPs also has impact on the patients. If they feel HCP's experience high pressure, it is a barrier to disturb them and ask for help (PT8).

"The barrier to change has been the high workload, due to the many tasks we have to do in collaboration with the patient, the shorter lengths of stay, more work in less time, which makes us forget the importance of daily exercise for the patients, although it should be part of our daily care routine"
[HCP12 female, unit manager, cardiology]

Other subthemes which came forward were focused on the built environment of the ward, the lack of space in the patient room, the possibility and attractiveness to walk in the corridors or to go to another room (e.g. a family or exercise room) or outside the ward (HCP10)(HCP7). Additionally, there was a wide variety of equipment and devices on the ward that could promote healthy behavior.

"You see patients walk '100.000' times around the ward and that gets boring. You see people want to be active, but it proves hard to find them a good way of doing so. This will almost encourage them to go back to their rooms"
[HCP7, female, nurse, hematology]

Community and society

HCPs stated that the culture and attention about the importance of movement behavior during hospitalization in both the community (hospital) and in the society (nationwide) may influence implementation.

"It is a topic other hospitals as well. In a journal for nurses, there also was a topic about the importance of inpatient physical activity."
[HCP3, female, 55 year, nurse, cardiology]

DISCUSSION

This study explored the perceived factors of influence on the implementation of interventions to improve inpatient movement behavior. This study found that using an iterative and step-by-step process was an important positive factor of influence within the theme implementation. Within the theme mechanisms of impact, continuous attention and the interaction of multiple interventions targeting multiple dimensions (individual, inter-professional, community and society) were perceived important. Within the theme context, the intrinsic motivation and inter-professional, community and societal culture towards physical activity was perceived to be of influence. To maintain enough focus on individual tools or interventions to be implemented, the amount of activities at one time should be limited. In addition, it is important to tailor the tools and interventions to the target group.

Changing the culture of physical inactivity requires fundamental changes in the current beliefs, practice and perception of inpatient movement behavior.[9] This study showed that an iterative and step-by-step process, although time consuming, were perceived as successful ingredients of the implementation approach. One of the mechanisms of impact found in this study was the continuous attention, which is a never-ending process to maintain achieved awareness and changes of inpatients movement behavior. Additionally, this study highlighted the importance of a multidisciplinary approach. This is in line with a previous published study which stated that an inter-professional communication, collaboration and teamwork is needed to change the culture of inactivity in the hospital.[23] The involvement of different disciplines all propagating the importance of physical activity, will strengthen the message. Thereby, it might enhance the incorporation of movement behavior in daily practice, which is important to achieve sustainable changes.[9] Additionally, engagement of the project team and involvement of important stakeholders on the ward had a crucial role in the success of the implementation project.

Comparable to our results, previous studies also reported the advantages of implementing a set of single interventions to change inpatients movement behavior.[12, 24] However, analyses on the adoption and reach of HiM showed a wide range in the familiarity of the single interventions (54-86%)(unpublished results).This indicates that a downside of implementing multiple interventions at the same time is that you might lose the focus of HCPs. This is acknowledged by HCPs in the interviews. For HCPs, the promotion of physical activity is just one of their many tasks. HCPs mentioned that the promotion of physical activity is important, but nevertheless it often ends at the bottom of the priority list.[25, 26] Therefore, to increase the reach and adoption of the single interventions, the number of interventions should be limited to maintain the focus.

Furthermore, our results show that each intervention should target multiple dimensions like those suggested by the Social Ecological Model (individual, inter-professional, community and society).[13] For example, for the group lunches on the ward patients received information and were stimulated to eat lunch outside the patient room (individual dimension). At the same time, the HCPs cooperated with the catering assistants and the ward assistant to facilitate the lunch (inter-professional dimension) and a designated area on the ward was created were the lunches could take place (community dimension).

Finally, each intervention should be tailored to the target group. This is in line with a previous study which stated that an existing intervention cannot easily be incorporated in another setting, but requires a site-specific analysis.[11] Even though the aim of HiM was to implement a tailored action plan per ward, several tools and interventions were implemented on all four wards. HCPs mentioned that there was some doubt if the interventions were suitable for their population. Although the project teams made conscious choices on which tools and interventions were implemented on their ward, the interventions might not have been tailored enough to the target population. More effort to tailor the interventions during the implementation is necessary to fulfill the specific needs per population.[27] Therefore, to enhance the success of future studies aiming to improve inpatients movement behavior, we recommend to explore the context in detail before developing or implementing interventions. In addition, we suggest to evaluate the adoption and appreciation of the individual interventions during the development and implementation frequently in order to optimize the integration of the interventions in practice.[28, 29]

Previous research that aimed to improve inpatient movement behavior showed a wide variety in the content of the interventions.[2, 3, 11, 14, 30] Since it is important that interventions are tailored, the variety of the interventions might increase, which makes it hard to compare effectiveness. Therefore it is important to gain insight in the 'active ingredients' of the interventions. This study provides insight in the perceived factors of influence of the implementation process. However, the active ingredients of the single interventions remain unclear. The classification of behavioral change techniques might be a suitable way to identify these active ingredients of interventions, which might contribute to the comparability of interventions between studies and aids in the development of effective interventions.[31]

Strengths and limitations

The strength of this study is the in-depth analysis of the perceived factors of influence of the HiM implementation process. Although some of our findings are not unique[2, 19, 32, 33], they help contextualize what might need to be considered for implementation efforts to promote movement behavior in an acute care setting. As the promotion of inpatient physical activity is a fairly new topic in scientific literature, it is important to have an overview highlighting the main factors of influence for implementation projects similar to HiM. Therefore, the gained insights might provide useful information for others who are about to start with the implementation of a similar project in a similar setting. A limitation of this study is the single center study design as participants were only familiar with the HiM project. Therefore, the single center design might have influenced the generalizability of our results. Another limitation is the execution of this study after the implementation period, making it difficult to adjust strategies during implementation. Finally, the involvement of the researchers in both the implementation process and the implementation evaluation might have led to reporting bias.

CONCLUSION

Many factors, within both the context, implementation and mechanisms of impact influenced the implementation of HiM. This finding emphasizes the complexity of implementation projects to improve inpatients' movement behavior. Impact can be achieved by creating continuous attention and by the interaction between different interventions. This applies for both during and after the implementation to attain sustainable results. Our results highlight the importance of a multidisciplinary approach and implementing a set of tailored interventions targeting multiple dimensions. We recommend future projects to include a process evaluation, with frequent evaluations during the implementation process of the implemented strategies, tools and interventions to enable adjustments during implementation when needed.

REFERENCES

1. Hoyer EH, Friedman M, Lavezza A, Wagner-Kosmakos K, Lewis-Cherry R, Skolnik JL, et al. Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. *J Hosp Med*. 2016;11:341-347
2. Mudge AM, McRae P, Cruickshank M. Eat walk engage: An interdisciplinary collaborative model to improve care of hospitalized elders. *Am J Med Qual*. 2015;30:5-13
3. Liu B, Moore JE, Almaawiy U, Chan WH, Khan S, Ewusie J, et al. Outcomes of mobilisation of vulnerable elders in ontario (move on): A multisite interrupted time series evaluation of an implementation intervention to increase patient mobilisation. *Age Ageing*. 2018;47:112-119
4. Sourdet S, Lafont C, Rolland Y, Nourhashemi F, Andrieu S, Vellas B. Preventable iatrogenic disability in elderly patients during hospitalization. *J Am Med Dir Assoc*. 2015;16:674-681
5. van Delft L, Bor P, Valkenet K, Slooter A, Veenhof C. The effectiveness of hospital in motion, a multidimensional implementation project to improve patients' movement behavior during hospitalization. *Phys Ther*. 2020
6. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. *J Hosp Med*. 2007;2:305-313
7. Oliver D. David oliver: Fighting pyjama paralysis in hospital wards. *BMJ*. 2017;357:j2096
8. Koenders N, van Oorsouw R, Seeger JPH, Nijhuis-van der Sanden MWG, van de Glind I, Hoogeboom TJ. "I'm not going to walk, just for the sake of walking...": A qualitative, phenomenological study on physical activity during hospital stay. *Disabil Rehabil*. 2018:1-8
9. Czaplijski T, Marshburn D, Hobbs T, Bankard S, Bennett W. Creating a culture of mobility: An interdisciplinary approach for hospitalized patients. *Hosp Top*. 2014;92:74-79
10. Prior M, Guerin M, Grimmer-Somers K. The effectiveness of clinical guideline implementation strategies--a synthesis of systematic review findings. *J Eval Clin Pract*. 2008;14:888-897
11. Zisberg A, Agmon M, Gur-Yaish N, Rand D, Hayat Y, Gil E. No one size fits all-the development of a theory-driven intervention to increase in-hospital mobility: The "walk-for" study. *BMC Geriatr*. 2018;18:91
12. Kozica-Olenski S, McRae P, Bew P, Mudge A. 'I will walk out of here': Qualitative analysis of older rehabilitation patients' perceptions of mobility. *Australas J Ageing*. 2020
13. Golden SD, Earp JA. Social ecological approaches to individuals and their contexts: Twenty years of health education & behavior health promotion interventions. *Health Educ Behav*. 2012;39:364-372
14. van de Port IG, Valkenet K, Schuurmans M, Visser-Meily JM. How to increase activity level in the acute phase after stroke. *J Clin Nurs*. 2012;21:3574-3578
15. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: The new medical research council guidance. *Bmj*. 2008;337:a1655

16. Moore GF, Audrey S, Barker M, Bond L, Bonell C, Hardeman W, et al. Process evaluation of complex interventions: Medical research council guidance. *BMJ*. 2015;350:h1258

17. van Delft LMM, Bor P, Valkenet K, Veenhof C. Hospital in motion, a multidimensional implementation project to improve patients' physical behavior during hospitalization: Protocol for a mixed-methods study. *JMIR Res Protoc*. 2019;8:e11341

18. Bakker SV, K.; Emmelot, M.; Drenth, C.; het Lam, J.; Mandersloot, t.; Veenhof, C. . Umc utrecht in beweging: De implementatie van een multidisciplinair beweegplan in de dagelijkse zorg op de verpleegafdeling geriatrie. *Nederlands Tijdschrift voor Geriatriefysiotherapie*. 2018;September:9

19. Grol R WM. *Improving patient care. The implementation of change in clinical practice*. Chichester: Wiley, BMJ Books; 2013.

20. Hsieh HF, Shannon SE. Three approaches to qualitative content analysis. *Qual Health Res*. 2005;15:1277-1288

21. Geelen SJG, Valkenet K, Veenhof C. Construct validity and inter-rater reliability of the dutch activity measure for post-acute care "6-clicks" basic mobility form to assess the mobility of hospitalized patients. *Disabil Rehabil*. 2019;41:2563-2569

22. Jette DU, Stilphen M, Ranganathan VK, Passek SD, Frost FS, Jette AM. Validity of the am-pac "6-clicks" inpatient daily activity and basic mobility short forms. *Phys Ther*. 2014;94:379-391

23. Johnson AM, Kuperstein J, Howell D, Dupont-Versteegden EE. Physical therapists know function: An opinion on mobility and level of activity during hospitalization for adult inpatients. *Hosp Top*. 2018;96:61-68

24. Moore JE, Mascarenhas A, Marquez C, Almaawiy U, Chan WH, D'Souza J, et al. Mapping barriers and intervention activities to behaviour change theory for mobilization of vulnerable elders in ontario (move on), a multi-site implementation intervention in acute care hospitals. *Implement Sci*. 2014;9:160

25. De Klein K, Valkenet K, Veenhof C. Perspectives of patients and health-care professionals on physical activity of hospitalized patients. *Physiother Theory Pract*. 2019:1-8

26. Kalisch BJ, Landstrom G, Williams RA. Missed nursing care: Errors of omission. *Nurs Outlook*. 2009;57:3-9

27. Baker R, Camosso-Stefinovic J, Gillies C, Shaw EJ, Cheater F, Flottorp S, et al. Tailored interventions to overcome identified barriers to change: Effects on professional practice and health care outcomes. *Cochrane Database Syst Rev*. 2010:Cd005470

28. Michie J, Francis, Hardeman, Eccles. From theory to intervention: Mapping theoretically derived behavioural determinants to behaviour change techniques. *Applied Psychology*. 2008;57:660-680

29. Simpson KM, Porter K, McConnell ES, Colón-Emeric C, Daily KA, Stalzer A, et al. Tool for evaluating research implementation challenges: A sense-making protocol for addressing implementation challenges in complex research settings. *Implement Sci*. 2013;8:2

30. Scheerman K, Raaijmakers K, Otten RHJ, Meskers CGM, Maier AB. Effect of physical interventions on physical performance and physical activity in older patients during hospitalization: A systematic review. *BMC Geriatr*. 2018;18:288

31. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Ann Behav Med*. 2013;46:81-95

32. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: A consolidated framework for advancing implementation science. *Implement Sci*. 2009;4:50

33. Glasgow RE, Vogt TM, Boles SM. Evaluating the public health impact of health promotion interventions: The re-aim framework. *Am J Public Health*. 1999;89:1322-1327

Chapter 5

The effectiveness of physical activity interventions using activity trackers during or after inpatient care: a systematic review and meta-analysis of randomized controlled trials

Marijke E de Leeuwerk
Petra Bor
Hidde P van der Ploeg
Vincent de Groot
Marike van der Schaaf
Marike van der Leeden
On behalf of the OPRAH consortium

Published in International Journal of Behavioral Nutrition and Physical Activity, 2022

ABSTRACT

Background: Promoting physical activity (PA) in patients during and/or after an inpatient stay appears important but challenging. Interventions using activity trackers seem promising to increase PA and enhance recovery of physical functioning.

Objective: To review the effectiveness of physical activity interventions using activity trackers on improving PA and physical functioning, compared to usual care in patients during and/or after inpatient care. In addition, it was determined whether the following intervention characteristics increase the effectiveness of these interventions: the number of Behaviour change techniques (BCTs) used, the use of a theoretical model or the addition of coaching by a health professional.

Design: Systematic review and meta-analysis.

Data Sources: PubMed, EMBASE, Cinahl, SportDiscus and Web of Science databases were searched in March 2020 and updated in March 2021.

Eligibility criteria for selecting studies: Randomized controlled trials (RCTs) including interventions using activity trackers and feedback on PA in adult patients during, or less than 3 months after, hospitalization or inpatient rehabilitation.

Methods: Following database search and title and abstract screening, articles were screened on full text for eligibility and then assessed for risk of bias by using the Physiotherapy Evidence Database (PEDro) scale. Meta-analyses, including subgroup analysis on intervention characteristics, were conducted for the outcomes PA and physical functioning.

Results: Overall, 21 RCTs totalling 2355 patients were included. The trials covered a variety of clinical areas. There was considerable heterogeneity between studies. For the 13 studies that measured PA as an outcome variable(N= 1435), a significant small positive effect in favour of the intervention was found (standardized mean difference (SMD)=0.34; 95%CI 0.12 - 0.56). For the 13 studies that measured physical functioning as an outcome variable (N= 1415) no significant effect was found (SMD=0.09; 95%CI -0.02 - 0.19). Effectiveness on PA seems to improve by providing the intervention both during and after the inpatient period and by using a theoretical model, multiple BCTs and coaching by a health professional.

Conclusion: Interventions using activity trackers during and/or after an inpatient period can be effective in increasing the level of PA. However, these improvements did not necessarily translate into improvements in physical functioning. Several intervention characteristics were found to increase the effectiveness of PA interventions.

INTRODUCTION

Admission to a hospital or rehabilitation centre often leads to a decline in physical functioning.[1-4] This may be caused by the initial disease or medical treatment, but also by a reduction in physical activity (PA). It has been shown that increasing PA during or after an inpatient period is effective in improving recovery in physical functioning.[2, 5-8] However, stimulating PA in patients during and after an inpatient stay appears to be challenging because healthcare professionals may have insufficient time and patients may experience physical discomfort or lack of motivation.[9-12] Therefore, extra support to increase PA levels is desired.[13]

Activity trackers are wearable devices to monitor PA and are commonly used in interventions to stimulate PA.[14-18] In various patient populations, for example in patients with COPD or with rheumatic and musculoskeletal diseases, the use of activity trackers was found effective in increasing PA.[14-18] The evidence of effectiveness of interventions with activity trackers on physical functioning has been studied less and is conflicting.[16, 17]

The use of interventions with activity trackers during or after an inpatient period is expected to be effective, because an inpatient period, for example after oncological surgery or after a neurological event, can be considered as a "teachable moment": a time frame following a health event which a patients is most conducive to behavioural change.[19, 20] However, the effectiveness of PA interventions with activity trackers during or after admission to a hospital or rehabilitation centre has not been summarized systematically to date.

There is a wide variation in interventions with activity trackers. It is therefore important to identify which intervention characteristics have the highest effect on increasing patients' PA. To systematically describe, develop and test active elements of behavioural health interventions a taxonomy of behaviour change techniques (BCTs) has been developed.[21] BCTs are "observable, replicable and irreducible components of an intervention designed to alter or redirect causal processes that regulate behaviour".[21] Interventions with activity trackers often contain several BCTs.[22] However, there is insufficient evidence about the potential for the use of BCTs to improve the effectiveness of an intervention in patients during or after an inpatient period.

Besides BCTs, there is evidence for the use of a theoretical model, e.g. the Trans theoretical Model (TTM), the Social Cognitive Theory (SCT) or the self-efficacy theory.[23-26] Theory-based interventions are expected to be more effective because they tend to be better substantiated and more carefully described and carried out. In addition, the engagement of coaching from a health professional during the intervention may also influence the impact on the targeted behaviour (PA).[27] It is expected that a health professional having insight into the level of PA will be more motivating to the patient and PA goals can be better adjusted by the health professional during the intervention.

The primary aim of this study was to review the effectiveness of physical activity interventions using activity trackers on PA and physical functioning, compared to usual care in patients during or after inpatient care. The secondary aim was to determine whether the following intervention characteristics increase the effectiveness of these interventions: the number of BCTs used, the use of a theoretical model or the addition of coaching by a health professional.

METHODS

Protocol and registration

The review protocol was registered in the International Prospective Register of Systematic Reviews (PROSPERO) at https://www.crd.york.ac.uk/prospero/ (registration number CRD42020175977, submitted on March 23th, 2020). This review applies a systematic approach according to the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) updated guideline.[28]

Search strategy

A systematic literature search was conducted in March 2020 and updated on 3 March 2021, using the databases PubMed, EMbase.com, Ebsco/CINAHL, Ebsco/SportDiscus and Clarivate Analytics/Web of Science Core Collection (by MEL and JCFK). The search strategy included the following search terms and their synonyms: [1] inpatient period, [2] activity trackers and [3] adult patients. The full search string is presented in Electronic Supplementary Material Table S1. The reference lists of the included studies were checked to detect additional articles.

Study selection

The software program 'Rayyan' was used for the study selection. The studies were independently screened by two reviewers (ML and PB), first on title and abstract and second on full text, to assess eligibility for inclusion. The reviewers were blinded to each other's decisions. If necessary, final judgement about the eligibility was made by a third reviewer (MvdL).

Eligibility criteria

Type of studies

Randomized controlled trials about interventions with the use of activity trackers and feedback on PA level were included. No restrictions concerning the language or year of publication were used.

Type of participants

The target population for this review were adults during or less than 3 months after hospitalization or inpatient rehabilitation. No restrictions were made for the medical reason of the inpatient period.

Type of intervention

All studies with an intervention that included [1] an objective measurement of PA with the use of an activity tracker (e.g. accelerometer or pedometer) and [2] feedback on PA level for the participant (e.g. visual feedback from the activity tracker or feedback from a therapist), alone, or in combination with other interventions, were included. Studies that only used activity trackers to measure activity of the upper body were excluded from this review.

Type of control group

Usual care or an intervention with activity trackers without any form of feedback on PA level.

Type of outcomes

The main outcomes of this review were PA and physical functioning. For this study, we used the definition of physical activity defined by the World Health Organization (WHO), i.e. any bodily movement produced by skeletal muscles that requires energy expenditure.[29] Up until now there is no consensus on the definition of physical functioning. For this study, physical functioning was defined as the ability to perform both basic and instrumental activities of daily living, this definition is more often used in other studies.[30] Studies were eligible if they had included an objectively measured outcome of PA (i.e. steps per day or active minutes per day) or if they had measured physical functioning by means of performance-based measures or by patient-reported measures (PROM) of function.

Data extraction

The following study characteristics were extracted from the included RCTs: author, year of publication, study population, group characteristics, setting, description of the intervention, intervention characteristics, description of the control group and outcome measures of the primary outcomes for this review. The following intervention characteristics were extracted: duration, coaching by a health professional during the intervention (yes/no), theory mentioned (e.g. social cognitive theory)(yes/no) and type of activity tracker. If an article reported multiple comparisons, we only extracted data from the groups of interest. For the outcome PA, we extracted steps per day if available. We had chosen for steps/day because this is the most common used outcome for PA and is currently the most convenient to interpret. When this data was not available, we extracted another outcome measured with the accelerometer (e.g. active minutes per day). For the outcome physical functioning, we had chosen to extract the most task-specific test (e.g. Short Physical Performance Battery rather than a muscle strength test), because task-specific tests are more indicative of patients ADL-functioning. The data was extracted by one reviewer and verified by a second reviewer. Disagreements were resolved by discussion.

Coding of behaviour change techniques

The BCT taxonomy (v1) of 93 hierarchically cluster techniques from Michie et al. was used to identify and code the BCTs reported in the intervention.[21] The most comprehensive description of the intervention was used (e.g. study protocol). Coding was carried out by one reviewer (ML) and a second independent reviewer (PB) double coded a random 20% of all descriptions to check for reliability. Disagreements were resolved via discussion. Cohen's kappa was used to measure the agreement between the reviewers. Both reviewers completed the BCT taxonomy v1 Online Training. The BCTs in the intervention and control group were identified separately and only the BCTs exclusively used in the intervention group were extracted. In addition, the total number of BCTs used in the intervention were recorded.

Evaluation of the methodological quality

The Physiotherapy Evidence Database (PEDro) scale was used to assess the methodological quality of the individual studies. The PEDro scale is a valid and reliable tool for assessing methodological quality of clinical trials and randomized controlled trials.[31, 32] The PEDro scale consists of 11 items; eight items (item 2-9) are used to asses internal validity and two (item 10-11) items are used to assess interpretability of the results. The first item, which assesses the external validity, is excluded in calculating the total score (following the methods of the PEDro score). [33] Therefore, the score ranges from 0 to 10 points. A higher score indicates a lower risk of bias. Trials with a score of ≥ 6 were considered as 'low risk' of bias. Trials were considered as 'high risk' of bias if they had a score < 6.[32] Quality assessment was independently conducted by two reviewers. Disagreement between the reviewers was discusses with a third reviewer (MvdL). Cohen's kappa was used to measure the agreement between the reviewers.

Data Analysis

Outcomes of the studies were collected at baseline, during the intervention, post-intervention (within one month after the end of the intervention period) and long term follow up if available. Outcomes not included in the meta-analyses were presented descriptively.

Meta-analysis

A meta-analysis was conducted for the post-intervention outcomes of PA and physical functioning. The studies varied in the use of statistics and reporting of the effect sizes. The mean difference and standard deviation (SD) between baseline and post-intervention were extracted. If not reported in the study results, the mean difference and SD were calculated. In case data was missing to calculate the mean difference, authors were contacted. If only median and interquartile ranges (IQR) were reported, the sample mean and standard deviation were estimated following the method of Wan et al.[34]

The software program Review Manager (version 5.3.5) was used to conduct the meta-analysis. Included studies were assessed on statistical and clinical heterogeneity by inspection of the forest plots and the I^2 statistics. If no considerable between-group statistical or clinical heterogeneity was detected, the fixed effects model was used; otherwise, a random effects model was used. Meta-analysis was performed to calculate the pooled treatment effect size with a 95% confidence interval for both outcomes. Results were visually presented using forest plots. An effect size of 0.2 was considered as small, 0.5 as moderate and 0.8 or higher as large.[35] A funnel plot and Egger's regression test was used to assess the presence of publication bias. If Egger's regression test shows a significance level ≤ 0.05, there is a high probability of publication bias. Leave-one-out sensitivity analysis was conducted in order to confirm that the results were not driven by any single study.

Subgroup-analyses

For this review a broad population has been included, therefore the different study populations were expected to be heterogeneous. To explore the contribution of different study characteristics on the overall outcome, pre-specified subgroup analyses were conducted for the following possible moderators: (1) setting (hospitalization vs rehabilitation), (2) period of intervention (during and/or after the inpatient period), (3) duration of the intervention (≤3 months or > 3 months) and the age group of the participants (mean age ≤ 60 years or mean age > 60 years). In addition, subgroup analyses were performed on methodological quality (low risk of bias vs. high risk of bias) to explore if the methodological quality has affected the overall effect size. Cochrane's Q test was performed to test whether there was a significant moderation effect ($p < 0.05$).

Given the small number of included studies and the large variety in combination of coded BCTs, it was not possible to determine the effect of combinations of different BCTs using meta-regression. It was decided not to perform sub-analysis of individual BCTs, because it is suggested that a combination of different BCTs is more important than the effect of a single BCT. [36] Therefore, subgroup analyses were conducted in the following intervention characteristics: (1) number of BCTs used in the intervention, theory-based interventions (yes/no) and (3) coaching by a health professional (yes/no). The cut-off value for the subgroup analysis of the number BCTs was determined by the mean number of BCTs used in the included studies. In addition, it was investigated how the use of BCTs differed between these subgroups.

RESULTS

Study selection

After removing duplicates from the initial search, a total of 7457 articles were screened on title and abstract. Of the 128 articles screened on full-text, 107 articles were excluded. Reasons for exclusion are shown in the flow diagram (Figure 1). A total of 21 RCTs were included in this review, totalling 2355 patients.

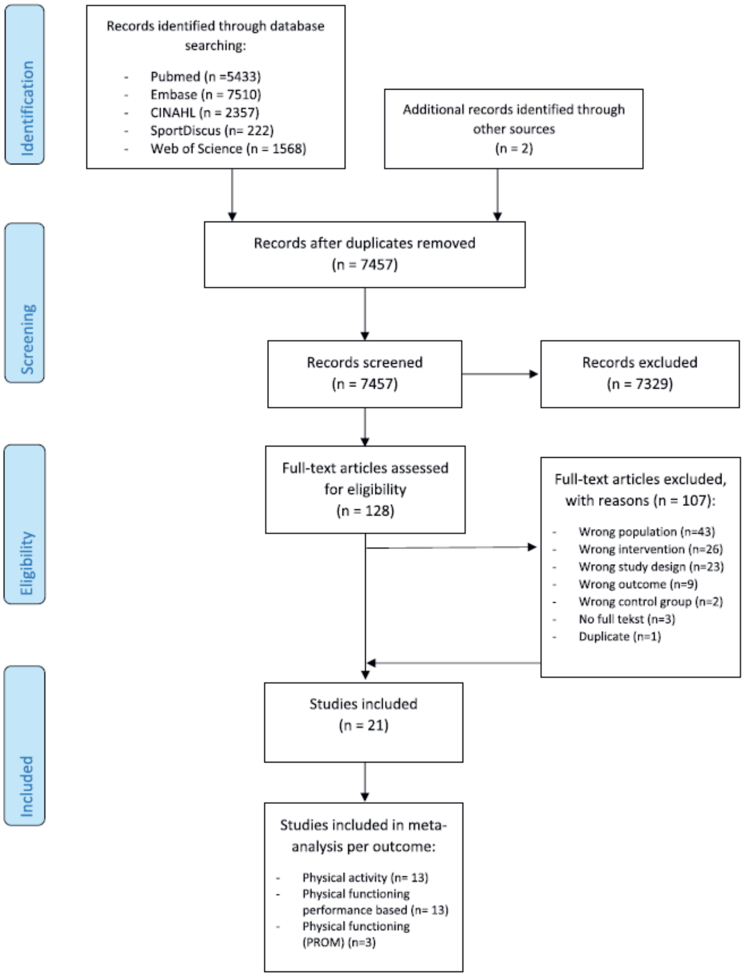


Figure 1. Flow diagram of selected studies (PRISMA)

Study characteristics

With the exception of the study of Izawa et al. (2005) [37], all trials were published between 2011 and 2020. The number of participants per study ranged from 30 to 344. The following patient populations were present in the included studies: patients with neurological diseases[38-42], patients with cardiovascular diseases[37, 43-45], patients after orthopaedic surgery[46-50], patients after abdominal surgery [51, 52], oncological patients [53], patients with COPD [54], patients after bariatric surgery [55], older patients admitted to post-acute care rehabilitation [56] and patients with low functional independence[57]. Eight trials were performed during the inpatient period, eight after the inpatient period and five trials both during and after the inpatient period. Eleven trials were performed during and/or after hospitalization, ten trials were performed during and/or after inpatient rehabilitation. Other study characteristics are presented in Table 1.

BCT coding

Overall, 20 of the 93 BCTs were coded exclusively in the intervention group compared to the control group. In two studies, two different interventions were included in the analyses; these interventions were coded on BCTs separately.[50, 55] Cohen's kappa between both reviewers (ML & PB) was 0.93. One BCT was coded by the second reviewer, who checked 20% of the trials, which was not coded by the first reviewer. Therefore, all other trials were checked again for that specific BCT. Overall, an agreement between the reviewers was reached.

The amount of BCTs used in the included interventions ranged from 1 to 12, with a mean of 6.2 (SD = 2.96). The BCT feedback on behaviour was used in all interventions (n=23). Other commonly used BCTs were goal setting (behaviour)(n=15), action planning (n=12), self-monitoring of behaviour (n=15), graded tasks (n=12) and adding objects to the environment (n=15). An overview of the coded BCT per intervention is presented in Electronic Supplementary Material Table S2.

Methodological quality

The results of the Risk of Bias assessment are presented in Table 2. Cohen's kappa between both reviewers was 0.79 (ML & PB). After discussion, full consensus was reached between both reviewers. The PEDro score of the included trials ranged from 3 to 8. Thirteen trials were judged as low risk of bias and eight trials as high risk of bias. With the exception of one trial [55], all studies had clearly specified the eligibility criteria. The study of Brandes et al. (2018) performed a pseudo-randomization and was therefore negatively assessed on the randomization procedure. Blinding of participants and therapists was not possible in any study due to the intervention setting.

Table 1. Characteristics of included RCT's

Author (year)	Population	Group characteristics, sample size; n, male; n(%), age; mean ±SD	Setting	Intervention					Control	PA outcome measure(s)**	PF performance-based outcome measure(s)**	PF patient reported outcome measure**	Short conclusion
				Descriptive	duration	Coaching by a health professional	Theory used	Type of activity tracker					
Atkins (2019) [57]	Patients with lower initial function independence measure scores and longer anticipated length of stay.	Intervention: n = 39, 20 (51), 74 ± 17 Control: n = 39, 12 (31), 78 ± 18	During inpatient rehabilitation	Usual care + pedometer with feedback on step count	1 month*	No	NA	Yamax Digiwalker SW200 pedometer	Usual care + pedometer without feedback on step count.	**Steps/day (D)** Daily upright time	**Morton mobility index (DEMMI) (P)**	NA	Pedometers without targets do not improve functional mobility
Brandes (2018) [46]	Patients after primary, unilateral joint replacement due to knee or hip osteoarthritis	Intervention: n = 23, 11 (48), 71 ± NA Control: n = 26, 12 (46), 70 ± NA	During inpatient rehabilitation	Usual care + activity tracker with physical activity counselling with tailored approach by adding +5% in daily steps compared to the previous days	3 weeks*	Yes (RL)	NA	Step Activity Monitor 3.0	Usual care	**Steps/day (P, FU)** Active minutes/day Inactive time	NA	**Oxford hip/knee score (P, FU)**	PA counselling during inpatient rehabilitation did not improve PA or functional outcomes
Christiansen (2020) [49]	Patients after a unilateral total knee replacement	Intervention: n=20, 12 (60), 66.5 ± 6.9 Control: n=23, 8 (35), 67.5 ± 7.2	After hospital discharge	Usual outpatient physiotherapy care + activity tracker with weekly steps/day goal and monthly follow-up calls	10 weeks outpatient physiotherapy* + 6 months follow up	Yes (RL+OD)	NA	Fitbit Zip	Usual outpatient physiotherapy care	**Steps/day (P, FU)** Minutes in moderate – vigorous PA	NA	NA	A PA intervention with supervision is feasible and may increase PA
Creel (2016) [55]	Patients after bariatric surgery	Intervention 1: n = 52, 8 (15), 42 ± 11 Intervention 2: n = 48, 8 (17), 44 ± 12	After hospital discharge	1)Pedometer intervention: Usual care + Pedometer + information sheet to increase PA to 10.000 steps/day	6 months	1)No 2)Yes (RL)	1)NA 2)Self-determination theory	Omron HJ 113 pedometer	Usual care	**Steps/day (D, P)** % time spent in sedentary activity	**Submaximal graded exercise test (P)**	NA	A counselling intervention using pedometers increased PA in the perioperative period

5

		Control: n = 50, 8 (16), 44 ± 11		2)Counseling intervention: Usual care + Pedometer + exercise counseling with Motivational Interviewing (MI)									
Dorsch (2015) [38]	Patients with stroke	Intervention: n = 78, 31 (40), 62 ± 16 Control: n = 73, 28 (38), 65 ± 13	During inpatient rehabilitation	Speed feedback + results and feedback on their summary activity graphs with a therapist	21 days*	Yes (RL)	NA	Tri-axial accelerometer (Gulf Coast Data Concepts)	Speed feedback only: verbal feedback about walking speed after 10m walking test.	**Time spent walking (P)**	**3-minute walking test (P)** 150m walking speed test	NA	Augmented feedback did not improve walking outcomes
Frederix (2015) [43]	Patients with acute coronary syndrome after a percutaneous coronary intervention or coronary artery bypass graft	Intervention: n = 32, 26 (81), 58 ± 9 Control: n = 34, 29 (85), 63 ± 10	During phase II cardiac rehabilitation.	Exercise training at home with telemonitoring support with accelerometers to encourage patients to increase his/her daily amount of steps wit 10% each week from baseline.	18 weeks	No	NA	Triaxial accelerometer (Yorbody company)	Exercise training in the hospital's rehabilitation centre	NA	**Maximal cardio-pulmonary exercise test (P)**	NA	PA monitoring might be effective to maintain exercise tolerance
Hassett (2020) [42]	Adults with mobility limitations undertaking aged care and neurological inpatient rehabilitation	Intervention: n = 149, 77 (52), 70 ± 18 Control: n = 151, 74 (49), 73 ± 15	During and after inpatient rehabilitation	Usual care + activity monitor, virtual reality video games and handheld computer devices with support by a physiotherapist	6 months	Yes (RL+OD)	NA	Fitbit Zip, One and Alta	Usual care	**Steps/day (D,P)** Time spent walking/day % of the day spent upright	**Short Physical Performance Battery (SPPB) (P)** DEMMI Step test	NA	The use of digitally enabled rehabilitation improved mobility
Hornikx (2015) [54]	Patients with COPD, hospitalized for an exacerbation of COPD	Intervention: n = 15, 8 (53), 66 ± 7 Control: n = 15, 9 (60), 68 ± 6	After hospital discharge	Pedometer + physical activity counselling with personalized goals	1 month	Yes (OD)	NA	Fitbit Ultra pedometer	Usual care	**Steps/day (P)** Time spent walking/day	**Six minutes walking test (P)** Quadriceps muscle strength	NA	PA counselling with pedometer feedback did not improve PA or clinical outcomes

Houle (2011) [44]	Patients < 80 years hospitalized for an acute coronary syndrome	Intervention: n = 32, 26 (81), 58 ± 8 Control: n = 33, 25 (76), 59 ± 9	After hospital discharge	Home based cardiac rehabilitation program + pedometer + exercise counseling by clinical nurse specialist with a target of 3000 steps per day increment in physical activity	12 months	Yes (RL+OD)	Social Cognitive theory	Yamax Digiwalker SW-200	Usual care	**Steps/day (D, P)**	NA	NA	A pedometer intervention was useful to improve average steps/day
Izawa (2005) [37]	Patients after completion of an acute-phase inpatient cardiac rehabilitation program	Intervention: n = 24, 21 (88), 64 ± 10 Control: n = 21, 17 (81), 65 ± 10	After inpatient rehabilitation	Usual care + self-monitoring of physical activity with feedback from a physical therapist	5 months	Yes (RL)	Bandura's self-efficacy theory	Kenz Liferecorder pedometer	Usual care	Steps/day (FU)	**Cardio-pulmonary exercise test (P)** Hand grip strength Quadriceps muscle strength	NA	Self-monitoring of PA may effectively increase PA
Izawa (2012) [45]	Consecutive cardiovascular patients	Intervention: n = 52, 41 (79), 59 ± 8 Control: n = 51, 42 (82), 59 ± 13	During hospitalization until the first outpatient contact with a physician after discharge.	Usual care + self-monitoring of physical activity with feedback from a physical therapist	7 weeks*	Yes (RL)	Self-efficacy theory of Bandura and Oka	Kenz Lifecorder EX 1-axial accelerometer	Usual care	**Steps/day (P)**	NA	NA	Self-monitoring of PA might effectively increase PA
Kanai (2018) [39]	Patients with acute ischemic stroke	Intervention: n = 23, 15 (65), 67 ± 10 Control: n = 25, 13 (52), 63 ± 9	During hospitalization	Usual care + self-monitoring of physical activity with feedback from a physical therapist	12 days*	Yes (RL)	Self-efficacy theory of Bandura	Fitbit One	Usual care	**Steps/day (P)**	NA	NA	Exercise training with accelerometer-based feedback effectively increased PA

Lawrie (2018) [40]	Patients with recent stroke during rehabilitation	Intervention: n = 14, 10 (71), 53 ± 12 Control: n = 16, 13 (81), 62 ± 12	During inpatient rehabilitation	Usual care + smartwatch with visual feedback and a set goals based on a 5% increase in the total activity.	3 weeks*	No	NA	ZGPAX S8 Android smartwatch	Usual care + smartwatch with limited visual feedback without goal setting.	NA	**Barthel Index (P)** 10m walk test Hand grip strength	NA	No effect was found on functional outcome
Mansfield (2015) [41]	Patients with sub-acute stroke attending inpatient rehabilitation	Intervention: n =29, 20 (69), 64 ± 19 Control: n = 28, 16 (57), 62 ± 13	During inpatient rehabilitation	Usual care + accelerometer-based daily walking activity reports with feedback from a physical therapist	2 weeks*	Yes (RL)	NA	Two tri-axial accelerometers (Gulf Data Concepts)	Usual care	**Steps/day (P)** Time spent walking/day	**6-meter walk test (P)**	NA	Feedback did not increase the amount of walking
Mehta (2020) [50]	Patients after hip or knee arthroplasty	Intervention: n=118, 38 (24), median age 66 (IQR 60-73) Control: n=124, 25 (20), median age 66 (IQR 57-73)	After hospital discharge	1) Intervention A: Usual care + remote monitoring alone 2)Intervention B: Usual care + remote monitoring with gamification and social support	45 days	1)No 2)No	NA	Withings physical activity monitor	Usual care	NA	**Timed up and Go test (P)**	NA	PA monitoring did not improve functional outcomes
Moller (2015) [53]	Inactive patients with breast or colon cancer referred to adjuvant chemotherapy	Intervention: n = 14, 1 (7), 48 ± 8 Control: n = 16, 2 (13), 47 ± 9	After surgery, during adjuvant chemotherapy	Usual care + Home-based individual progressive pedometer intervention with health promotion counselling and symptom management by a clinical nurse specialist	12 weeks	Yes (RL)	NA	Omron Walking Style Pro pedometer	Usual care	NA	**Cardio-respiratory fitness test (P)** Muscle strength (leg press and chest press)	NA	No effect was found on functional outcomes
Peel (2016) [56]	Patients admitted to post-acute care rehabilitation (aged 60 years and older)	Intervention: n = 128, 50 (39), 81 ± 9 Control: n = 127, 57 (45), 82 ± 8	During inpatient rehabilitation	Usual care + accelerometer based feedback and goal setting on daily walking time by therapist	4 weeks	Yes (RL)	NA	Triaxial ALIVE Heart and Activity Monitors and ActivPAL	Usual care	**Non-therapy walking time (D, P)**	**Short Physical Performance Battery (SPPB) (P)**	NA	Daily feedback on PA using accelerometers increased walking time

Pol (2019) [47]	Patients > 65 years old after hip fracture	Intervention: n =76, 11 (14), 84 ± 7 Control: n =87, 21 (24), 83 ± 7	During and after institutional-ization in a skilled nursing facility	Usual occupational care + Cognitive Behavioural Treatment (CBT) + sensor monitoring	4 months	Yes (RL)	Self-efficacy theory of Bandura	PAM AM300	Usual occupational care + CBT	NA	**Performed-Oriented Mobility Assessment (POMA) (P, FU)** Timed up and Go test	**Canadian Occupational Performance Measure (COPM) – performance scale (P, FU)**	Sensor monitoring occupation therapy was more effective in improving patient reported daily functioning than usual care
Van der Meij (2018) [51]	Adult patients scheduled for laparoscopic adnexal surgery, laparoscopic or open hernia inguinal surgery or laparoscopic cholecystectomy	Intervention: n = 173, 78 (45), 52 ± NA Control: n = 171, 79 (46), 51 ± NA	During and after hospitalization	Usual care + Personalized E-health program including self-monitoring on PA	6 weeks	Yes (OD)	NA	UP MOVE, Jawbone	Usual care	NA	NA	**Patient Reported Outcomes Measurement Information System (PROMIS) – Physical Functioning (P)**	A personalised e-health program speeds up the return to normal activities compared to usual care
Van der Walt (2018) [48]	Adults undergoing primary elective hip or knee arthroplasty	Intervention: n = 81, 45 (56), 67 ± 9 Control: n = 82, 36 (44), 66 ± 9	During and after hospitalization	Usual care + activity tracker with daily step goals	6 weeks	No	NA	Garmin Vivofit 2	Usual care + activity tracker with obscured display	**% of preoperative step count (D, P, FU)**	NA	Knee Injury and osteoarthritis outcome score (KOOS) (FU)	Patients who received feedback from a activity tracker had significant higher activity levels
Wolk (2019) [52]	Patients scheduled for elective open and laparoscopic surgery of the colon, rectum, stomach, pancreas or liver.	Intervention: n = 27, 16 (59), 61 ± 10 Control: n = 27, 19 (70), 56 ± 11.1	During the first 5 postoperative days	Usual care + activity trackers with daily step goals	5 days	No	NA	Polar Loop activity tracker	Usual care + activity tracker with obscured display	**Steps/day (P)**			

NA = not applicable, *dependent on admission time, RL = real life, OD = on distance, D=during the intervention, P=post-intervention, FU = long term follow up, **Bold = included in meta-analysis

Table 2. Risk of bias assessment of included studies (n=21)

	Eligibility criteria were specified	Subjects were randomly allocated to groups	Allocation concealment	Groups were similar at baseline	Subject blinding	Therapist blinding	Assessor blinding	Drop out < 15%	Intention-to-treat analysis	Between-group difference reported	Point estimate and variability reported	Overall risk of bias
Atkins 2019	+	+	+	+	−	−	+	+	+	+	+	+
Brandes 2018	+	−	−	+	−	−	−	−	?	+	+	−
Christiansen 2020	+	+	+	+	−	−	+	−	?	+	+	+
Creel 2016	−	+	+	+	−	−	−	−	+	+	+	+
Dorsch 2016	+	+	+	+	−	−	+	−	?	+	+	+
Frederix 2015	+	+	+	+	−	−	−	−	?	+	+	−
Hassett 2020	+	+	+	+	−	−	+	+	+	+	+	+
Hornikx 2015	+	+	?	+	−	−	−	+	?	+	+	−
Houle 2011	+	+	+	+	−	−	−	+	+	+	+	+
Izawa 2005	+	+	?	+	−	−	−	+	?	+	+	−
Izawa 2012	+	+	?	+	−	−	−	−	?	+	+	−
Kanai 2018	+	+	+	+	−	−	−	+	?	+	+	+
Lawrie 2018	+	+	+	−	−	−	+	−	?	−	+	−
Mansfield 2015	+	+	+	+	−	−	+	+	+	+	+	+
Mehta 2020	+	+	+	+	−	−	?	−	+	+	+	+
Moller 2015	+	+	+	+	−	−	−	−	+	−	+	−
Peel 2016	+	+	+	+	−	−	+	+	+	+	+	+
Pol 2019	+	+	−	+	−	−	+	−	+	+	+	+
Van der Meij 2018	+	+	+	+	−	−	−	+	+	+	+	+
Van der Walt 2018	+	+	+	+	−	−	−	−	+	+	+	+
Wolk 2019	+	+	+	−	−	−	−	−	+	+	+	−

Primary outcomes

Physical activity

Of the 21 included studies, 15 studies measured the effect of the intervention on objectively measured PA.[37-39, 41, 42, 44-46, 48, 49, 52, 54-57] The most frequent outcome measure of PA was steps per day, which was used in eleven studies.[37, 39, 41, 42, 44-46, 49, 54, 55, 57] Other outcome measures of PA were time spent walking [38], non-therapy walking time [56], percentage of preoperative step count at follow up [48] and mean step count during the first five postoperative days [52]. Six studies reported PA during the intervention of which five studies showed a significant positive effect in favour of the intervention group compared to the control group.[48, 55-58] The post-intervention outcome was reported in 13 studies; seven studies showed a significant positive effect in favour of the intervention group [39, 44, 45, 48, 49, 55, 56] and one study showed a significant positive effect in favour of the control group [52]. Four studies reported a long-term follow up of 6 months after intervention: three studies reported a significant positive effect in favour of the intervention group.[37, 48, 49]

Meta-analysis was conducted for the mean difference between baseline and post-intervention comparing the intervention and control group, for which 13 studies provided data. Of these, only four studies reported the mean difference between baseline and post-intervention [38, 48, 52, 54], therefore the mean difference had to be calculated for the other studies. Three authors were contacted with success, because data to measure the mean difference was not available.[48, 55, 56] In the study of Creel et al. [55] and the study of Wolk et al. [52], data analysis was performed in two different population groups: these groups have been included separate in the meta-analysis.

Data was pooled in a random effects meta-analysis using data from 1435 participants (729 intervention/706 control). The model resulted in an overall estimated effect size in terms of standardized mean difference (SMD) of 0.34 (95%CI 0.12; 0.56) indicating a significant effect in favour of the intervention group (p = 0.002). The level of heterogeneity (I^2) was 73% (Figure 2). The Funnel plot is presented in Electronic Supplementary Material Figure S1. Egger's regression test indicated no significant asymmetry of the funnel plot (Egger's Test = 0.205 p = 0.373). The SMD of Izawa et al. (2012) and Wolk et al. (open surgery) deviated the most from the overall effect size (SMD 1.42 and -0.54, respectively). However, leave-one-out sensitivity analysis showed that the effect sizes remained within the 95%CI after iteratively removing both studies from analysis (SMD 0.26, 95%CI 0.09;0.43, p = 0.003 resp. SMD 0.40, 95%CI 0.19; 0.60, p =0.0002).

	Intervention			Control				Std. Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Brandes 2018	-233	2,525.5	23	-500	2,517.2	26	5.9%	0.10 [-0.46, 0.67]
Christiansen 2020	3,245	2,072.9	17	1,727	1,652.4	19	5.0%	0.80 [0.11, 1.48]
Creel (C) 2016	1,593	2,408.9	35	1,117	2,269.3	37	6.8%	0.20 [-0.26, 0.66]
Creel (P) 2016	610	2,448.7	35	1,117	2,269.3	37	6.8%	-0.21 [-0.68, 0.25]
Dorsch 2016	16.6	14.3	67	15.1	13.1	58	7.8%	0.11 [-0.24, 0.46]
Hassett 2020	3,288	2,257.6	146	2,543	2,369.4	124	8.8%	0.32 [0.08, 0.56]
Hornikx 2015	984	1,208	12	1,013	1,275	15	4.5%	-0.02 [-0.78, 0.74]
Houle 2011	4,005	3,264.1	32	1,933	3,249.5	33	6.5%	0.63 [0.13, 1.13]
Izawa 2012	4,021.6	2,609	52	357.7	2,499.2	51	7.1%	1.42 [0.99, 1.86]
Kanai 2018	2,453.7	2,131.8	23	708.6	1,301	25	5.6%	0.98 [0.38, 1.58]
Mansfield 2015	904	2,903.6	29	669	2,522.6	28	6.3%	0.09 [-0.43, 0.60]
Peel 2016	10.1	18.5	126	5.2	16.2	125	8.7%	0.28 [0.03, 0.53]
Van der Walt 2018	103.2	39.3	76	85	38.9	74	8.1%	0.46 [0.14, 0.79]
Wolk (lap) 2019	2,227.2	2,038.4	29	1,371.5	1,251.8	27	6.2%	0.49 [-0.04, 1.03]
Wolk (open) 2019	927	829.4	27	1,496.6	1,212.3	27	6.1%	-0.54 [-1.08, 0.00]
Total (95% CI)			**729**			**706**	**100.0%**	**0.34 [0.12, 0.56]**

Heterogeneity: Tau² = 0.12; Chi² = 52.42, df = 14 (P < 0.00001); I² = 73%
Test for overall effect: Z = 3.09 (P = 0.002)

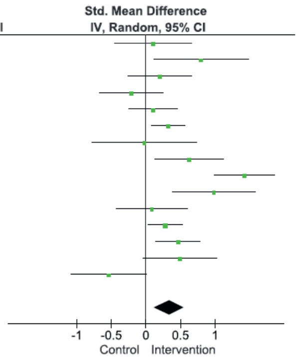


Fig. 2 Forest plot for the outcome physical activity

Physical functioning (performance based)

A total of 13 trials reported a performance based outcome of physical functioning.[37, 38, 40-43, 47, 50, 53-57] The most common used outcome measure was peak oxygen uptake (peak VO_2) measured during an cardiopulmonary exercise test and was reported in three studies.[37, 43, 53] Other outcome measures were the Short Physical Performance Battery [42, 56], three or six minutes walking distance [38, 54], the Morton Mobility Index [57], exercise tolerance (MET's) [55], the Barthel Index [40], walking speed [41], the Performance-Oriented Mobility Assessment [47] and the Timed Up and Go test [50]. All studies reported post-intervention outcome of which three reported a significant positive effect in favour of the intervention group.[41-43] Only the study of Pol et al. reported a long term follow-up, but did not found a significant effect.[47]

The mean difference was reported in two studies and had to be calculated for the other ten studies. The study of Creel et al. [55] included two different intervention groups (see Table 1), therefore these groups have been included separate in the meta-analysis. In the study of Moller et al. [53] data analysis was performed in two different population groups (colon and breast cancer). However, one group has been excluded for meta-analysis due to the low number of participants in both intervention and control group (n=4). In the study of Mehta et al., only the median and IQR were reported, therefore the sample mean and SD were estimated as described in the method section. Data was pooled in a random effects model meta-analysis including 1415 participants (696 intervention/719 control). The model resulted in an overall estimated effect size in terms of standardized mean difference of 0.09 (95%CI -0.02; 0.20, I^2

= 8%). No significant effect was found between groups (P = 0.11) (Figure 3). Funnel plot (Electronic Supplementary Material Figure S2) and Egger's regression test indicated that publication bias was unlikely to have influenced de results (Egger's Test = -0,063; p = 0.914).

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Fixed, 95% CI
Atkins 2019	12.6	14.5	36	14.8	13.9	32	4.8%	-0.15 [-0.63, 0.32]
Creel (C) 2016	1.6	5.8	24	1.2	7.3	36	4.1%	0.06 [-0.46, 0.58]
Creel (P) 2016	1.5	5.5	24	1.2	7.3	36	4.1%	0.04 [-0.47, 0.56]
Dorsch 2016	56.2	68.7	72	57.7	70.5	63	9.6%	-0.02 [-0.36, 0.32]
Frederix 2015	4	6.5	32	1	6	34	4.6%	0.47 [-0.02, 0.96]
Hassett 2020	0.8	0.7	128	0.6	0.8	129	18.2%	0.27 [0.02, 0.51]
Hornikx 2015	67	84	12	64	59	15	1.9%	0.04 [-0.72, 0.80]
Izawa 2005	5.5	3.7	24	4.5	5.4	21	3.2%	0.21 [-0.37, 0.80]
Lawrie 2018	3	3.85	14	1	4.3	16	2.1%	0.47 [-0.25, 1.20]
Mansfield 2015	0.2	0.2	18	0	0.3	17	2.3%	0.77 [0.08, 1.46]
Mehta 2020	23	11.6	118	24.2	14.1	123	17.2%	-0.09 [-0.35, 0.16]
Moller (breast) 2015	-4.7	6.4	10	-2.8	5.9	10	1.4%	-0.30 [-1.18, 0.59]
Moller (colon) 2015	3.6	5.2	2	13.5	10.2	2		Not estimable
Peel 2016	1.8	2.5	128	1.6	2.5	127	18.2%	0.08 [-0.17, 0.33]
Pol 2019	5.11	4.26	56	5.37	4.34	60	8.3%	-0.06 [-0.42, 0.30]
Total (95% CI)			**696**			**719**	**100.0%**	**0.09 [-0.02, 0.19]**

Heterogeneity: Chi² = 14.18, df = 13 (P = 0.36); I² = 8%
Test for overall effect: Z = 1.67 (P = 0.09)

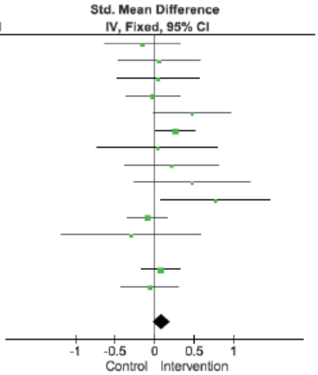


Fig. 3 Forest plot for outcome performance based physical functioning

Physical functioning (patient reported)

Four studies reported a PROM of physical functioning.[46-48, 51] The study of Brandes et al. used the Oxford knee/hip score as outcome, but did not find a significant difference between the intervention and control group post-intervention or at 6 months follow up.[46] Also in the study of Van der Walt et al., no significant effect was found at six months follow up on the Knee Injury and Osteoarthritis Outcome Score.[48] On the other hand, a significant positive treatment effect was found on the Canadian Occupational Performance Measure (COPM) post intervention and at six months follow-up in the study of Pol et al. [47] In the study of van der Meij et al, a significant positive effect on the median days return to normal activities, measured with the Patient Reported Outcomes Measurement Information System – Physical Functioning (PROMIS-PF), was found in favour of the intervention group.[51] However, no significant difference between groups was found in the PROMIS-PF post-intervention compared to baseline.

Overall, meta-analysis of patient reported outcome of physical functioning post-intervention using a random effects model resulted in an overall estimated effect size of 0.15 (95% CI -0.18; 0.47) (Figure 4). A funnel plot and Eggers test was not performed because of the low number of included studies.

Study or Subgroup	Intervention Mean	Intervention SD	Intervention Total	Control Mean	Control SD	Control Total	Weight	Std. Mean Difference IV, Random, 95% CI
Brandes 2018	19.2	17.1	23	12.2	17.4	26	20.3%	0.40 [-0.17, 0.97]
Pol 2019	4.03	1.68	76	3.54	1.6	87	36.1%	0.30 [-0.01, 0.61]
Van der Meij 2018	-26.3	7.5	163	-25.6	7.4	167	43.5%	-0.09 [-0.31, 0.12]
Total (95% CI)			**262**			**280**	**100.0%**	**0.15 [-0.18, 0.47]**

Heterogeneity: Tau² = 0.05; Chi² = 5.58, df = 2 (P = 0.06); I² = 64%
Test for overall effect: Z = 0.90 (P = 0.37)

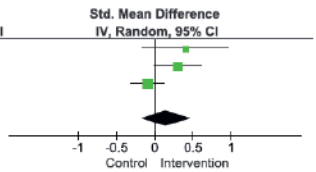


Fig. 4 Forest plot for patient reported outcome measure of physical functioning

Subgroup analysis study characteristics

Meta-analysis for PA presented high heterogeneity (73%, see Figure 2), therefore subgroup analyses were conducted to explore the contribution of different study characteristics on the overall effect. No significant differences were found between subgroups (Table 3). However, interventions that took place both during and after the inpatient period showed a high significant effect in favour of the intervention group (SMD = 0.71, 95%CI 0.13;1.29), whereas interventions that only took place during or after the inpatient period did not reveal significant effects (SMD = 0.21, 95%CI -0.07; 0.48 resp. SMD = 0.26, 95%CI -0.11; 0.64). This also applies for the age group, however differences in effect sizes were less in these groups (Table 3). Methodological quality had no significant effect on effect size (p = 0.97): studies with a higher risk of bias did not result in different effect sizes.

Subgroup analysis for the outcome performance based and patient reported physical functioning were not conducted, because the meta-analysis either presented low heterogeneity (I^2 = 8%) or included a low number of studies.

Table 3. Subgroup analysis study characteristics

Study characteristics	Outcome PA (n=15)				
	n	Combined sample size	Pooled mean SMD (95% CI)	Q	p
Setting				0.88	0.35
- Hospitalization	10	683	0.43 (0.06; 0.79)*		
- Rehabilitation	5	752	0.24 (0.10; 0.38)*		
Period				2.38	0.30
- During	7	640	0.21 (-0.07; 0.48)		
- After	5	272	0.26 (-0.11; 0.64)		
- During and after	3	523	0.71 (0.13; 1.29)*		
Duration of the intervention				0.04	0.84
- ≤3 months	10	920	0.35 (0.04; 0.66)*		
- >3 months	5	515	0.31 (0.02; 0.60)*		
Age group				0.00	0.95
- Mean age ≤ 60 years	6	422	0.34 (-0.23; 0.91)		
- Mean age > 60 years	9	1013	0.32 (0.16; 0.48)*		
Risk of Bias				0.00	0.97
- Low risk	10	1146	0.32 (0.15; 0.49)*		
- High risk	5	289	0.31 (-0.42; 1.04)		

*p<0.05, Q = cochrane's Q

Subgroup analysis intervention characteristics

The mean number of BCTs in the included interventions was 6.4. Therefore, subgroup analysis was conducted for interventions with ≥ 7 BCTs and < 7 BCTs. Interventions with ≥ 7 BCTs showed an significant effect on PA (SMD = 0.60, 95%CI 0.18;1.02, p = 0.005), whereas interventions with < 7 BCTs did not (SMD = 0.18, 95%CI -0.04;0.39, p = 0.11). The forest plot is presented in Electronic Supplementary Material Figure S3. The following BCTs were only used in the subgroup with ≥ 7 BCTs: problem solving (n=5), instructions on how to perform a behavior (n=3), information about health consequences (n=1), information about social and environmental consequences (n=1), social comparison (n=1), prompts/cues (n=3) and social reward (n=2).

The SMD of theory-based interventions with activity trackers was higher (SMD = 0.66, 95%CI 0.14; 1.18, p = 0.01) compared to interventions without a theoretical model (SMD = 0.20. 95%CI -0.00; 0.40, p = 0.04)(Electronic Supplementary Material Figure S4). The mean number of BCTs used in theory-based interventions was higher: 8.4 compared to 5.3. The BCTs that were exclusively coded in the subgroup with theory-based interventions were: information about health consequences (n=1), information about social and environmental consequences (n=1), social comparison (n=1) and social reward (n=2).

Interventions with coaching by a health professional showed a larger effect on PA (SMD = 0.44, 95%CI 0.19; 0.69, p = 0.0004) compared to interventions without coaching by a health professional (SMD = 0.07, 95%CI -0.42; 0.56, p = 0.78) (Electronic Supplementary Material Figure S5). In the interventions with supervision by a health professional more different BCTs were used: the mean number of BCTs was 6.8 compared to 4.8. The following BCTs were exclusively coded in interventions with coaching by a health professional: problem solving (n=5), review behaviour goals (n=4), instructions on how to perform a behaviour (n=3), information about health consequences (n=1), information about social and environmental consequences (n=1), social comparison (n=1), prompts/cues (n=3) and social reward (n=3).

DISCUSSION

The results of this systematic review and meta-analysis showed that interventions using activity trackers during and/or after an inpatient period are heterogeneous, but are generally more effective in increasing the level of PA compared to usual care. However, this does not necessarily translate into an improvement in physical functioning. There was high variability of study populations, characteristics and intervention strategies across the included studies. Subgroup analysis of study characteristics suggest that interventions taking place both during and after an inpatient period may be more effective in stimulating PA compared to interventions only during or only after inpatient treatment. In addition, interventions using more BCTs, theory based interventions and interventions in combination with coaching by a health professional also seem to increase the effect on the level of PA.

A small positive effect on PA in favour of the intervention group was found. These results are in line with the results of meta-analyses in other patient populations.[15-18] In the review of Braakhuis et al, a small positive effect of healthcare interventions using objective feedback on PA was found (SMD = 0.34, p<0.01) in a heterogeneous patient population (patients with COPD, stroke, cardio-vascular diseases, Parkinson's disease and geriatric patients).[18] A moderate positive effect on PA was found in a meta-analysis in people with type 2 diabetes (SMD 0.57, p<0.01) and in a meta-analysis in patients with COPD using step counters (SMD 0.57, p<0.05).[15, 17] A high positive effect on daily step count was found in a meta-analysis in patients with rheumatic and musculoskeletal diseases (SMD 0.83, $p<0.01$).[16] The lower effect in our study compared to these studies may be caused by patients experiencing more barriers to increase their level of PA during or after an inpatient period due to impact of the ‘acute event’ (e.g. having symptoms, such as pain or fatigue or due to overall reduced strength and condition as result of the acute event) compared to patients with chronic conditions in a daily life setting.[10, 11, 13]

Although a positive effect was found on PA in favour of the intervention group, no effect was found on the outcome physical functioning in our meta-analysis. In other patient populations, previous reviews have found conflicting results on the effectiveness of activity tracker interventions on physical functioning. A small significant positive effect was found on physical functioning in patients with COPD (SMD = 0.32, $p < 0.05$) [17], whereas no significant effect was found in patients with rheumatic and musculoskeletal diseases (SMD = 0.09, $p > 0.05$). [16] Of the individual included studies in our meta-analysis, two studies supported the effect that increased PA contributes to recovery in physical functioning.[42, 43] In contrast, no significant effect on physical functioning was found in four studies reporting a significant effect on PA in favour of the intervention group.[48, 55-57] One possible explanation for these differences in effectiveness is the timing of physical functioning measurements, as PA-interventions may have more effect on the rate than on the level of functional recovery. In other words, patients in the intervention group may have a physical functioning level similar to that of the control group after a certain time, but it may take them less time to reach that level. This could be particularly true in patient populations that fully recover to their pre-treatment physical functioning levels. Another explanation could be the very low number of studies that used a patient-reported outcome measure of physical functioning. Patient-reported outcomes are important because they can provide unique information on the impact of a medical condition and its intervention from the patient’s perspective. Finally, high variability in outcome measures and small sample sizes in our review lead to low certainty of evidence of the results for both performance-based and patient-reported physical functioning, according to the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[59] To gain a better understanding of the effect of interventions using activity trackers during and/or after an inpatient period, conducting clinical trials measuring both patient-reported and performance-based outcomes of physical functioning at multiple follow-up times is warranted.

Subgroup analysis of study characteristics suggested that interventions conducted both during and after an inpatient period may be more effective in increasing the level of PA. This may be explained by the fact that in the interventions during the inpatient period, activity trackers were often added to standard interventions aimed at improving PA, whereas in the interventions after discharge, the activity tracker was often the only component aimed at improving PA. Three studies that conducted the intervention only during inpatient rehabilitation also mentioned the high load of usual rehabilitation care in the control group as possible explanation that no significant effect on PA was found.[38, 41, 46] In most cases priority was even given in the intervention group to the rehabilitation goals of usual care instead of the experimental intervention goals (daily step count). Also, if the intervention starts during inpatient stay and continues after discharge, patients might be more aware of their PA behaviour being back at home. Therefore, it is suggested that these interventions may be more effective when implemented both during and after discharge.

Our results support previous studies suggesting that theory-based interventions are generally more effective in promoting PA.[23-26] It is assumed that in theory-based interventions, the active ingredients of the interventions are more carefully described and implemented. This is supported by our results of coded BCTs in both subgroups, as the mean number of coded BCTs was higher in theory-based interventions (8.4 vs. 5.7).

Interventions using a higher number of BCTs were found to be more effective in improving PA, as also found in other studies.[60, 61] This is in line with the finding that interventions with coaching by a health professional are more effective, because more different BCTs can be used if interventions are supported by a health professional (e.g. problem solving, social reward). Besides that, it is suggested that activity trackers as standalone intervention might not be sufficient for special patient populations, because most activity trackers do not include BCTs that are specific to a certain population.[22, 62] Incorporating coaching by a health professional to the intervention gives the opportunity to provide targeted advice and interventions for a specific population group with a more personal touch. These findings are also supported by earlier research.[27, 63]

Results suggest that interventions using activity trackers increase PA levels of surgical and non-surgical patients during and/or after an inpatient period. The advantage of activity trackers is the minimal burden on the user in relation to the data that can be produced, and the ability to provide real-time feedback on PA. Activity trackers can thereby motivate and support patients and reduce the time and resources required for traditional methods of ongoing support.

Strengths and limitations

To our knowledge, this is the first meta-analysis investigating the effect of interventions with activity trackers in patients during and/or after an inpatient period. The study provides insight into which intervention characteristics may improve the effectiveness, which can be helpful in the development of interventions with activity trackers in this population. An internationally validated taxonomy was used to identify BCTs in these interventions. Two trained researchers coded BCTs individually and agreement was received through discussion. Other strengths of this study are that only objective data of PA was used as outcome measurement for PA and that the outcome measurements were corrected for baseline status.

This study has also several limitations. First, there was considerable heterogeneity among the included studies in terms of study populations, duration of intervention and intensity of intervention. Because the high level of heterogeneity, standardized mean difference (SMD) was used. However, using SMD only partly resolves the problem of comparing different outcomes. Therefore, results should be interpreted carefully. Second, heterogeneity in the terminology and insufficient description of the active ingredients of the interventions impaired the coding of BCTs. As a result, it is likely that BCTs are underreported. Unfortunately, this problem is common in research on the effect of different BCTs.[64] Third, not all studies reported the mean difference between the post-intervention and baseline measurement. In these studies, the mean difference was calculated based on available or requested data. In the study of Hassett et al., this has led to a difference in significance of the outcome due to a different analysis method.[42] Our calculation of the mean difference in the study of Hassett et al. resulted in a significant effect on PA, whereas Hassett et al. reported a non-significance effect (p=0.09). However, the estimated effect was roughly similar to our result. Finally, the meta-analysis could only be conducted for short-term outcomes (post-intervention), due to the lack of long-term outcomes (e.g., three or six months of follow-up). However, it is likely that the effect of interventions and the role of BCTs differ between short- and long-term outcome assessments[65], so intervention studies are encouraged to include long-term outcome assessments.

CONCLUSION

Interventions using activity trackers during and/or after an inpatient period have the potential to increase the level of PA across a wide range of surgical and non-surgical populations. Despite the expectation that higher levels of PA have a positive effect on physical functioning, no significant effect on physical functioning was found. The intensity and quality of the interventions seem to improve by providing the intervention both during and after the inpatient period, by using more BCTs, integrating a theoretical model, and providing coaching by a healthcare professional, as a greater effect on PA increase has been found in studies using these intervention characteristics. Thus, interventions using activity trackers have the potential to be included as an effective tool to motivate patients and to assist health professionals to provide ongoing monitoring and support with minimal resource expenditure. However, results of this review should be interpreted carefully due to the high heterogeneity between studies. Future RCTs investigating the use of activity trackers should investigate the effect on the course of recovery in physical functioning and should pay attention to a sufficient description of the active ingredients of both the intervention and control conditions, enabling the comparison of different BCTs on outcomes of these interventions.

REFERENCES

1. Cabilan CJ, Hines S. The short-term impact of colorectal cancer treatment on physical activity, functional status and quality of life: a systematic review. JBI Database System Rev Implement Rep. 2017;15(2) doi:
2. van Zutphen M, Winkels RM, van Duijnhoven FJ, van Harten-Gerritsen SA, Kok DE, van Duijvendijk P, et al. An increase in physical activity after colorectal cancer surgery is associated with improved recovery of physical functioning: a prospective cohort study. BMC Cancer. 2017;17(1) doi:
3. Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg. 2004;199(5) doi:
4. Hara T, Kubo A. Relationship between physical activity and function in elderly patients discharged after surgical treatment for gastrointestinal cancer. J Phys Ther Sci. 2015;27(9) doi:
5. Askim T, Bernhardt J, Churilov L, Fredriksen KR, Indredavik B. Changes in physical activity and related functional and disability levels in the first six months after stroke: a longitudinal follow-up study. J Rehabil Med. 2013;45(5) doi:
6. van der Leeden M, Balland C, Geleijn E, Huijsmans RJ, Dekker J, Paul MA, et al. In-Hospital Mobilization, Physical Fitness, and Physical Functioning After Lung Cancer Surgery. Ann Thorac Surg. 2019;107(6) doi:
7. Hokstad A, Indredavik B, Bernhardt J, Langhammer B, Gunnes M, Lundemo C, et al. Upright activity within the first week after stroke is associated with better functional outcome and health-related quality of life: A Norwegian multi-site study. J Rehabil Med. 2016;48(3) doi:
8. Resnick B, Boltz M. Optimizing Function and Physical Activity in Hospitalized Older Adults to Prevent Functional Decline and Falls. Clin Geriatr Med. 2019;35(2) doi:
9. Brown CJ, Williams BR, Woodby LL, Davis LL, Allman RM. Barriers to mobility during hospitalization from the perspectives of older patients and their nurses and physicians. J Hosp Med. 2007;2(5) doi:
10. Hoyer EH, Brotman DJ, Chan KS, Needham DM. Barriers to early mobility of hospitalized general medicine patients: survey development and results. Am J Phys Med Rehabil. 2015;94(4) doi:
11. Granger CL, Connolly B, Denehy L, Hart N, Antippa P, Lin KY, et al. Understanding factors influencing physical activity and exercise in lung cancer: a systematic review. Support Care Cancer. 2017;25(3) doi:
12. Geelen SJG, Giele BM, Engelbert RHH, de Moree S, Veenhof C, Nollet F, et al. Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals. Disability and rehabilitation. 2021 doi:
13. Koenders N, Weenk M, van de Belt TH, van Goor H, Hoogeboom TJ, Bredie SJH. Exploring barriers to physical activity of patients at the internal medicine and surgical wards: a retrospective analysis of continuously collected data. Disability and rehabilitation. 2019 doi:

14. de Vries HJ, Kooiman TJ, van Ittersum MW, van Brussel M, de Groot M. Do activity monitors increase physical activity in adults with overweight or obesity? A systematic review and meta-analysis. Obesity (Silver Spring). 2016;24(10) doi:

15. Baskerville R, Ricci-Cabello I, Roberts N, Farmer A. Impact of accelerometer and pedometer use on physical activity and glycaemic control in people with Type 2 diabetes: a systematic review and meta-analysis. Diabet Med. 2017;34(5) doi:

16. Davergne T, Pallot A, Dechartres A, Fautrel B, Gossec L. Use of Wearable Activity Trackers to Improve Physical Activity Behavior in Patients With Rheumatic and Musculoskeletal Diseases: A Systematic Review and Meta-Analysis. Arthritis Care Res (Hoboken). 2019;71(6) doi:

17. Qiu S, Cai X, Wang X, He C, Zugel M, Steinacker JM, et al. Using step counters to promote physical activity and exercise capacity in patients with chronic obstructive pulmonary disease: a meta-analysis. Ther Adv Respir Dis. 2018;12 doi:

18. Braakhuis HEM, Berger MAM, Bussmann JBJ. Effectiveness of healthcare interventions using objective feedback on physical activity: A systematic review and meta-analysis. J Rehabil Med. 2019;51(3) doi:

19. Bell K. Remaking the self: trauma, teachable moments, and the biopolitics of cancer survivorship. Cult Med Psychiatry. 2012;36(4) doi:

20. Robinson A, Slight R, Husband A, Slight S. The value of teachable moments in surgical patient care and the supportive role of digital technologies. Perioper Med (Lond). 2020;9 doi:

21. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013;46(1) doi:

22. Lyons EJ, Lewis ZH, Mayrsohn BG, Rowland JL. Behavior change techniques implemented in electronic lifestyle activity monitors: a systematic content analysis. J Med Internet Res. 2014;16(8) doi:

23. Webb TL, Joseph J, Yardley L, Michie S. Using the internet to promote health behavior change: a systematic review and meta-analysis of the impact of theoretical basis, use of behavior change techniques, and mode of delivery on efficacy. J Med Internet Res. 2010;12(1) doi:

24. Gourlan M, Bernard P, Bortolon C, Romain AJ, Lareyre O, Carayol M, et al. Efficacy of theory-based interventions to promote physical activity. A meta-analysis of randomised controlled trials. Health Psychol Rev. 2016;10(1) doi:

25. Avery L, Flynn D, Dombrowski SU, van Wersch A, Sniehotta FF, Trenell MI. Successful behavioural strategies to increase physical activity and improve glucose control in adults with Type 2 diabetes. Diabet Med. 2015;32(8) doi:

26. Finne E, Glausch M, Exner AK, Sauzet O, Stölzel F, Seidel N. Behavior change techniques for increasing physical activity in cancer survivors: a systematic review and meta-analysis of randomized controlled trials. Cancer Manag Res. 2018;10 doi:

27. Spring B, Stump T, Penedo F, Pfammatter AF, Robinson JK. Toward a health-promoting system for cancer survivors: Patient and provider multiple behavior change. Health Psychol. 2019;38(9) doi:

28. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ (Clinical research ed). 2021;372 doi:

29. World Health Organization. Physical Activity: World Health Organization; 2020 [Available from:

30. Garber CE, Greaney ML, Riebe D, Nigg CR, Burbank PA, Clark PG. Physical and mental health-related correlates of physical function in community dwelling older adults: a cross sectional study. BMC geriatrics. 2010;10 doi:

31. de Morton NA. The PEDro scale is a valid measure of the methodological quality of clinical trials: a demographic study. Aust J Physiother. 2009;55(2) doi:

32. Maher CG, Sherrington C, Herbert RD, Moseley AM, Elkins M. Reliability of the PEDro scale for rating quality of randomized controlled trials. Physical therapy. 2003;83(8).

33. Cashin AG, McAuley JH. Clinimetrics: Physiotherapy Evidence Database (PEDro) Scale. J Physiother. 2020;66(1) doi:

34. Wan X, Wang W, Liu J, Tong T. Estimating the sample mean and standard deviation from the sample size, median, range and/or interquartile range. BMC Med Res Methodol. 2014;14 doi:

35. Cohen J. Statistical Power Analysis for the Behavioral Sciences. 2nd ed. New York: Routlegde; 1988.

36. Michie S, Abraham C, Whittington C, McAteer J, Gupta S. Effective techniques in healthy eating and physical activity interventions: a meta-regression. Health Psychol. 2009;28(6) doi:

37. Izawa KP, Watanabe S, Omiya K, Hirano Y, Oka K, Osada N, et al. Effect of the self-monitoring approach on exercise maintenance during cardiac rehabilitation: a randomized, controlled trial. Am J Phys Med Rehabil. 2005;84(5) doi:

38. Dorsch AK, Thomas S, Xu X, Kaiser W, Dobkin BH. SIRRACT: An International Randomized Clinical Trial of Activity Feedback During Inpatient Stroke Rehabilitation Enabled by Wireless Sensing. Neurorehabil Neural Repair. 2015;29(5) doi:

39. Kanai M, Izawa KP, Kobayashi M, Onishi A, Kubo H, Nozoe M, et al. Effect of accelerometer-based feedback on physical activity in hospitalized patients with ischemic stroke: a randomized controlled trial. Clinical rehabilitation. 2018;32(8) doi:

40. Lawrie S, Dong Y, Steins D, Xia Z, Esser P, Sun S, et al. Evaluation of a smartwatch-based intervention providing feedback of daily activity within a research-naive stroke ward: a pilot randomised controlled trial. Pilot Feasibility Stud. 2018;4 doi:

41. Mansfield A, Wong JS, Bryce J, Brunton K, Inness EL, Knorr S, et al. Use of Accelerometer-Based Feedback of Walking Activity for Appraising Progress With Walking-Related Goals in Inpatient Stroke Rehabilitation: A Randomized Controlled Trial. Neurorehabil Neural Repair. 2015;29(9) doi:

42. Hassett L, van den Berg M, Lindley RI, Crotty M, McCluskey A, van der Ploeg HP, et al. Digitally enabled aged care and neurological rehabilitation to enhance outcomes with Activity and MObility UsiNg Technology (AMOUNT) in Australia: A randomised controlled trial. PLoS Med. 2020;17(2) doi:

43. Frederix I, Van Driessche N, Hansen D, Berger J, Bonne K, Alders T, et al. Increasing the medium-term clinical benefits of hospital-based cardiac rehabilitation by physical

activity telemonitoring in coronary artery disease patients. Eur J Prev Cardiol. 2015;22(2) doi:

44. Houle J, Doyon O, Vadeboncoeur N, Turbide G, Diaz A, Poirier P. Innovative program to increase physical activity following an acute coronary syndrome: randomized controlled trial. Patient Educ Couns. 2011;85(3) doi:.

45. Izawa KP, Watanabe S, Hiraki K, Morio Y, Kasahara Y, Takeichi N, et al. Determination of the effectiveness of accelerometer use in the promotion of physical activity in cardiac patients: a randomized controlled trial. Archives of physical medicine and rehabilitation. 2012;93(11) doi:

46. Brandes M, Wirsik N, Niehoff H, Heimsoth J, Mohring B. Impact of a tailored activity counselling intervention during inpatient rehabilitation after knee and hip arthroplasty - an explorative RCT. BMC Musculoskelet Disord. 2018;19(1) doi:

47. Pol MC, Ter Riet G, van Hartingsveldt M, Krose B, Buurman BM. Effectiveness of sensor monitoring in a rehabilitation programme for older patients after hip fracture: a three-arm stepped wedge randomised trial. Age Ageing. 2019;48(5) doi:

48. Van der Walt N, Salmon LJ, Gooden B, Lyons MC, O'Sullivan M, Martina K, et al. Feedback From Activity Trackers Improves Daily Step Count After Knee and Hip Arthroplasty: A Randomized Controlled Trial. J Arthroplasty. 2018;33(11) doi:

49. Christiansen MB, Thoma LM, Master H, Voinier D, Schmitt LA, Ziegler ML, et al. Feasibility and Preliminary Outcomes of a Physical Therapist-Administered Physical Activity Intervention After Total Knee Replacement. Arthritis Care Res (Hoboken). 2020;72(5) doi:

50. Mehta SJ, Hume E, Troxel AB, Reitz C, Norton L, Lacko H, et al. Effect of Remote Monitoring on Discharge to Home, Return to Activity, and Rehospitalization After Hip and Knee Arthroplasty: A Randomized Clinical Trial. JAMA Netw Open. 2020;3(12) doi:

51. van der Meij E, Anema JR, Leclercq WKG, Bongers MY, Consten ECJ, Schraffordt Koops SE, et al. Personalised perioperative care by e-health after intermediate-grade abdominal surgery: a multicentre, single-blind, randomised, placebo-controlled trial. Lancet (London, England). 2018;392(10141) doi:

52. Wolk S, Linke S, Bogner A, Sturm D, Meissner T, Mussle B, et al. Use of Activity Tracking in Major Visceral Surgery-the Enhanced Perioperative Mobilization Trial: a Randomized Controlled Trial. J Gastrointest Surg. 2019;23(6) doi:

53. Moller T, Lillelund C, Andersen C, Bloomquist K, Christensen KB, Ejlertsen B, et al. The challenge of preserving cardiorespiratory fitness in physically inactive patients with colon or breast cancer during adjuvant chemotherapy: a randomised feasibility study. BMJ Open Sport Exerc Med. 2015;1(1) doi:

54. Hornikx M, Demeyer H, Camillo CA, Janssens W, Troosters T. The effects of a physical activity counseling program after an exacerbation in patients with Chronic Obstructive Pulmonary Disease: a randomized controlled pilot study. BMC Pulm Med. 2015;15 doi:

55. Creel DB, Schuh LM, Reed CA, Gomez AR, Hurst LA, Stote J, et al. A randomized trial comparing two interventions to increase physical activity among patients undergoing bariatric surgery. Obesity (Silver Spring). 2016;24(8) doi:

56. Peel NM, Paul SK, Cameron ID, Crotty M, Kurrle SE, Gray LC. Promoting Activity in Geriatric Rehabilitation: A Randomized Controlled Trial of Accelerometry. PLoS One. 2016;11(8) doi:

57. Atkins A, Cannell J, Barr C. Pedometers alone do not increase mobility in inpatient rehabilitation: a randomized controlled trial. Clinical rehabilitation. 2019;33(8) doi:

58. Houle J, Doyon O, Vadeboncoeur N, Turbide G, Diaz A, Poirier P. Effectiveness of a pedometer-based program using a socio-cognitive intervention on physical activity and quality of life in a setting of cardiac rehabilitation. Can J Cardiol. 2012;28(1) doi:

59. Atkins D, Best D, Briss PA, Eccles M, Falck-Ytter Y, Flottorp S, et al. Grading quality of evidence and strength of recommendations. BMJ (Clinical research ed). 2004;328(7454) doi:

60. Eisele A, Schagg D, Krämer LV, Bengel J, Göhner W. Behaviour change techniques applied in interventions to enhance physical activity adherence in patients with chronic musculoskeletal conditions: A systematic review and meta-analysis. Patient Educ Couns. 2019;102(1) doi:

61. Bishop FL, Fenge-Davies AL, Kirby S, Geraghty AW. Context effects and behaviour change techniques in randomised trials: a systematic review using the example of trials to increase adherence to physical activity in musculoskeletal pain. Psychol Health. 2015;30(1) doi:

62. Chia GLC, Anderson A, McLean LA. Behavior Change Techniques Incorporated in Fitness Trackers: Content Analysis. JMIR Mhealth Uhealth. 2019;7(7) doi:

63. Low CA. Harnessing consumer smartphone and wearable sensors for clinical cancer research. npj Digital Medicine. 2020;3(1) doi:

64. Direito A, Carraça E, Rawstorn J, Whittaker R, Maddison R. mHealth Technologies to Influence Physical Activity and Sedentary Behaviors: Behavior Change Techniques, Systematic Review and Meta-Analysis of Randomized Controlled Trials. Ann Behav Med. 2017;51(2) doi:

65. Samdal GB, Eide GE, Barth T, Williams G, Meland E. Effective behaviour change techniques for physical activity and healthy eating in overweight and obese adults; systematic review and meta-regression analyses. Int J Behav Nutr Phys Act. 2017;14(1) doi:

Chapter 6

Improving physical activity in hospitalized patients: the impact of the GOALintervention

Juul W.M. van Grootel
Petra Bor
Jolien A. Netjes
Cindy Veenhof
Karin Valkenet

Under review

ABSTRACT

Objective: To evaluate the effectiveness of a goal directed movement intervention using a movement sensor on physical activity of hospitalized patients.

Design: prospective, pre-post study.

Setting: A university medical centre.

Participants: Patients admitted to the pulmonology and nephrology/gastro-enterology wards.

Intervention: The movement intervention consisted of 1) self-monitoring of patients' physical activity 2) setting daily movement goals and 3) posters with exercises and walking routes. Physical activity was measured with a movement sensor (PAM AM400), which measures active minutes per day.

Main measures: Primary outcome was the mean difference in active minutes per day pre- and post-implementation. Secondary outcomes were hospital length of stay, discharge destination, immobility related complications, physical functioning, difficulty to move, 30-day readmission, 30-day mortality and the adoption of the intervention.

Results: A total of 61 patients were included pre-implementation and a total of 56 patients were included post-implementation. Pre-implementation, patients were 38±21 minutes (mean±SD) active per day, and post-implementation 50±31 minutes active per day (Δ12, p=.031). Difficulty to move decreased from 3.4 to 1.7 (0-10) (Δ1.7, p=.008). No significant differences were found in other secondary outcomes.

Conclusion(s): The GOAL-intervention seems to increase physical activity levels during hospitalization. Therefore, this intervention might be useful for other hospitals to stimulate inpatients physical activity.

INTRODUCTION

During hospitalization, patients are physically inactive. (1–4) In general, they spend up to 23 hours per day sitting or lying in bed. (5) This low amount of physical activity (PA) is associated with pulmonary complications and thrombosis. (6) These are in turn associated with an increased length of stay and a higher risk of mortality even after hospital admission. (7) Overall, in-hospital inactivity is associated with functional decline (8), defined as having difficulties in performing activities in daily life. (9)

Despite several studies showing the adverse effects of inactivity during hospital stay, inactivity is still deeply rooted in the hospital culture. (10–14) Therefore, multidimensional interventions have been developed to improve in-hospital PA. Studies evaluated the effectiveness of a multidimensional intervention to improve PA and found a reduced time spent in bed (10,11), less functional decline during hospitalization (12–14), shorter length of stay (11–13) and more patients being discharged to home. (11) Despite these positive effects, the effects on time being physically active were lower than anticipated. (10,11)

Previous research stated that in surgical populations movement sensors are useful to objectively, continuously and remotely monitor patients. (15). During hospitalization movement sensors are mainly used for research purposes, while they can also be used to stimulate PA. (3,16–18)(19) Therefore, an intervention to stimulate PA using a movement sensor was developed using Intervention Mapping (IM) (Grootel, van., et al., 2023, submitted). The goal-directed movement intervention (GOAL) enables healthcare professionals (HCPs) and patients to have continuous access to the amount of PA per patient and to set personalized movement goals.

The primary objective of this study was to investigate the effectiveness of the GOAL intervention on PA in hospitalized patients. The secondary objective was to evaluate the effectiveness of the GOAL-intervention on length of stay, discharge destination, the incidence of immobility related complications, 30-day readmission, mortality, physical functioning at discharge and difficulty to move at discharge. Furthermore, the adoption of the GOAL-intervention from patient and HCPs perspective was evaluated.

METHODS

Setting

The GOAL-intervention was developed following an IM approach in collaboration with HCPs (Grootel, van., et al., 2023, submitted). (20) Next, the intervention was implemented as usual care at the pulmonology and nephrology/gastro-enterology wards of the University Medical Centre of Utrecht, The Netherlands. The study protocol was assessed and approved by the local Medical Ethics Committee (study protocol number 22-537). Written informed consent was obtained from all included patients.

Design

A pre-post design was used to evaluate the effectiveness of the GOAL-intervention. Pre-implementation measurements were performed between April – June 2022. Post-implementation measurements were performed between November 2022 – January 2023 (figure 1).

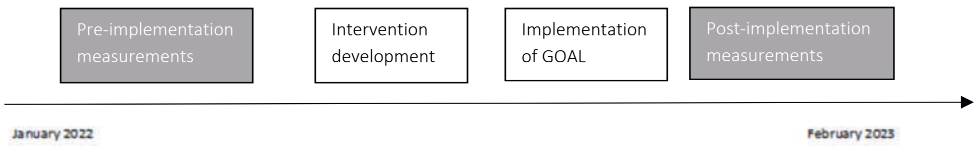


Figure 1. timeline

GOAL: a goal directed movement intervention

The GOAL-intervention included the following three main components: 1) HCPs had access to patients' PA data via electronic patient records and a public screen on the ward. Patients had access to their own PA via a public screen on the ward and their personal mobile device. 2) Setting daily movement goals, with a standard baseline goal of 30 minutes. HCPs evaluated and increased movement goals by 5-10 minutes when a goal was achieved. 3) Posters with exercises and walking routes on the walls and floor of the wards. See appendix 1 for a detailed description of the GOAL-intervention. The implementation of the intervention also consisted of three main components, based on IM (Grootel, van., et al., 2023, under review): 1) Key-users (experienced nurses) were assigned in order to build support, to embed the movement sensor in usual care and to answer questions about using the movement intervention. 2) Education sessions were organized and protocols for HCPs were developed, and 3) PA data was incorporated into team meetings, e.g. multidisciplinary consultations. Progress and successes were shared at weekly meetings to encourage the use of the movement sensor and the amount of active minutes of the patients.

Study population

Patients who were admitted to the pulmonology or nephrology/gastro-enterology ward with an expected hospital length of stay of three days or more were eligible to be included in this study. Patients were excluded if they were wheelchair dependent, had a delirium, had a life expectancy less than one month or had language restrictions that made them unable to provide informed consent.

Procedures

The senior nurse of the ward was asked for approval for approaching patients. Every patient who met the eligibility criteria was asked for participation in this study by a member of the research team (JvG and JN). If patients approved to participate in the pre-implementation measurement, they received a movement sensor as the movement sensor was not yet implemented as usual care and were asked several questions (see measurements). Post-implementation patients who received a movement sensor as part of usual care, were asked to participate. Characteristics of the patients were retrospectively collected from the electronic patient record (EPR). The post implementation measurements started after implementation goals were achieved, i.e. when >70% of eligible patients wore the movement sensor and >50% of those patients had movement goals.

Measurements

The primary outcome was PA measured in minutes per day using the Physical Activity Monitor (PAM) AM400. This ankle-worn movement sensor is a small button-shaped device which registers movements with an intensity of 1.4 METs and above. The active minutes are divided in light, medium and heavy intensity. The PAM has a strong agreement (ICC=0.955) with the ActiGraph, a well-established activity monitor. (21) PA was measured continuously during hospital admission.

Secondary outcomes on patient level were length of stay, discharge destination (i.e., home or nursing home), the incidence of immobility-related complications (i.e., pneumonia, pulmonary embolism, deep-venous thrombosis, urinary tract infection, and pressure sores) (22), 30-day readmission rate, and mortality. Measurements of physical functioning were collected at admission (within 2 days after hospital admission, if possible) and at discharge (within two days before hospital discharge, if possible). Physical functioning was measured with the Activity Measure for Post-Acute Care (AM-PAC) "6-Clicks" inpatient Basic Mobility at hospital discharge. (23) The AM-PAC is a short form that has six items that were scored by the researchers on a 4-point ordinal scale and has an excellent reliability and validity in acute hospitalized patients. (23,24) The total score ranges from 6 to 24 with higher scores indicating better function. (23) Because most of the patients score high on the AM-PAC, but there is a wide variability in effort to reach this score, the perceived difficulty to move was measured using a Numeric Rating Scale (NRS) ranging from 0 to 10.

Another secondary outcome was the adoption of the intervention of both patients and HCPs using the Net Promotor Score (NPS) for patients at hospital discharge. HCPs were asked to fill in the NPS after the post-implementation measurements. (25) The NPS is based on a single question: How likely is it that you would recommend this intervention to a friend or colleague? Participants can give an answer ranging from 0 ('not at all likely') to 10 ('extremely likely'). (25) The assumption is that individuals scoring a 9 or a 10 will give positive word-of-mouth advertising; they are called 'promoters'. Individuals answering 7 or 8 are considered indifferent called 'passives'. Finally, individuals answering 0–6 are likely to be dissatisfied customers and are labelled as 'detractors'. (25) The total NPS ranges from -100 to +100, and can be calculated by % promotors - % detractors, a score above 20 is considered "good/acceptable", a score above 50 and indicates "great" and a score above 70 indicates "excellent". (26) Scores were calculated via the NPS calculator. (27) Experienced comfort while wearing the movement sensor is scored on a NRS from 0 to 10.

In addition, the following patient characteristics were collected: gender, age, body mass index, days of wearing the movement sensor, planned surgery (yes/no), restrictions (yes/no) (i.e., urinary catheter, thorax drain, intravenous infusion) (28), pain and fatigue using a NRS from 0 to 10.

Sample size

A previous study evaluating PA levels during hospital stay after oncological surgery, using the same movement sensor, found a mean of 37 active minutes per day, with a standard deviation of 13. (29) An effect size of 0.21 was chosen based on previous studies. (29,30) Based on a power of 90%, this resulted a minimal sample size of 59 per arm. (31) Based on a power of 80%, a minimal sample size of 44 is needed. Sample size analysis was conducted using Statulator: An online statistical calculator. (31)

Data analyses

Statistical analyses were conducted using IBM SPSS statistics software version 26 (IBM Corp). All continuous variables were tested for normality with the Kolmogorov-Smirnov test. Means were presented for normally distributed data and medians were presented for non-normally distributed data. Patient characteristics were described using descriptive statistics and tested with the Mann Whitney test or independent sample t-test. For the PA, minutes per intensity (i.e., light, medium or heavy) per day and the total active minutes per day were calculated. Differences in PA between pre- and post-implementation were tested using the independent sample t-test. For secondary outcomes on patient level differences between pre- and post-implementation were also tested using the independent sample t-test. Numbers and percentages were presented for the NPS scores. The level of significance is set at p≤0.05.

RESULTS

A total of 61 patients (n=28 on pulmonology ward, n=33 on nephrology/gastro-enterology ward) were included in the pre-implementation measurements and 56 patients (n=26 on pulmonology ward, n=30 on nephrology/gastro-enterology ward) were included in the post-implementation measurements. There were partially missing data for PA in 3 patients in the pre-implementation measurements (n=2 on pulmonology ward, n=1 on nephrology/gastro-enterology ward) and 5 patients in the post-implementation measurements (n=2 on pulmonology ward, n=1 on nephrology/gastro-enterology ward). The main reason for missing data were non-wear (n=2) and technical issues (n=6). Table 1 presents the characteristics of the study population. No significant differences were observed in the characteristics pre-implementation and post-implementation for total group analysis. For the pulmonology ward, pre-implementation significantly more patients underwent a planned surgery (table 1). Pre-implementation the mean wearing time was 6±3 days, which was 46% of the total hospital admission days. Post-implementation, the mean wearing time was 7±4 days, which was 58% of the total hospital admission days.

Table 1. Patient characteristics

	Total group			**Pulmonology ward**			**Nephrology/Gastro-enterology ward**		
	Pre-impl. n=61	Post-impl. n=56	Indep. Sample T-test	Pre-impl. n=28	Post-impl. n=26	Mann-Whitney U	Pre-impl. n=33	Post-impl. n=30	Mann-Whitney U
Gender; n (%)									
- Male	31 (51)	31 (55)	.627	13 (46)	14 (54)	.589	18 (55)	17 (57)	.867
- Female	30 (49)	25 (45)		15 (54)	12 (46)		15 (45)	13 (43)	
Age; years mean (SD)	60±16	60±14	.908	61±15	65±12	.615	59±18	55±14	.250
BMI; mean (SD)	24 ±5	24±5	.854	25±5	24±6	.340	23±5	24±5	.872
Planned surgery; n (%)	29 (48)	18 (32)	.068	10 (36)	2 (8)	.014	19 (58)	16 (53)	.647
Urinary catheter; n (%)	17 (28)	18 (32)	.573	3 (11)	1 (4)	.340	14 (42)	17 (57)	.207
Thorax drain; n (%)	19 (31)	16 (29)	.812	7 (25)	3 (12)	.207	12 (37)	13 (43)	.501
Intravenous infusion; n (%)	27 (44)	20 (36)	.436	13 (46)	10 (39)	.558	14 (42)	10 (33)	.596
Pain *admission* NPRS; mean (SD)	3±3	3±3	.736	4±4	3±3	.907	3±3	4±3	.489
Fatigue *admission* NRS; mean (SD)	6±3	5±3	.054	6±3	5±3	.111	5±3	4±3	.263
AM-PAC *admission;* mean (SD)	21±4	22±3	.311	21±4	22±2	.167	21±3	21±3	.486
Difficulty to move *admission* NRS; mean (SD)	5±3	4±3	.502	5±3	5±3	.257	4±3	4±3	.791

Abbreviations: impl.=implementation, n=number, SD: standard deviation, BMI=body mass index, NPRS=numeric pain rating scale, NRS=numeric rating scale, AM-PAC=acute measure for post-acute care

Physical activity per ward

The mean of total PA in minutes per day increased with 32% from 38±21 pre-implementation to 50±31 post-implementation (Δ12, p=.031). The mean changes of PA per day per intensity level were: light 29±15 to 34±15 (Δ5, p=.101), medium 9±7 to 16±21 (Δ7, p=.018) and heavy 0±1 to 0±1 (Δ0, p=.075) (Table 2). See also table 2 for detailed PA data of the total group and stratified per ward.

Table 2. Physical activity outcomes

	Total group					**Pulmonology ward**		**Nephrology/gastro-enterology ward**	
	Pre- impl. n=61	Post-impl. n=56	*p.*	95% CI Lower	Upper	Pre- impl. n=28	Post-impl. n=26	Pre- impl. n=33	Post-impl. n=30
Physical activity *minutes*; mean SD									
- Light	29±15	34±15	.101	-10.355	.933	28±17	36±17	30±13	32±12
- Medium	9±7	16±21	.018	-13.624	-1.313	8±6	17±25	10±9	16±17
- Heavy	0±1	0±1	.075	-.584	.028	0±0	0±1	0±1	0±1
- Total	38±21	50±31	.031	-21.238	-1.057	37±22	53±37	40±20	47±26

Abbreviations: impl.= implementation, SD=standard deviation, CI=confidence interval, *p*=p-value

Secondary outcomes on patient level

Table 3 provides an overview of the secondary outcome measures on patient level. The difficulty to move at discharge changed from 3.4 points pre-implementation to 1.7 points post-implementation on a scale from 0-10 (Δ1.7, p=.008), exceeding the minimal clinical important difference. (26) No significant differences were observed on other secondary outcome measures.

Table 3. Secondary outcomes on patient level

	Total group					Pulmonology ward		Nephrology/gastro-enterology ward	
	Pre- impl. n=61	Post-impl. n=56	*p.*	95% CI Lower	Upper	Pre- impl. n=28	Post-impl. n=26	Pre- impl. n=33	Post-impl. n=30
LOS *days,* mean (SD)	13.0±13.5	11.8±12.6	.638	-3.673	5.971	11.8±9.3	8.4±8.6	13.9±16.4	14.9±14.8
Discharge destination; n (%)									
-Home	59 (98)	51 (91)	.201	0.144	0.031	27 (96)	23 (89)	32 (97)	28 (93)
-Nursing home	2 (2)	5 (9)				1 (4)	3 (11)	1 (3)	2 (7)
Immobility related complications; n (%)	18 (30)	10 (18)	.140	-.039	.272	8 (30)	3 (12)	10 (30)	7 (23)
AM-PAC *discharge;* mean (SD)	22.9±2.4	23.2±1.3	.417	-.1021	.426	23.0±1.4	23.1±1.3	22.8±3.1	23.3±1.3
Difficulty to move *discharge* NRS; mean (SD)	3.4±3.2	1.7±2.8	.008	.465	2.938	4.4±3.1	2.7±3.1	2.4±2.9	0.7±1,8
30-day readmission n (%)	15 (25)	10 (18)	.377	-.083	.218	7 (25)	4 (15)	8 (24)	6 (21)
30-day mortality n (%)	0	0	-	-	-	0	0	0	0

Abbreviations: impl.= implementation, SD: standard deviation, LOS:=length of stay, n=number, AM-PAC= activity measure for post-acute care, NRS= numeric rating scale, CI=confidence interval, *p.*=p-value

Secondary outcome adoption

After the implementation the adoption of the intervention was evaluated. Patients and HCPs were asked how likely they would recommend the GOAL-intervention to a friend or colleague. As result of a protocol error, NPS of patients were collected retrospectively after discharge. In total 13 (23%) patients responded. The mean score was 9±1 and the total NPS for patients was 46. Of all patients, 46% scored a 9 or higher and are considered “promotors”, 54% scored a 7 or 8 and are considered “passives”. Among HCPs, n=23 responded of which n=19 nurses, n=2 doctors and n=2 physical therapists. Of all HCPs, 31% scored a 9 or higher and are considered "promoters", 65% scored a 7 or 8 and are considered “passives”, 4% scored a 6 or less and are considered “detractors”. The mean score was 8±1 and the total NPS for HCPs was 26. The total NPS scores of both patients and HCP’s are considered “good/acceptable” (26). Of all patients, n=67 (57%) provided a score for the comfort of wearing the movement sensor. The mean score was 8±2 (out of 10).

DISCUSSION

The purpose of this study was to evaluate the effectiveness of the GOAL-intervention on PA in hospitalized patients on two medical wards. The results showed that post-implementation the mean level of PA was 12 minutes higher compared to pre-implementation (p=.031). This resulted in an increase of 32% of PA per day. Perceived difficulty to move at discharge decreased from 3.4 to 1.7 points (Δ1.7, p=.008). There were no statistically significant changes in other secondary outcomes.

Previous studies evaluating the effect of interventions using activity trackers mainly focused on the minimal clinical important change of step counts in patients with a chronic disease. (32–35) Only few studies evaluated interventions with an activity tracker during hospital stay, whereby step count significantly increased. (36,37) Another study evaluated a smartphone application with an activity tracker in hospitalized patients on standing and walking time. (38) This study found an increase of 28 minutes (39%) in standing and walking, which was considered as clinically relevant. (38) An increased time spend active seems important to reduce the risk of functional decline and postoperative complications. (14,34,35) Therefore, the increase of 32% in active minutes per day found in this study seems relevant. However, guidelines on the recommended amount of physical activity do not yet exist. (14,34) The question remains what amount of PA is needed to prevent functional decline.

Important active ingredients and of the GOAL intervention are; self-monitoring for patients, feedback of movement behavior and a multidisciplinary approach (Grootel, van., et al., 2023, under review). The behavioral change techniques (BCTs) of the GOAL-intervention were: feedback & monitoring, goals & planning and associations & antecedents. These BCTs proved to be successful in previous literature in non-hospitalized patients (39–41) and are expected to have contributed to the change of PA. Additionally, research suggests that interventions using self-monitoring, among other BCTs, are more effective than those without. (42) Furthermore, the integration of PA data in the EPR is ensured because difficulties in integrating sensor data into the EPR are a frequent reported barrier to implementation. (43) PA data is visible for HCPs in usual care. Using activity trackers in usual care can support to achieve a common language regarding PA, which might enhance responsibility in the entire team. (44)

The perceived difficulty to move, scored on a NRS, changed from 3.4 to 1.7 (Δ1.7, p=.008) post-implementation. Although no literature is available on the minimal clinical difference in difficulty to move, literature stated that a change of 1.65 on the NRS for pain is a minimal clinical important difference in patients with acute pain. (27). The change of 1.7 on the NRS might be clinically relevant, as it indicates that patients have less difficulty with performing activities like transferring, walking and climbing the stairs. Furthermore, a previous study showed that higher physical fitness at discharge predicted better physical functioning at follow-up, in a surgical population. (45) Besides this, the decrease in difficulty to move at discharge might lead to higher levels of physical activity which could contribute to a better recovery after discharge. (14)

Besides information about the effectiveness of the intervention, insight in the practical use of the intervention on the ward is needed for long term change. Therefore, the adoption of the intervention of both patients and HCPs was evaluated in this study. The NPS for patients and HCPs in this study is considered “good/acceptable”. This is in line with another study that investigated the usability of the software used in this study in a oncologic surgery population. This study stated the user experiences of patients were largely positive. (46) Despite most of the users are satisfied with the GOAL-intervention, the NPS score might indicate that there is room for improvement to achieve long-term changes. To minimize the effort for HCPs to use the movement sensor, the software platform used to link a movement sensor to a patient, to visualize PA data and to apply goal-setting was integrated in the EPR. Nurses mentioned evaluating PA data with patients is mostly a task for physical therapists. Educating nurses in evaluating PA data and let them understand their role in this task might improve the adoption. Furthermore, during implementation, there were some technical issue when synchronizing patient data into the EPR. Solving technical problems might improve the adoption.

There were some limitations in this study. First, the measurements of the adoption and usage were restricted to the implementation period. To guarantee usage on the long term, structural evaluation is needed whereby the adoption and numbers of patients wearing the movement sensor should be measured. Second, due to a protocol error, there were many missing data in the evaluation of the adoption of the intervention from patients perspective. This could have led to an overestimating of the results. Third, a pragmatic pre-post design was used to evaluate the effectiveness. Therefore, the effectiveness of the intervention might have been influenced by other factors like time and confounders. (47) However, no significant differences were found in baseline characteristics in the total group. A pre-post design has also major advantages. Within the study design an iterative and dynamic process could be followed whereby the intervention was implemented in daily care. Hereby, the pre-post design provides an evaluation of actual change in daily care.

CONCLUSION

The GOAL-intervention (including self-monitoring, goal setting and adjustments to the built environment) in hospitalized patients seems to be effective in increasing PA levels during hospital stay. Therefore, this intervention might be useful for other wards and hospitals to stimulate inpatients PA. More research is needed to investigate the effectiveness of the GOAL-intervention on outcomes after hospital discharge, such as recovery of patients on the long term.

CLINICAL MESSAGES

- The use of activity trackers in daily hospital care seems promising
- A goal directed movement intervention seems to contribute to an increase of PA In hospitalized patients.

REFERENCES

1. Brown CJ, Redden DT, Flood KL, Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc. 2009;57(9):1660–5.
2. Mudge AM, McRae P, McHugh K, Griffin L, Hitchen A, Walker J, et al. Poor mobility in hospitalized adults of all ages. J Hosp Med 2016, 11(4):289–91.
3. Pedersen MM, Bodilsen AC, Petersen J, Beyer N, Andersen O, Lawson-Smith L, et al. Twenty-four-hour mobility during acute hospitalization in older medical patients. J Gerontol A Biol Sci Med Sci 2013;68(3):331–7.
4. Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E, Admi H. Low mobility during hospitalization and functional decline in older adults. J Am Geriatr Soc. 2011;59(2):266–73.
5. Kirk AG, Behm KJ, Kimmel LA, Ekegren CL. Levels of Physical Activity and Sedentary Behavior During and After Hospitalization: A Systematic Review. Arch Phys Med Rehabil. 2021 102(7):1368–78.
6. Knight J, Nigam Y, Jones A. Effects of bedrest 1: cardiovascular, respiratory and haematological systems Exploring what happens to processes in the body when a person is bedridden, and what nurses should look for when monitoring such patients. 2009
7. Biswas A, Oh PI, Faulkner GE, Bajaj RR, Silver MA, Mitchell MS, et al. Sedentary time and its association with risk for disease incidence, mortality, and hospitalization in adults: a systematic review and meta-analysis. Ann Intern Med. 2015;162(2):123–32.
8. Zisberg A, Shadmi E, Gur-Yaish N, Tonkikh O, Sinoff G. Hospital-associated functional decline: the role of hospitalization processes beyond individual risk factors. J Am Geriatr Soc. 2015;63(1):55–62.
9. Hébert R, Brayne C, Spiegelhalter D. Incidence of functional decline and improvement in a community-dwelling, very elderly population. Am J Epidemiol. 1997 145(10):935–44.
10. van Delft LMM, Bor P, Valkenet K, Slooter AJC, Veenhof C. The Effectiveness of Hospital in Motion, a Multidimensional Implementation Project to Improve Patients' Movement Behavior During Hospitalization. Phys Ther. 2020 Dec 7;100(12):2090–8.
11. Koenders N, Potkamp-Kloppers S, Geurts Y, Akkermans R, Nijhuis-van der Sanden MWG, Hoogeboom TJ. Ban Bedcentricity: A Multifaceted Innovation to Reduce Sedentary Behavior of Patients During the Hospital Stay. Phys Ther 2021
12. Hoyer EH, Friedman M, Lavezza A, Wagner-Kosmakos K, Lewis-Cherry R, Skolnik JL, et al. Promoting mobility and reducing length of stay in hospitalized general medicine patients: A quality-improvement project. J Hosp Med . 2016
13. Mudge AM, McRae P, Cruickshank M. Eat walk engage: an interdisciplinary collaborative model to improve care of hospitalized elders. Am J Med Qual. 2015
14. Cohen Y, Zisberg A, Chayat Y, Gur-Yaish N, Gil E, Levin C, et al. Walking for Better Outcomes and Recovery: The Effect of WALK-FOR in Preventing Hospital-Associated Functional Decline Among Older Adults. J Gerontol A Biol Sci Med Sci. 2019;74(10):1664–70.
15. Amin T, Mobbs RJ, Mostafa N, Sy LW, Choy WJ. Wearable devices for patient monitoring in the early postoperative period: a literature review. Mhealth. 2021;7:50.

16. Valkenet K, Veenhof C. Validity of three accelerometers to investigate lying, sitting, standing and walking. Harezlak J, editor. PLoS One. 2019 May 23;14(5):e0217545.

17. Valkenet K, Bor P, van Delft L, Veenhof C. Measuring physical activity levels in hospitalized patients: a comparison between behavioural mapping and data from an accelerometer. Clin Rehabil. 2019;33(7):1233–40.

18. Fazio S, Stocking J, Kuhn B, Doroy A, Blackmon E, Young HM, et al. How much do hospitalized adults move? A systematic review and meta-analysis. Appl Nurs Res. 2020 51:151189.

19. Wells CI, Xu W, Penfold JA, Keane C, Gharibans AA, Bissett IP, et al. Wearable devices to monitor recovery after abdominal surgery: scoping review. BJS Open. 2022 6(2).

20. Fernandez ME, ten Hoor GA, van Lieshout S, Rodriguez SA, Beidas RS, Parcel G, et al. Implementation Mapping: Using Intervention Mapping to Develop Implementation Strategies. Front Public Health 2019;7:158.

21. Valkenet K, Bor P, Reijneveld E, Veenhof C, Dronkers J. Physical activity monitoring during hospital stay: a validation study. Disabil Rehabil. 2022 17;1–6.

22. AVERT Trial Collaboration group T. Articles Efficacy and safety of very early mobilisation within 24 h of stroke onset (AVERT): a randomised controlled trial. 2015

23. Jette DU, Stilphen M, Ranganathan VK, Passek SD, Frost FS, Jette AM. Validity of the AM-PAC "6-Clicks" inpatient daily activity and basic mobility short forms. Phys Ther. 2014

24. Geelen SJG, Valkenet K, Veenhof C. Construct validity and inter-rater reliability of the Dutch activity measure for post-acute care "6-clicks" basic mobility form to assess the mobility of hospitalized patients. Disabil Rehabil. 2019;41(21):2563–9.

25. Adams C, Walpola R, Schembri AM, Harrison R. The ultimate question? Evaluating the use of Net Promoter Score in healthcare: A systematic review. Health Expectations . 2022 Aug 19

26. Net Promoter Score (NPS) | Bain & Company [Internet]. [cited 2023 Mar 27].

27. Bahreini M, Safaie A, Mirfazaelian H, Jalili M. How much change in pain score does really matter to patients? Am J Emerg Med. 2020 Aug;38(8):1641–6.

28. Valkenet K, Mcrae P, Reijneveld E, Jans M, Bor P, van Delft L, et al. Inpatient physical activity across a large university city hospital: a behavioral mapping study Inpatient physical activity across a large university city hospital: a behavioral mapping study. 2022

29. Bor P, de Leeuwerk ME, Valkenet K, van Hillegersberg R, Veenhof C. Physical functioning and physical activity after gastrointestinal or bladder oncological surgery: An observational cohort study. Eur J Cancer Care (Engl)

30. Gardner AW, Montgomery PS, Wang M, Shen B. Minimal clinically important differences in daily physical activity outcomes following supervised and home-based exercise in peripheral artery disease. Vasc Med. 2022;27(2):142–9.

31. Dhand NK, Khatkar MS. Statulator: An online statistical calculator. Sample Size Calculator for Comparing Two Independent Means. How to Practice Academic Medicine and Publish from Developing Countries? Springer Nature Singapore; 2014 p. 81–93.

32. Motl R, Pilutti L, Learmonth Y, Godlman M, Brown T. Clinical importance of steps taken per day among persons with Multiple Sclerosis. PLoS One 2013

33. de Leeuwerk ME, Bor P, van der Ploeg HP, de Groot V, van der Schaaf M, van der Leeden M, et al. The effectiveness of physical activity interventions using activity trackers during or after inpatient care: a systematic review and meta-analysis of randomized controlled trials. International Journal of Behavioral Nutrition and Physical Activity. 2022 21];19(1):59.

34. Pavon JM, Sloane RJ, Pieper CF, Colón-Emeric CS, Cohen HJ, Gallagher D, et al. Accelerometer-Measured Hospital Physical Activity and Hospital-Acquired Disability in Older Adults. J Am Geriatr Soc. 2020 Feb 1;68(2):261–5.

35. Nevo Y, Shaltiel T, Constantini N, Rosin D, Gutman M, Zmora O, et al. Activity Tracking After Surgery: Does It Correlate With Postoperative Complications? Am Surg. 2022 Feb 1 88(2):226–32.

36. Wolk S, Linke S, Bogner A, Sturm D, Meißner T, Müssle B, et al. Use of Activity Tracking in Major Visceral Surgery-the Enhanced Perioperative Mobilization Trial: a Randomized Controlled Trial. J Gastrointest Surg. 2019 Jun 15;23(6):1218–26.

37. Izawa KP, Watanabe S, Hiraki K, Morio Y, Kasahara Y, Takeichi N, et al. Determination of the effectiveness of accelerometer use in the promotion of physical activity in cardiac patients: a randomized controlled trial. Arch Phys Med Rehabil. 2012 Nov;93(11):1896–902

38. van Dijk-Huisman HC, Weemaes ATR, Boymans TAEJ, Lenssen AF, de Bie RA. Smartphone App with an Accelerometer Enhances Patients' Physical Activity Following Elective Orthopedic Surgery: A Pilot Study. Sensors 2020, Vol 20, Page 4317. 2020 20(15):4317.

39. Bravata DM, Smith-Spangler C, Sundaram V, Gienger AL, Lin N, Lewis R, et al. Using pedometers to increase physical activity and improve health: a systematic review. JAMA . 2007 Nov 21;298(19):2296–304.

40. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: building an international consensus for the reporting of behavior change interventions. Ann Behav Med. 2013

41. Compernolle S, DeSmet A, Poppe L, Crombez G, de Bourdeaudhuij I, Cardon G, et al. Effectiveness of interventions using self-monitoring to reduce sedentary behavior in adults: a systematic review and meta-analysis. International Journal of Behavioral Nutrition and Physical Activity. 2019 Dec 13 ;16(1):63.

42. Schroé H, Van Dyck D, De Paepe A, Poppe L, Loh WW, Verloigne M, et al. Which behaviour change techniques are effective to promote physical activity and reduce sedentary behaviour in adults: A factorial randomized trial of an e- A nd m-health intervention. International Journal of Behavioral Nutrition and Physical Activity. 2020 Oct 7 ;17(1):1–16.

43. Low CA. Harnessing consumer smartphone and wearable sensors for clinical cancer research. npj Digital Medicine 2020 3:1. 2020 Oct 27;3(1):1–7.

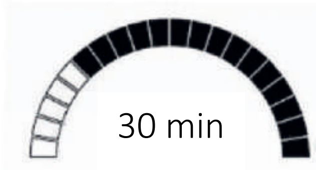
44. Stutzbach J, Jones J, Taber A, Recicar J, Burke RE, Stevens-Lapsley J. Systems Approach Is Needed for In-Hospital Mobility: A Qualitative Metasynthesis of Patient and Clinician Perspectives. Arch Phys Med Rehabil. 2021;102(5):984–98.

45. van der Leeden M, Balland C, Geleijn E, Huijsmans RJ, Dekker J, Paul MA, et al. In-Hospital Mobilization, Physical Fitness, and Physical Functioning After Lung Cancer Surgery.

46. de Leeuwerk ME, Botjes M, van Vliet V, Geleijn E, de Groot V, van Wegen E, et al. Self-monitoring of Physical Activity After Hospital Discharge in Patients Who Have Undergone Gastrointestinal or Lung Cancer Surgery: Mixed Methods Feasibility Study. JMIR Cancer. 2022;8(2).

47. Goodacre S. Uncontrolled before-after studies: discouraged by Cochrane and the EMJ. Emerg Med J. 2015;32(7):507–8.

Appendix 1 Detailed description of the GOAL-intervention

Intervention component	Explanation	BCT	Example
1. Feedback of movement behavior	Insight into the patients' movement behavior via bedside tablets, the EPR and public screen on the ward.	Feedback & monitoring	
2. Goal setting	HCPs can set movement goals. A predefined movement goal is based on previous baseline measurements, 30 minutes on both wards in this study.	Goals & planning	
3. Environment	Exercise posters on the walls. Walking routes on the floors (nudging). Educational posters in patients' room.	Associations & antecedents	

Abbreviations: BCT: behavioral change technique, EPR: electronic patient record, HCP: healthcare professional

Part II

Optimizing recovery after major oncological surgery

Chapter 7

Decrease of physical fitness during neoadjuvant chemoradiotherapy predicts the risk of pneumonia after esophagectomy

Petra Bor
Feike B Kingma
Ad Kerst
Elles Steenhagen
Jelle P. Ruurda
Richard van Hillegersberg
Karin Valkenet
Cindy Veenhof

Published in Diseases of the Esophagus, 2021

ABSTRACT

Background Although neoadjuvant chemoradiotherapy is frequently used in esophageal cancer patients undergoing treatment with curative intent, it can negatively impact patients' physical fitness. A decline in physical fitness during chemoradiotherapy may be an indication of vulnerability. The aim of this study was to evaluate whether changes in physical fitness, weight and Fat Free Mass Index during neoadjuvant chemoradiotherapy can predict the risk of postoperative pneumonia.

Methods A retrospective longitudinal observational cohort study was performed in patients who received curative treatment for esophageal cancer between September 2016 and September 2018 in a high-volume center for esophageal cancer surgery. Physical fitness (handgrip strength, leg extension strength and exercise capacity), weight and Fat Free Mass Index were measured before and after chemoradiotherapy. To be included in the data analyses, pre- and post nCRT data had to be available of at least one of the outcome measures. Logistic regression analyses were performed to evaluate the predictive value of changes in physical fitness, weight and Fat Free Mass Index during neoadjuvant chemoradiotherapy on postoperative pneumonia, as defined by the Uniform Pneumonia Scale.

Results In total, 91 patients were included in the data analyses. Significant associations were found between the changes in handgrip strength (OR 0.880, 95%CI: 0.813-0.952) and exercise capacity (OR 0.939, 95%CI: 0.887-0.993) and the occurrence of postoperative pneumonia. All pneumonias occurred in patients with declines in handgrip strength and exercise capacity after neoadjuvant chemoradiotherapy.

Conclusions A decrease of handgrip strength and exercise capacity during neoadjuvant chemoradiotherapy predicts the risk of pneumonia after esophagectomy for cancer. Measuring physical fitness before and after chemoradiotherapy seems an adequate method to identify patients at risk of postoperative pneumonia.

BACKGROUND

Esophageal cancer is the eighth most common cancer worldwide, with an annual incidence of 572.000.(1) Curative treatment involves esophagectomy and is often preceded by neoadjuvant chemoradiotherapy (nCRT) to attain a 5-year survival rate of approximately 40-50%.(2, 3) Although nCRT increases overall survival, it can impact a patients' physical fitness.(4) Lower levels of physical fitness, defined as muscle strength and exercise capacity, are associated with a lower likelihood of both completing neoadjuvant treatment and undergoing the planned esophagectomy.(4) Additionally, patients undergoing esophagectomy have a relatively high risk of postoperative complications like anastomotic leakage and pneumonia and survivors often suffer from decreased physical fitness levels.(5, 6) Physical fitness parameters closely interact with nutritional status. Since one out of two patients with esophageal cancer deteriorated in nutritional status during nCRT, both physical fitness parameters and nutritional status like weight and fat free mass index (FFMI) will be taken into account in this study.(7) Several systematic reviews show that postoperative pneumonia in cardiac and major abdominal surgery can be reduced by prehabilitation.(8-10) In patients following cardiac surgery, the incidence of postoperative pneumonia even reduced by 50% after a prehabilitation intervention.(11) This suggests that postoperative pneumonia might be a influenced by the preoperative nutritional state and physical fitness of a patient.

Currently available literature about the predictive properties of physical fitness and postoperative outcomes in patients undergoing esophagectomy seems contradictive.(12, 13) Studies measuring physical fitness parameters at only one single preoperative time point are contradictive about the association between preoperative fitness and postoperative outcome.(14) Contrary, in studies that evaluated changes in physical fitness and skeletal muscle mass during nCRT, an association with overall survival after esophagectomy is reported.(4, 15, 16). Change scores provide insight in patients' adaptive capacity and resilience to stressors like nCRT. It is suggested that patients with weakened adaptive capacity and resilience to stressors have a greater risk of poor outcomes following surgery.(17) Therefore, change scores of physical fitness, weight and Fat Free Mass Index (FFMI) during nCRT may be better at predicting postoperative outcomes compared to single measurements. A decline during nCRT, may be an indication of vulnerability and therefore imply a higher risk of developing postoperative pneumonia.

Therefore, the aim of this study was to explore the changes in physical fitness, weight and FFMI during nCRT and to evaluate whether these changes can predict the risk of postoperative pneumonia.

METHODS

Study design and participants

A single-center, longitudinal, retrospective observational cohort study was performed at the University Medical Centre (UMC) Utrecht, a high-volume tertiary referral center for esophagogastric surgery. All patients with esophageal cancer undergoing nCRT followed by esophagectomy between September 2016 and September 2018 were eligible to be included. To be included in the data analyses, data from both pre- and post nCRT visits had to be available of at least one of the outcome measures. The study protocol was assessed and approved by the medical ethics committee of the UMC Utrecht (study protocol number 17/844).

Procedures of usual care

Patients received 5 cycles of nCRT (carboplatin/paclitaxel) and 23 concurrent radiation doses (41.4 Gy) according to the CROSS regimen.(2) Measurements of physical fitness, weight and FFMI were performed as part of usual care by an experienced physiotherapist and dietitian before the start of nCRT and 2 weeks after nCRT.(Figure 1) The appointment was part of an outpatient multidisciplinary assessment including the surgeon, nurse specialist, dietitian and physical therapist. After the nCRT period, which usually takes 5 weeks in total, patients had a planned recovery period of 6-10 weeks until esophagectomy with two-field lymphadenectomy and gastric conduit reconstruction was performed. During the recovery period, patients were advised to be physically active for at least 30 minutes per day. A standardized enhanced recovery protocol was used for perioperative care. This protocol included immediate extubation after surgery and the start of postoperative mobilization on day 1 (Appendix 1).

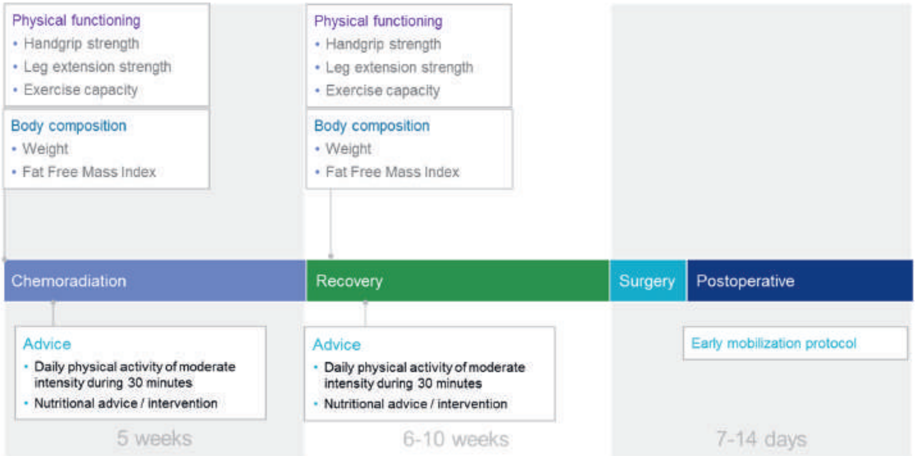


Figure 1. procedures of usual care

Outcome measures

Perioperative outcomes

Baseline characteristics included gender, age, Body Mass Index (BMI), nutritional status (Patient-Generated Subjective Global Assessment classification), surgical risk (American Society of Anesthesiologists classification), tumor location, pathological TNM-classification, surgical details (procedure and location of anastomoses), pathological outcomes, length of stay (total and at Intensive Care Unit) and 30 day readmission rate. The primary endpoint of this study was the incidence of postoperative pneumonia, as defined by the uniform pneumonia score (UPS).(18, 19) Secondary endpoints were the rate of completion of nCRT and the overall rate of postoperative complication with a Clavien-Dindo score of ≥2.(20) Baseline and perioperative outcomes were retrieved from a prospectively maintained surgical database.

Physical fitness

Physical fitness measurements included muscle strength (defined as handgrip and leg extension strength) and exercise capacity. Handgrip strength (kilogram) was evaluated with the Jamar handheld dynamometer (Lafayette Instrument Company, USA). A change of 6 kilogram (kg) is assumed to indicate a clinical relevant difference.(21, 22) The Jamar handheld dynamometer has a good to excellent test-retest reproducibility (r>0.80) and excellent inter-rater reliability (r=0.98).(23) Leg extension strength was tested by measuring the quadriceps strength (Newton) with a Hand-Held Dynamometer (Hoggan, microFET 2).(24) Exercise capacity (Wpeak) was measured by the SteepRamp Test (SRT). The SRT is a short maximal cycle ergometer test in which patients are asked to cycle at a pedal frequency of 70-80 rpm while the investigator increases the workload by 25 Watt each 10 seconds.(25) The test-retest reliability of the SRT is very high (Intraclass correlation coefficient of 0.996 (95% CI, 0.989-0.998)) and valid in cancer patients.(25)

Weight and Fat Free Mass Index

Bioelectrical Impedance Analyses (BIA) measurements were performed using Body Quadscan 4000. Raw BIA data (impedance, resistance and reactance) at 50kHz were used to calculate the FFMI, using the Kyle equation.(26)

Statistical analysis

Physical fitness, weight and FFMI measurements pre- and post nCRT were statistically tested by the paired sample t test. Relative changes in physical fitness, weight and FFMI during nCRT were calculated in percentages for complete cases (relative change = ((post nCRT– pre nCRT) / pre nCRT) *100). To evaluate the predicted value of the relative changes and the risk of pneumonia, multivariate logistic regression analyses were performed separately for each parameter. As age and pulmonary comorbidity are known risk factors for postoperative pneumonia, they were entered in the model as co-variates in each multivariable analysis. When a significant association was found with pneumonia, post hoc subgroup analyses were performed. For the post hoc analyses, patients were divided in 4 quartiles based on their relative changes in physical fitness, weight or FFMI. The incidence of pneumonia was presented for each quartile. To gain insight in the potential correlation between the selected parameters, multicollinearity was tested for handgrip strength, leg extension strength, exercise capacity, weight and FFMI using pearson correlation coefficients (rating r≥0.50 as moderate and r≥0.80 as strong correlation).(27)

RESULTS

Patients and surgical characteristics

An overview of the inclusion of patients, and the performed physical fitness, weight and Fat Free Mass Index measurements is shown in figure 2. Missing measurements occurred both pre- and post nCRT. Between September 2016 and September 2018 in total 131 patients underwent esophagectomy with curative intent, Of these in 91 patients there was data pre and post nCRT available of at least one of the outcome measures. Since relative change scores could only be calculated in complete cases, only these patients were included in the data analyses.

The mean age was 64 years (SD 9) and the majority were male (73%). Robot-assisted minimally invasive esophagectomy (RAMIE) was most often performed (n=83, 91%) and almost half of the patients had a cervical anastomosis (n=38, 42%).

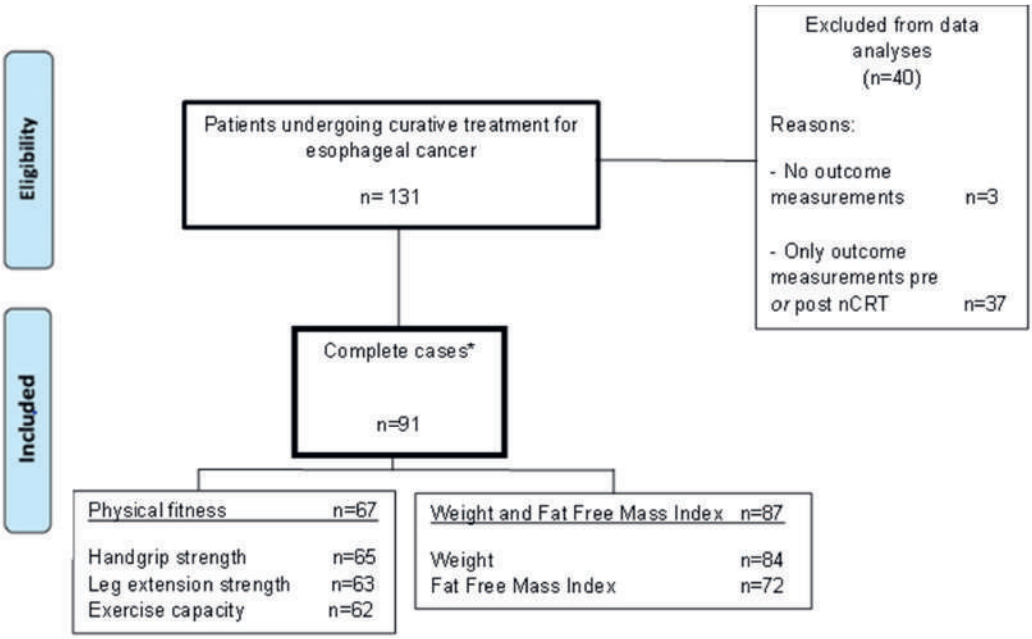


Figure 2. Overview of performed physical fitness, weight and Fat Free Mass Index measurements

Postoperative outcomes

Overall, of the included 91 patients, 66 patients (73%) developed at least one postoperative complication. Pneumonia occurred in 17 (19%) patients. The median length of stay was 11 days [IQR 8-15]. All postoperative outcomes are presented in table 1.

Between patients with a complete case (n=91) and patients with an incomplete case (n=40) no statistically significant differences were found in preoperative patient and surgical characteristics. In the postoperative outcomes, significant differences were seen in de incidence of postoperative pneumonia (19% versus 38%, p=0.021) and total LOS (median of 11 versus 15 days, p=0.040).

Changes and impact of physical fitness, weight and FFMI

Table 2 shows the level of physical fitness, weight and FFMI of patients before and after nCRT. Significant decreases were seen in exercise capacity (-5%, P=0.007), weight (-2%, P=0.000) and FFMI (-2%, P=0.016). No multicollinearity was found between handgrip strength, leg extension strength, exercise capacity, weight and FFMI (R≤0.314).

Postoperative pneumonia was significantly more likely to occur in patients who had greater decreases in handgrip strength (OR 0.880 [95%CI 0.813 - 0.952]) and exercise capacity (OR 0.939 [95%CI: 0.887 - 0.993]) during nCRT (Table 3). No significant associations were found between changes in leg extension strength, weight, or Fat Free Mass Index and the occurrence of postoperative pneumonia (Table 3). The post hoc analyses showed that none of the patients with stable or improved exercise capacity and handgrip strength developed pneumonia. All pneumonias occurred in patients with declined exercise capacity and handgrip strength (Table 4). No association was found between changes in physical fitness, weight or FFMI and the risk of overall postoperative complications (Appendix 2).

Table 1. Patient and surgical characteristics and postoperative outcomes

	All patients n=131	Complete cases n=91	Incomplete case n=40	p-value (complete versus incomplete cases)
Patient and surgical characteristics				
Male, n(%)	99(76)	66(73)	33(83)	0.221
Age in years, mean(SD)	64(9)	64(9)	65(9)	0.625
BMI, mean(SD)	26(4)	26(4)	26(5)	0.533
PG-SGA classification, n(%)				N.A.
- A = well nourished	59(45)	57(63)	2(5)	
- B = moderate malnutrition	26(20)	25(28)	1(3)	
- C = severe malnutrition	0(0)	0(0)	0(0)	
- Missing	46(35)	9(10)	37(93)	
ASA-classification, n(%)				0.383
- I	14(11)	11(12)	3(8)	
- II	84(64)	60(66)	24(60)	
- III	33(25)	20(22)	13(33)	
pTNM-classification, n(%)				
T: 0 / 1 / 2 / 3 / 4	40(31) / 21(16) / 13(10) / 54(41) / 3(2)	26(29) / 18(20) / 10(11) / 35(39) / 2(2)	14(35) / 3(8) / 3(8) / 19(48) / 1(3)	0.421
N: 0 / 1 / 2 / 3	74(57) / 33(25) / 14(11) / 10(8)	49(54) / 25(28) / 11(12) / 6(7)	25(63) / 8(20) / 3(8) / 4(10)	0.582
Comorbidities, n(%)				
- Pulmonary	29(22)	19(21)	10(25)	0.601
- Cardiac	32(24)	24(26)	8(20)	0.434
- Vascular	55(42)	42(46)	13(33)	0.145
- Diabetes Mellitus	21(16)	15(17)	6(15)	0.831
Tumor location, n(%)				0.354
- Proximal	6(5)	5(6)	1(3)	
- Middle	18(14)	11(12)	7(18)	
- Distal	97(74)	70(77)	27(68)	
- GEJ	10(8)	5(6)	5(13)	
Histology, n(%)				0.497
- Adenocarcinoma	89(68)	63(69)	26(65)	
- Squamous cell carcinoma	35(27)	24(26)	11(28)	
- Other	7(5)	4(4)	2(5)	
Completion of nCRT, n(%)	128(98)	90(99)	38(95)	0.169
Surgical procedure, n(%)				0.289
- Transthoracic	117(89)	83(91)	34(85)	
- Transhiatal	14(11)	8(9)	6(15)	
Location anastomose, n(%)				0.255
- intrathoracic	72(55)	53(58)	19(48)	
- cervical	59(45)	38(42)	21(53)	
Postoperative outcomes				
Postoperative complications, n(%)				
- Pneumonia	32(24)	17(19)	15(38)	0.021*
- Anastomotic leakage	36(28)	23(25)	13(33)	0.394

7

- Chyle leakage	11(8)	8(9)	3(8)	0.806
- Recurrent laryngeal nerve	9(7)	7(8)	2(5)	0.575
Patients with at least one postoperative complication, n(%)	100(76)	66(73)	34(85)	0.122
Clavien-Dindo score, n(%) I / II / IIIa / IIIb / IV / V	9(7) / 43(33) / 19(15) / 13(10) / 24(18) / (1)	8(9) / 32(35) / 15(17) / 7(8) / 11(12) / 1(1)	1(3) / 11(28) / 4(1) / 6(15) / 13(33) / 0(0)	0.067
Hospitalization(days), median (IQR)				
- ICU stay	2(1-4)	1(1-4)	3(1-7)	0.093
- Total length of stay	12(9-18)	11(8-15)	15(11-22)	0.040*
30- day readmission, n(%)	19(15)	14(15)	5(13)	0.666

BMI = Body Mass Index, PG-SGA = Patient Generated Subjective Global Assessment, ASA-classification = American Society of Anesthesiologists Classification of physical health, pTNM –classification; pathological Classification of Malignant Tumors (T=size of direct extent of the primary tumor 1-4, N = Degree of spread to regional lymph noded 0-3. nCRT = neoadjuvant chemoradiotherapy, All patients (all patients who underwent esophagectomy with curative intent between september 2016 and september 2018), complete cases (patients with at least one of the outcome measurements was available pre *and* post nCRT), incomplete case (patients with no or only one outcome measure pre *or post* nCRT). N.A.: not applicable, due to the high percentage of missing values.

Table 2. Measurements of physical fitness, weight and FFMI pre- and post nCRT

	n	**Pre nCRT**	**Post nCRT**	**Relative change (%)**	**p-value**
Handgrip strength (kg), mean (SD)	65	37 (12)	36 (11)	0 (20)	0.156
Leg extension strength (Newton), mean (SD)	63	398 (79)	402 (90)	2 (19)	0.667
Exercise capacity (Wpeak), mean (SD)	62	245 (57)	233 (65)	-5 (17)	0.007*
Weight (kg), mean (SD)	84	79 (15)	77 (15)	-2 (4)	0.000*
Fat Free Mass Index (kg/m^2), mean (SD)	72	19 (3)	18 (3)	-2 (8)	0.016*

Descriptive statistics are presented as mean (SD), statistical analysis includes the paired sample t-test.

Table 3. The association between indicators of relative change in physical fitness, weight and Fat Free Mass Index and the occurrence of pneumonia

	Postoperative pneumonia					
	n	**No**	**n**	**Yes**	**Odds Ratio (95%CI)**	**p-value**
Δ Handgrip strength (kg), mean (SD)	54	3 (21)	11	-13 (11)	0.880 (0.813, 0.952)	0.001*
Δ Leg extension strength (Newton), mean (SD)	53	4 (20)	10	-6 (9)	0.958 (0.909, 1.009)	0.108
Δ Exercise capacity, (Wpeak), mean (SD)	50	-3 (16)	12	-16 (20)	0.939 (0.887, 0.993)	0.028*
Δ Weight (kg), mean (SD)	67	-3 (4)	17	-2 (4)	1.045 (0.914, 1.195)	0.518
Δ FFMI (kg/m2), mean (SD)	57	-3 (9)	15	-1 (3)	1.035 (0.955, 1.123)	0.402

The indicator is represented as relative change score. Descriptive statistics are presented as mean (SD), logistic regression analysis was corrected for the baseline characteristics age and pulmonary comorbidities.

Table 4. Post hoc analyses: the incidence of pneumonia per percentile based on the relative changes in handgrip strength and exercise capacity

Handgrip strength			**Exercise capacity**		
Percentiles	n (total)	Pneumonia, n (%)	Percentiles	n (total)	Pneumonia, n (%)
25 (low – -7.8041)	16	8 (50)	25 (low – -12.9464)	15	4 (27)
50 (-7.8042 - 0.0000)	23	3 (13)	50 (-12.9465- -8.3333)	17	6 (35)
75 (0.0001 - 4.4643)	10	0 (0)	75 (-8.3334-0.0000)	18	2 (11)
100 (4.4644 - higher)	16	0 (0)	100 (0.0001- higher)	12	0 (0)

DISCUSSION

This study describes the changes in physical fitness, weight and FFMI during nCRT for esophageal cancer and the association of these changes with the risk of pneumonia after esophagectomy. Exercise capacity, weight and FFMI decreased significantly during nCRT. Besides that, a decrease in handgrip strength and exercise capacity during nCRT is associated with an increased risk of postoperative pneumonia after esophagectomy for cancer. All pneumonias occurred in patients with declined physical fitness during nCRT. Patients who were not included in the data analyses because they missed the physical therapy and/or dietetic counseling pre- and post nCRT, appeared to be the patients with a higher incidence of postoperative pneumonia and prolonged length of stay.

7

Previous studies demonstrated a significant decrease of exercise capacity during nCRT.(4, 28, 29) In addition, two previous studies found an association between the change of exercise capacity during nCRT and the risk of postoperative pulmonary complications and overall survival.(4, 15) One of these studies showed that patients who improved their physical fitness during nCRT had a lower risk of pulmonary complications compared to patients who remained stable or declined, which is in line with our results.(15) An association was not found between the change in physical fitness during nCRT and overall postoperative complications, which also is in line with a previous study.(30) This might be explained by the fact that complications such as anastomotic leakage are also relatively common complications after esophagectomy. Literature showed that there are several numbers of risk factors for the occurrence of anastomotic leakage after esophagectomy.(31) Therefore, the risk of anastomotic leakage might not be influences by one factor, such as changes in physical fitness.

This study showed that handgrip strength was associated with the occurrence of postoperative pneumonia, whereas leg extension strength was not. This contrary result might be explained by the fact that the correlation between the two measures were low. Furthermore, literature showed that measuring leg extension strength with a hand held dynamometer, is a less reliable instrument compared to the 'gold standard' of isokinetic testing.(32) However, isokinetic testing is expensive and time consuming. For that reason, a handheld dynamometer was used in the context of usual care in our institute during the study period. To optimize the reliability of measuring leg extension strength, the measurements were performed by a small trained group of physical therapists. Since this study showed that handgrip strength is an adequate method to identify changes during nCRT and can select the patients who are at risk for postoperative pneumonia, this is the recommended method for evaluating muscle strength as predictor for postoperative pneumonia.

In patients undergoing major abdominal surgery, the value of testing preoperative exercise parameters to identify patients at risk for postoperative morbidity is widely studied.(33, 34) However, for patients undergoing esophagectomy, literature seems to be contradictive in the relation between physical fitness and postoperative complications, especially when physical fitness measurements were performed at a single moment in time.(12, 13, 35-37) Our study showed that relative changes in physical fitness during nCRT can identify patients at risk of postoperative complications. For these patients exercise training might be beneficial. A previous review showed that preoperative exercise training can result in improved levels of physical fitness in patients with gastrointestinal cancer.(38) Therefore, preoperative exercise might be beneficial for patients who are at risk for postoperative pneumonia, particularly patients who show a decline in physical fitness during nCRT. However, further research is needed to explore if a decline in physical fitness is a modifiable risk factor and whether these patients can reduce the risk of the postoperative pneumonia by intensified training exercises before surgery (prehabilitation).

This study has several limitations. First, this study was single centered making the results hard to generalize. Second, missing data occurred. Reasons for missing data were that some patients received their nCRT in another hospital, leading to missing pre-nCRT measurements. Another reason was due to logistic reasons. Patients had a comprehensive program including several disciplines and appointments. Some patients were unable to attend all appointments, missing the physical therapy appointment. Since the missing data were not at random, no imputation was performed. As seen in the results, patients with incomplete data (and therefore not included in the data analyses) had a higher incidence of pneumonia and length of hospital stay after surgery. However, based on the table 1, these findings cannot be explained by bias in terms of patient and surgical characteristics, since no significant differences were found. Nevertheless, there might have been other factors, not measured in this study, which have played a role in the high incidence of postoperative pneumonia and prolonged length of hospital stay in the missing data. The authors did not have a clear explanation for these differences found in postoperative outcomes. However, it could be that patients who did not complete their preoperative physical therapy and/or dietetic counseling were less well prepared prior to surgery, which might explain a higher incidence of pneumonia and prolonged length of hospital stay.

CONCLUSION

A decrease of handgrip strength and exercise capacity during nCRT predicts the risk of pneumonia after esophagectomy for cancer. Measuring physical fitness before and after chemoradiotherapy might identify patients at risk of unwanted postoperative events and is therefore being suggested as standard of practice. Attention in daily care is needed for the patients who missed the physical therapy and the dietetic counseling in usual care, since these patients have the highest incidence of postoperative pneumonia and prolonged length of hospital stay. Future research should investigate if preoperative physical fitness can be improved in patients awaiting esophagectomy and whether an intensified preoperative exercise program can reduce the risk of complications after esophagectomy for cancer.

REFERENCES

1. GLOBOCAN. Estimated cancer incidence, mortality and prevalence worldwide. http://gco.iarc.fr/today/data/factsheets/cancers/6-Oesophagus-fact-sheet.pdf, 2018 (accessed 25 februari 2020)

2. Shapiro J, van Lanschot JJB, Hulshof M, van Hagen P, van Berge Henegouwen MI, Wijnhoven BPL, et al. Neoadjuvant chemoradiotherapy plus surgery versus surgery alone for oesophageal or junctional cancer (CROSS): long-term results of a randomised controlled trial. The Lancet Oncology. 2015;16(9):1090-8.

3. Sjoquist KM, Burmeister BH, Smithers BM, Zalcberg JR, Simes RJ, Barbour A, et al. Survival after neoadjuvant chemotherapy or chemoradiotherapy for resectable oesophageal carcinoma: an updated meta-analysis. The Lancet Oncology. 2011;12(7):681-92.

4. Jack S, West MA, Raw D, Marwood S, Ambler G, Cope TM, et al. The effect of neoadjuvant chemotherapy on physical fitness and survival in patients undergoing oesophagogastric cancer surgery. European journal of surgical oncology. 2014;40(10):1313-20.

5. Gannon JA, Guinan EM, Doyle SL, Beddy P, Reynolds JV, Hussey J. Reduced fitness and physical functioning are long-term sequelae after curative treatment for esophageal cancer: a matched control study. Diseases of the esophagus. 2017;30(8):1-7.

6. Park DP, Welch CA, Harrison DA, Palser TR, Cromwell DA, Gao F, et al. Outcomes following oesophagectomy in patients with oesophageal cancer: a secondary analysis of the ICNARC Case Mix Programme Database. Critical care (London, England). 2009;13 Suppl 2:S1.

7. Rietveld SCM, Witvliet-van Nierop JE, Ottens-Oussoren K, van der Peet DL, de van der Schueren MAE. The Prediction of Deterioration of Nutritional Status during Chemoradiation Therapy in Patients with Esophageal Cancer. Nutr Cancer. 2018;70(2):229-35

8. Katsura M, Kuriyama A, Takeshima T, Fukuhara S, Furukawa TA. Preoperative inspiratory muscle training for postoperative pulmonary complications in adults undergoing cardiac and major abdominal surgery. Cochrane Database Syst Rev. 2015(10):Cd010356.

9. Moran J, Guinan E, McCormick P, Larkin J, Mockler D, Hussey J, et al. The ability of prehabilitation to influence postoperative outcome after intra-abdominal operation: A systematic review and meta-analysis. Surgery. 2016;160(5):1189-201.

10. Kendall F, Oliveira J, Peleteiro B, Pinho P, Bastos PT. Inspiratory muscle training is effective to reduce postoperative pulmonary complications and length of hospital stay: a systematic review and meta-analysis. Disabil Rehabil. 2018;40(8):864-82.

11. Hulzebos EH, Helders PJ, Favié NJ, De Bie RA, Brutel de la Riviere A, Van Meeteren NL. Preoperative intensive inspiratory muscle training to prevent postoperative pulmonary complications in high-risk patients undergoing CABG surgery: a randomized clinical trial. Jama. 2006;296(15):1851-7.

12. Tatematsu N, Park M, Tanaka E, Sakai Y, Tsuboyama T. Association between physical activity and postoperative complications after esophagectomy for cancer: a prospective observational study. Asian Pac J Cancer Prev. 2013;14(1):47-51.

13. van Egmond MA, van der Schaaf M, Klinkenbijl JH, Engelbert RH, van Berge Henegouwen MI. Preoperative functional status is not associated with postoperative surgical complications in low risk patients undergoing esophagectomy. Diseases of the esophagus. 2017;30(1):1-7.

14. O'Neill L, Moran J, Guinan EM, Reynolds JV, Hussey J. Physical decline and its implications in the management of oesophageal and gastric cancer: a systematic review. Journal of cancer survivorship : research and practice. 2018;12(4):601-18.

15. Whibley J, Peters CJ, Halliday LJ, Chaudry AM, Allum WH. Poor performance in incremental shuttle walk and cardiopulmonary exercise testing predicts poor overall survival for patients undergoing esophago-gastric resection. European journal of surgical oncology. 2018;44(5):594-9

16. Jarvinen T, Ilonen I, Kauppi J, Salo J, Rasanen J. Loss of skeletal muscle mass during neoadjuvant treatments correlates with worse prognosis in esophageal cancer: a retrospective cohort study. World journal of surgical oncology. 2018;16(1):27.

17. Ethun CG, Bilen MA, Jani AB, Maithel SK, Ogan K, Master VA. Frailty and cancer: Implications for oncology surgery, medical oncology, and radiation oncology. CA: a cancer journal for clinicians. 2017;67(5):362-77.

18. Seesing MFJ, Wirsching A, van Rossum PSN, Weijs TJ, Ruurda JP, van Hillegersberg R, et al. Defining pneumonia after esophagectomy for cancer: validation of the Uniform Pneumonia Score in a high volume center in North America. Diseases of the esophagus. 2018;31(6).

19. Weijs TJ, Seesing MF, van Rossum PS, Koeter M, van der Sluis PC, Luyer MD, et al. Internal and External Validation of a multivariable Model to Define Hospital-Acquired Pneumonia After Esophagectomy. Journal of gastrointestinal surgery. 2016;20(4):680-7.

20. Low DE, Alderson D, Cecconello I, Chang AC, Darling GE, D'Journo XB, et al. International Consensus on Standardization of Data Collection for Complications Associated With Esophagectomy: Esophagectomy Complications Consensus Group (ECCG). Ann Surg. 2015;262(2):286-94.

21. Nitschke JE, McMeeken JM, Burry HC, Matyas TA. When is a change a genuine change? Journal of Hand Therapy. 1999;12(1):25-30.

22. Bohannon RW. Minimal clinically important difference for grip strength: a systematic review. J Phys Ther Sci. 2019;31(1):75-8.

23. Peolsson A, Hedlund, R and Oberg, B. Intra- and inter-tester reliability and reference values for hand strength. J Rehab Med 2001;33:36–41.

24. Arnold CM, Warkentin KD, Chilibeck PD, Magnus CRA. The reliability and validity of handheld dynamometry for the measurement of lower-extremity muscle strength in older adults Journal of Strength and Conditioning Research. 2010;24(3):815–24.

25. De Backer IC, Schep G, Hoogeveen A, Vreugdenhil G, Kester AD, van Breda E. Exercise testing and training in a cancer rehabilitation program: the advantage of the steep ramp test. Arch Phys Med Rehabil. 2007;88(5):610-6.

26. Kyle UG, Genton L, Karsegard L, Slosman DO, Pichard C. Single prediction equation for bioelectrical impedance analysis in adults aged 20--94 years. Nutrition. 2001;17(3):248-53.

27. Zou KH, Tuncali K, Silverman SG. Correlation and simple linear regression. Radiology. 2003;227(3):617-22.

28. Navidi M, Phillips AW, Griffin SM, Duffield KE, Greystoke A, Sumpter K, et al. Cardiopulmonary fitness before and after neoadjuvant chemotherapy in patients with oesophagogastric cancer. The British journal of surgery. 2018;105(7):900-6.

29. Sinclair R, Navidi M, Griffin SM, Sumpter K. The impact of neoadjuvant chemotherapy on cardiopulmonary physical fitness in gastro-oesophageal adenocarcinoma. Annals of the Royal College of Surgeons of England. 2016;98(6):396-400.

30. Drummond RJ, Vass D, Wadhawan H, Craig CF, MacKay CK, Fullarton GM, et al. Routine pre- and post-neoadjuvant chemotherapy fitness testing is not indicated for oesophagogastric cancer surgery. Annals of the Royal College of Surgeons of England. 2018;100(7):515-9.

31. Kassis ES, Kosinski AS, Ross P, Jr., Koppes KE, Donahue JM, Daniel VC. Predictors of anastomotic leak after esophagectomy: an analysis of the society of thoracic surgeons general thoracic database. Ann Thorac Surg. 2013;96(6):1919-26.

32. Stark T, Walker B, Phillips JK, Fejer R, Beck R. Hand-held dynamometry correlation with the gold standard isokinetic dynamometry: a systematic review. Pm r. 2011;3(5):472-9.

33. Richardson K, Levett DZH, Jack S, Grocott MPW. Fit for surgery? Perspectives on preoperative exercise testing and training. Br J Anaesth. 2017;119

34. Levett DZ, Grocott MP. Cardiopulmonary exercise testing for risk prediction in major abdominal surgery. Anesthesiol Clin. 2015;33(1):1-16.

35. Inoue T, Ito S, Kanda M, Niwa Y, Nagaya M, Nishida Y, et al. Preoperative six-minute walk distance as a predictor of postoperative complication in patients with esophageal cancer. Diseases of the esophagus. 2019; 0:1-6.

36. Sato S, Nagai E, Taki Y, Watanabe M, Watanabe Y, Nakano K, et al. Hand grip strength as a predictor of postoperative complications in esophageal cancer patients undergoing esophagectomy. Esophagus. 2018;15(1):10-8.

37. Lam S, Alexandre L, Hardwick G, Hart AR. The association between preoperative cardiopulmonary exercise-test variables and short-term morbidity after esophagectomy: A hospital-based cohort study. Surgery. 2019;166(1):28-33.

38. Vermillion SA, James A, Dorrell RD, Brubaker P, Mihalko SL, Hill AR, et al. Preoperative exercise therapy for gastrointestinal cancer patients: a systematic review. Systematic reviews. 2018;7(1):103.

APPENDICES

Appendix 1 Postoperative protocol

EROES Enhanced Recovery after OEsophageal Surgery

UMC Utrecht

Drains and lines per day

Esophagectomy (DAY 0)
1x thick chest tube
1-2x chest Jackson-Pratt drain
Central venous line
Gastric decompression tube
Epidural catheter (PEPMEN trial)
Urinary catheter
Jejunostomy tube only in selected cases

↓

DAY 1 (ICU / MCU)
Remove thick chest tube (unless there is air leak)

↓

DAY 2 (MCU / surgical ward)
Remove chest Jackson-Pratt drain (in case <200cc/24u)

↓

DAY 3 (surgical ward)
Remove central venous line
Remove epidural catheter
Remove urinary catheter
Remove gastric decompression tube (in case <300cc retention)
Remove chest Jackson-Pratt drain (in case <200cc/24u)

↓

DAY 4 until discharge (surgical ward)
Remove gastric decompression tube (in case <300cc retention)
Remove chest Jackson-Pratt drain (in case <200cc/24u)

EROES Enhanced Recovery after OEsophageal Surgery

UMC Utrecht

ACTIVITIES PER DAY

	Mobilisation	Intake	Other
DAY 0 (surgery)	▪ Bed in sitting position	▪ Ice lolly every hour	▪ Keep track of daily activities
DAY 1	▪ Bed in sitting position ▪ 2 times ≥3 minutes walking	▪ Ice lolly or sips of water every hour	▪ Keep track of daily activities
DAY 2	▪ Bed in sitting position ▪ 3 times ≥3 minutes walking	▪ Ice lolly or sips of water every hour	▪ Keep track of daily activities
DAY 3	▪ Bed in sitting position ▪ 4 times ≥3 minutes walking	▪ Ice lolly or sips of water every hour	▪ Keep track of daily activities
DAY 4	▪ Bed in sitting position ▪ 5 times ≥3 minutes walking ▪ Bicycle exercise	▪ Start liquid diet	▪ Keep track of daily activities
DAY 5 until discharge	▪ Reduce the time in bed ▪ 6 times ≥3 minutes walking ▪ Bicycle exercise	▪ Liquid diet	▪ Keep track of daily activities

DAY 7	DISCHARGE (continue liquid diet until first outpatient visit)

Appendix 2 The association between indicators of relative change in physical fitness, weight and Fat Free Mass Index and the risk of postoperative complications (clavien dindo classification ≥2)

	Postoperative complications					
	N	No n=31	N	Yes n=100	Odds Ratio (95%CI)	p-value
Δ Handgrip strength (kg), mean (SD)	16	1 (9)	49	0 (23)	0.999 (0.972,1.026)	0.941
Δ Leg extension strength (Newton), mean (SD)	16	4 (15)	47	1 (20)	0.999 (0.970,1.028)	0.927
Δ Exercise capacity (Wpeak), mean (SD)	13	-6 (11)	49	-5 (19)	1.004 (0.967,1.042)	0.835
Δ Weight (kg), mean (SD)	21	-2 (5)	63	-3 (4)	0.971 (0.856, 1.101)	0.642
Δ Fat Free Mass Index (kg/m^2), mean (SD)	18	-0 (6)	54	-3 (9)	0.945 (0.855,1.045)	0.269

The indicator is represented as relative change score. Descriptive statistics are presented as mean (SD), logistic regression analysis was corrected for the baseline characteristics age and pulmonary comorbidities.

7

Chapter 8

Physical functioning and physical activity after oncological surgery: an observational cohort study

Petra Bor
Marijke E. de Leeuwerk
Karin Valkenet
Richard van Hillegersberg
Cindy Veenhof

Published in European Journal of Cancer Care 2022

ABSTRACT

Objective To investigate the recovery of physical functioning and objective physical activity levels up to 3 months after oncological surgery and to determine the association between physical activity levels and the recovery of physical functioning.

Methods Longitudinal observational cohort study in patients who underwent oncological surgery. Recovery of physical functioning was measured preoperatively, and 1 and 3 months after discharge. Physical activity was objectively measured with an accelerometer during hospitalization, and 1 and 3 months after discharge.

Results Between February-November 2019, 68 patients were included. Half of the patients (n=33, 49%) were not recovered in physical functioning 3 months after surgery. During hospitalization, physical activity increased from 13 to 46 median active minutes per day. At 1 and 3 months after discharge, patients were physically active for 138 and 159 median minutes per day respectively. Patients with higher levels of physical activity 1 month after discharge showed to have higher levels of physical functioning up to 3 months after discharge.

Conclusion At 3 months after surgery, physical functioning is still diminished in half of the patients. It is important to evaluate both physical activity levels and physical functioning levels after surgery to enable tailored postoperative mobility care.

INTRODUCTION

Undergoing oncological surgery is a major life event. Studies evaluating postoperative recovery in patients who underwent oncological surgery mostly evaluate medical outcomes, such as length of hospital stay or complications.[1] However, other outcomes may be more relevant for patients as they want to return to normal physical functioning in daily life as soon as possible after surgery.[2, 3] Physical functioning is described as the ability to perform daily activities required to participate in the society and is a patient-reported outcome measure (PROM).[4] Other relevant PROMs are levels of fatigue and a patients' life-space.[5, 6] More insight into PROMs after oncological surgery is needed to identify patients with an increased need for support after surgery and to optimize postoperative care.[7]

One of the factors of influence on the level of physical functioning, is the level of physical activity.[8-10] Elderly patients with low levels of physical activity during hospitalization have a high risk of functional decline and loss of independence.[11-13] Several studies suggest that physical activity levels both during and after hospitalization are an important predictor for the recovery of physical functioning after oncological surgery.[8-10] Nevertheless, current studies evaluating physical activity after oncological surgery did not measure physical activity with objective measures like an accelerometer, or did not include physical functioning measures as well.[14-16]

Therefore, more research is needed to evaluate both physical functioning and physical activity during and after hospitalization for oncological surgery. The primary aim of this study was to investigate recovery of physical functioning, fatigue levels and life space up to 3 months after oncological surgery. The secondary aim was to assess physical activity during and after hospitalization and its association with the recovery of physical functioning after surgery.

METHODS

Study design and population

A prospective observational cohort study was conducted at the University Medical Centre Utrecht in the Netherlands between February-November 2019. Inclusion criteria were adult patients undergoing gastrointestinal (esophagus, stomach, colorectal, liver, pancreas) or bladder oncological surgery. Patients were purposefully sampled to achieve an objective reflection of the population on the clinical ward. Patients were excluded if they had a life expectancy of less than 3 months, if the patient was not able to fill in or sign the informed consent form due to cognitive problems or if the patient was completely dependent on a wheelchair. The study protocol was assessed and approved by the medical ethics committee of University Medical Centre Utrecht (research protocol number 19/026). All participants signed informed consent and all methods were performed in accordance with the Declaration of Helsinki.

Outcome measures

Primary outcome

Physical functioning was measured using a translated version of the Boston University Measure for Post-Acute Care (AM-PAC) Basic Mobility Outpatients Routine Short Form.[17] This questionnaire consists of 18 questions about the difficulty to perform a specific activity in the outpatient setting on a scale from 1 (unable) to 4 (none). The total score ranged from 0 to 72 points, whereby a higher score represents less difficulty with performing daily activities. The questionnaire was translated into Dutch by using a forward-backward translation protocol following the guideline for the process of cross-cultural adaption of self-report measures.[18] The AM-PAC has a minimal administration burden and excellent reliability, validity and sensitivity to changes.[4, 19] The minimal clinically important change lies between 3.9 and 5 points.[20] Therefore, in this study participants were labelled as 'recovered' when their postoperative AM-PAC score reached their preoperative score minus 5 points.

Secondary outcome

Physical activity was measured with the Physical Activity Monitor (PAM) version AM400. The PAM-AM400 (PAM B.V. Doorwerth, the Netherlands) is a small 3-axial accelerometer. The PAM was attached around the ankle. The PAM was connected by the researcher to a smartphone application called 'AtrisZorg' via Bluetooth by which the data was sent to a data cloud. During hospitalization, the participants were not able to see their physical activity levels. Postoperatively, patients had to synchronize the data with the 'AtrisApp' (Peercode B.V. Geldermalsen, the Netherlands), whereby active minutes became visual for the patient and data was stored in the data cloud. The PAM registers active minutes categorized into 3 subgroups based on metabolic equivalent of task (MET) values: light 1.4-2.4 MET, medium 2.5-5.9 MET, heavy ≥6.0 MET. The concurrent validity of the PAM was evaluated in 19 hospitalized patients admitted to different wards (gastrointestinal surgery, internal medicine, cardiology, oncology and lung disease) of the University Medical Centre Utrecht. The level of agreement between the PAM and the ActiGraph (wGT3X-BT) was strong with an Intraclass Correlation Coefficient of 0.849 indicating that the PAM is a suitable device to validly measure active minutes in hospitalized patients.(Valkenet et al 2021, published)

Other secondary study parameters were fatigue, life-space and perceived recovery. Furthermore, it was recorded if patients met the Dutch physical activity guideline and if patients trained under supervision of a physiotherapist postoperative. Fatigue was measured with the shortened fatigue questionnaire and consists of four questions ('I feel tired', 'I tire easily', 'I feel fit' and 'I feel physically exhausted'), which were answered on a 7-point scale. The total score ranged from 4 to 28, with higher scores representing higher levels of fatigue.[21] The life-space was assessed with the Life Space Assessment (LSA) which evaluates the mobility of the past 4 weeks by the investigation of 5 space-levels (bedroom, in and around the house, the neighborhood, inside the city and outside the city).[22] The total score ranges from 0 to 120, with a higher score representing a higher level of patients' mobility within their home and community.[23] The perceived recovery was obtained by answering the question; 'to what extent are you recovered from the surgery' on a 10 point scale (0= not at all, 10 fully recovered). The Dutch physical activity guideline was assessed by asking the question 'on how many days a week are you physically active for more than 30 consecutive minutes, on a moderate intensity' and 'on how many days a week do you perform muscle strength exercises'. Participants met the Dutch physical activity guideline if they engaged in moderate physical activity for more than 30 consecutive minutes a day on 5 or more days a week and if they performed muscle strengthening exercises at least twice a week.[24] Additionally, patients were asked if they received postoperative physical therapy treatment to improve their physical functioning levels.

Baseline and clinical data

Baseline and clinical data were retrieved from the electronic patients file. Baseline data included gender, age, Body Mass Index (BMI), living situation, comorbidities (pulmonary, cardiovascular disease and diabetes mellitus), tumor location, operation technique (open versus laparoscopic) and the American Society of Anesthesiologists classification of physical health (ASA classification). Clinical data included the number of complications and the severity of the complication, graded with the Clavien Dindo

Score.[25] Additionally, (neo)adjuvant therapy with chemo- and/or radiotherapy, length of hospital stay and destination after discharge were collected.

Procedures

The assessments took place during hospitalization and 1 and 3 months after discharge.

Procedure during hospitalization

Within 72 hours after surgery patients received information about the research and were asked to participate. If patients were eligible for the study and signed informed consent, the participants were asked to wear the PAM 24 hours a day during their hospital stay. Furthermore, the participants were asked to retrospectively fill in the questionnaires within 1 week after surgery about their physical status in the last week before surgery.

Procedure after discharge

At 1 and 3 months after discharge the participants received a digital questionnaire via e-mail. The PAM was sent by post and the participants were asked to wear the PAM 24 hours a day for a period of 7 consecutive days. After 1 week, the participants were contacted by phone by the researcher to connect the PAM with the AtrisApp to synchronize the data with the data cloud.

Data-analysis

SPSS statistics software (IBM statistics version 25) was used for statistical analysis. Data was checked for outliers, data-entry errors and missing data. Patterns of missing data were analyzed. Multiple imputation with Predictive Mean Measurements was used for imputation of all data with patient characteristics and pre- and postoperative measurements as predictors for imputation.[26, 27]

Categorical data are presented as numbers and percentages (%). Normally distributed continuous data are presented as means with standard deviations (SD) and non-normally distributed continuous data as medians with interquartile ranges [IQR]. To determine differences between preoperative levels of physical functioning and after 3 months statistical analyses were performed. For not normally distributed continuous data, a Wilcoxon sign-rank test was performed and for dichotomous data a McNemar test was performed. A linear mixed model analysis was performed to explore the association of physical activity levels (during hospitalization and 1 month after discharge) with the level of physical functioning. Since ASA-classification is associated with postoperative physical functioning, this variable was entered in the mixed model analyses as covariate.[7]

RESULTS

Baseline and clinical data

A total of 68 patients were included in this study. Figure 1 provides the flow chart of the data collection. All patients filled out the preoperative questionnaire, 48 patients after 1 month and 46 patients after 3 months. The reasons for missing physical functioning data were lost to follow up (not willing to participate after discharge and re-admission) and not filled out the questionnaire (1 month after discharge n=5, 3 months after discharge n=7). Physical activity was measured in 48 patients (71%) during hospitalization, in 41 patients (60%) after 1 months and 33 patients (49%) after 3 months. The main reason for missing physical activity data were non-wear and technical issues.

Table 1 provides an overview of the patient characteristics, surgical characteristics and postoperative outcomes in patients after oncological surgery. Overall, the mean (SD) age was 63±12 and 63% of the patients were male. Patients had a tumor in the esophagus (n=18, 27%), stomach (n=5, 7%), colon or rectum (n=17, 25%), liver (n=15, 22%), pancreas (n=4, 6%) or bladder (n=9, 13%). Complications occurred in 16 patients (24%). No statistical significant differences were found in baseline and clinical data between patients with complete and incomplete data.

Recovery of physical functioning

Preoperatively, the median score of physical functioning was 61 (IQR 18) out of 72. One and 3 months postoperatively, patients had a median score of respectively 51 (IQR 11) and 55 (IQR 10). Patients had a significant lower level of physical functioning 3 months after discharge compared to preoperatively (-6, p<0.001). Furthermore, a significant lower level of fatigue and life-space was seen 3 months after discharge compared to preoperatively (fatigue +7, <0.001) (life-space -17, <0.001), see table 2. No difference in physical activity was found between preoperative levels compared to levels 3 months after discharge (Table 2)

After 1 month, 22 patients (32%) were recovered in physical functioning compared to their preoperative score. After 3 months, 33 patients (49%) were recovered. Physical functioning 1 month after discharge was significantly lower compared to the level of physical functioning 3 months after discharge (β -2.853; 95%CI -4.803- -0.903, p=0.004) (Table 4).

Physical activity levels during and after hospitalization

Overall, the median number of active minutes during the first 5 days during hospitalization on the nursing department was 37 (IQR 13) minutes a day (Table 3). An increase in active minutes per day was seen from day 1 to day 5. One and three months after discharge, the median active minutes per day was respectively 138 (IQR 11) and 159 (IQR 7) minutes (Table 3).

Association between the amount of physical activity and the level of physical functioning after discharge

A higher level of physical activity 1 month after discharge was associated with a higher level of physical functioning between 1 and 3 months after discharge (β 0.151; 95%CI 0.095-0.207, p<0.001) (Table 4).

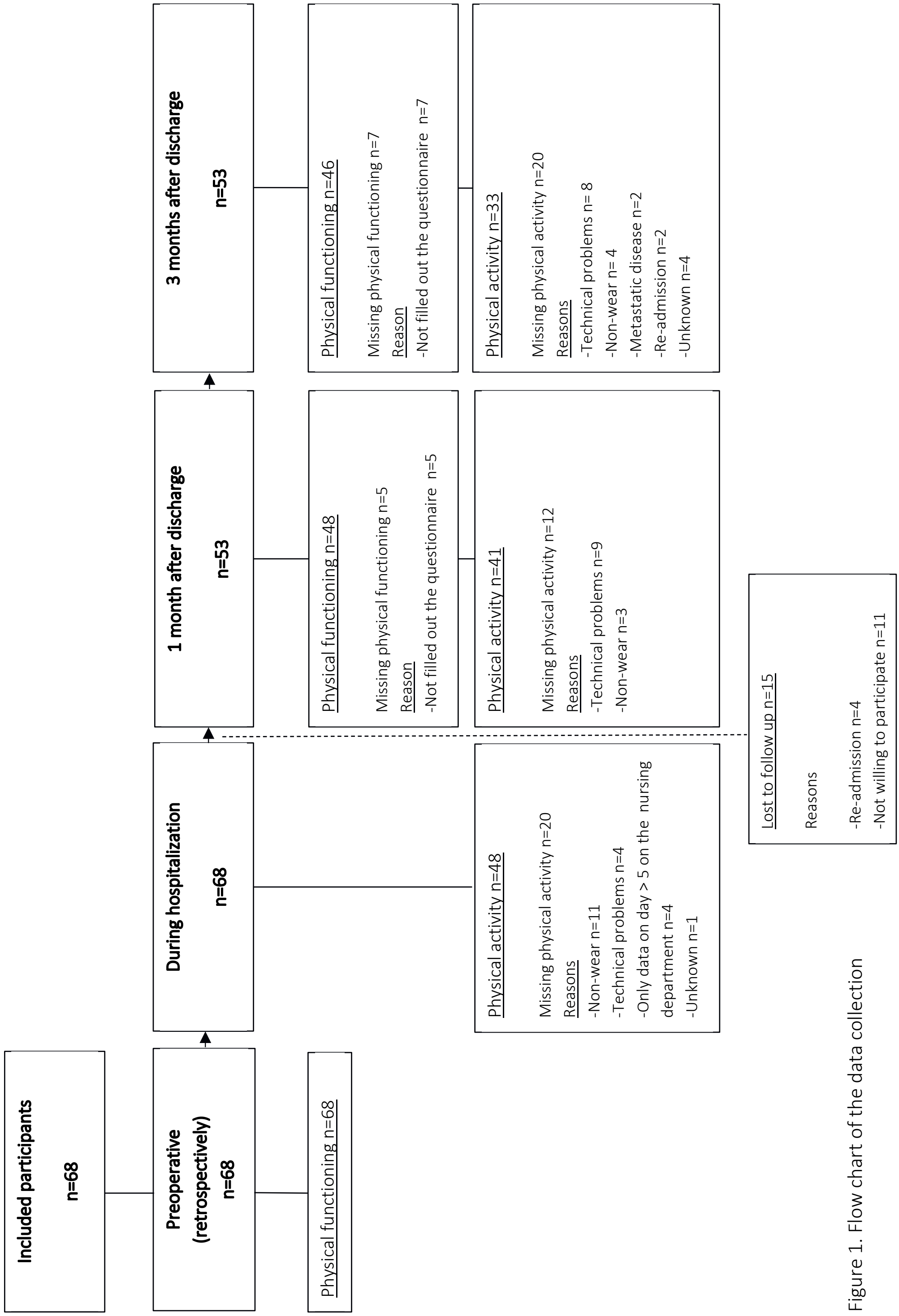


Figure 1. Flow chart of the data collection

Table 1. Patients characteristics, surgical characteristics and postoperative outcomes in patients after oncological surgery

Patient characteristics	**n = 68**
Male, n (%)	43 (63)
Age in years, mean±SD	63±12
BMI, mean±SD	26±4
Living alone, n (%)	11 (16)
Comorbidities, n (%)	
- Pulmonary	9 (13)
- Cardiovascular	22 (32)
- Diabetes Mellitus	7 (10)
ASA-classification, n (%)	
- I	4 (6)
- II	44 (65)
- III	17 (25)
- Unknown	3 (4)
Pre-treatment, n (%)	
- No	36 (53)
- Chemotherapy	13 (19)
- Radiotherapy	4 (6)
- Chemoradiotherapy	15 (22)
Surgical characteristics	
Tumor location, n (%)	
- Esophagus	18 (27)
- Stomach	5 (7)
- Colorectal	17 (25)
- Liver	15 (22)
- Pancreas	4 (6)
- Bladder	9 (13)
Operation technique, n (%)	
- Laparoscopic	57 (84)
- Open	7 (10)
- Other (transurethral resection)	4 (6)
Postoperative outcomes	
Complications, n (%)	16 (24)
Clavien Dindo Classification, n (%)	
I / II / III / IV	3 (4) / 5 (7) / 5 (7) / 3 (4)
Length of stay in hospital, median (IQR)	7 (7)
Destination after discharge, n (%)	
- Home	63 (93)
- Rehabilitation center	5 (7)
Post-treatment, n (%)	
- No	56 (82)
- Chemotherapy	6 (9)
- Missing	6 (9)

BMI = Body Mass Index, ASA classification= American Society of Anesthesiologists Classification of physical health, IQR = interquartile range

Table 2. Physical functioning preoperative and 1 and 3 months postoperative

	n	Pre-operative	1 month after discharge	3 months after discharge	Differences (preoperative – 3 months after discharge)	p-value
Physical functioning, median (IQR)	68	61 (18)	51 (11)	55 (10)	-6	0.000*
Fatigue, median (IQR)	68	11 (16)	17 (4)	18 (4)	7	0.000*
Life-space, median (IQR)	68	90 (26)	56 (19)	73 (13)	-17	0.000*
Dutch guideline of physical activity, n (%)	68	17(25)	13(19)	20(29)	3	0.678
Perceived recovery 0-10, median (IQR)	68	N.A.	6 (2)	7 (1)	N.A.	N.A.
Physical therapy treatment, n (%)	68	N.A.	7(10)	11(16)	N.A.	N.A.

Statistical analysis includes the Wilcoxon signed-rank test for continuous data and the McNemar test for dichotomous data.
IQR = interquartile range, N.A. = not applicable, *p-value < 0.05

Table 3. Median number of active minutes during hospitalization and 1 and 3 months after discharge in patient after oncological surgery

8

Active minutes per day	n	Light	Medium	Heavy	Total
During hospitalization (day 1-5), median (IQR)	68	27 (8)	7 (6)	0 (0)	37 (13)
- Day 1		11 (3)	3 (1)	0 (0)	13 (3)
- Day 2		24 (6)	5 (4)	0 (0)	28 (5)
- Day 3		30 (10)	7 (6)	0 (0)	37 (11)
- Day 4		31 (6)	8 (6)	0 (0)	42 (8)
- Day 5		33 (6)	12 (9)	0 (1)	46 (8)
1 month after discharge, median (IQR)	68	84 (8)	51 (11)	3 (1)	138 (11)
3 months after discharge, median (IQR)	68	97 (6)	57 (5)	5 (3)	159 (7)

IQR = interquartile range, light = 1.4-2.4 MET, medium = 2.5-5.9 MET, heavy = ≥6.0 MET

Table 4. Regression coefficients for the relationship between physical activity, time and the course of physical functioning after discharge

	n	β (95%CI)	p-value
Active minutes during hospitalization (day 1-5)	68	0.056 (-0.048-0.160)	0.286
Active minutes 1 month after discharge	68	0.151 (0.095-0.207)	0.000*
Time**	68	-2.815 (-4.846--0.785)	0.007*

Statistical analyses included a linear mixed model analyses, corrected for ASA-classification. β = regression coefficient, 95%CI = 95% confidence interval, *p-value < 0.05, **the reference value is physical functioning at 3 months

DISCUSSION

This prospective observational cohort study investigated the recovery of physical functioning in patients undergoing oncological surgery. Half of the patients (n=33, 49%) were not recovered in physical functioning 3 months after surgery. During the first 5 days of hospitalization, physical activity increased from 13 to 46 active minutes per day. After discharge, physical activity levels were respectively 138 and 159 active minutes per day 1 and 3 months after discharge. Higher levels of physical activity 1 month after discharge were associated with higher levels of physical functioning up to 3 months after discharge.

For patients it is important to return to their preoperative level of physical functioning as soon as possible. The low percentage of patients that recovered 3 months after discharge is in line with previous studies that evaluated the recovery of physical functioning after colorectal and abdominal surgery.[8, 14] These findings emphasize the high impact of oncological surgery on physical functioning of patients after oncological surgery, not only during hospitalization but also in the period after discharge.

In this study, patients were physically active 3% of the day during hospitalization, which is in line with previous studies who found low physical activity levels during hospitalization.[28-31] No association was found between the level of physical activity during hospitalization and the recovery of physical functioning after discharge. This is in contrast with previous published studies who concluded that the level of physical activity during hospitalization is related to functional decline 1 month after hospitalization.[11, 13] The low variety in levels of physical activity in our study could be the reason why no association was found, since outcomes could not be compared to patients with higher levels of physical activity during hospitalization.

At 1 and 3 months after discharge, patients were on average physically active for 138 and 159 minutes per day respectively. The physical activity levels found in this study were lower compared to a previous published study which showed that patients where 266 minutes per day physical active 4 weeks after abdominal surgery.[32] However, these patients underwent other types of abdominal surgery (adnexal, inguinal hernia repair, cholecystectomy and hysterectomy), which makes it hard to compare. Our study showed that a higher level of physical activity after 1 month was associated with higher levels of physical functioning after discharge. This is in line with another study in patients with colorectal cancer, which showed that a higher physical activity level 6 months after surgery was associated with enhanced recovery of physical functioning.[14] However, the question remains if higher activity levels lead to higher physical functioning levels or that patients with higher physical functioning were able to be more physically active.

Nevertheless, a causal relationship between higher levels of physical activity and enhanced postoperative recovery of physical functioning is plausible. A recent published systematic review showed the impact of mobilization during hospitalization in medically ill patients on postoperative recovery of physical functioning.[33] Additionally, literature shows that better adherence to in-hospital mobilization protocols after lung cancer surgery is related to improved physical fitness after hospital discharge.[34] Since physical inactivity is deeply rooted in the hospital culture, it seems important to start promoting physical activity levels early after surgery to optimize recovery after surgery.[33, 35, 36] A promising and upcoming technology to improve physical activity levels are activity trackers.[32, 35, 37] They can provide insight in the trajectory of physical activity levels following surgery for both the patient and healthcare professional.[15] Hereby, healthcare professionals can provide more tailored advise to optimize physical activity levels, or can identify patients showing signs of inadequate progress of recovery in their home-situation.[15] Therefore, the next step of our research is to implement an activity tracker in usual care to improve physical activity levels after surgery and to explore the effect on the recovery of physical functioning.

Strengths and limitations

This study showed that oncological surgery has a high impact on daily functioning up to 3 months after discharge. In addition, physical activity was objectively measured. This insight might contribute to initiatives to improve postoperative physical activity levels in the future. There were also some limitations in this study. First of all, preoperative physical functioning was measured retrospectively. This might have caused recall bias. However, literature suggests that a short recall period reduces the chance of recall bias.[38] Second, there was a large amount of missing data. Although not all the missing data was at random, imputation gives less biased estimates in comparison to not addressing the missing data at all.[26, 39] Third, the researchers observed that the participants with more complications were more often not willing to participate in this study, which might have led to selection bias and potentially to an overestimation of physical activity and physical functioning levels. Fourth, as this study included a heterogeneous population in terms of operation type, the ability to determine patient recovery trajectories to specific patients populations is limited. Finally, Enhanced Recovery After Surgery (ERAS) protocols including early mobilization are widely implemented after surgery. As each patient population has its own ERAS protocol, differences in postoperative care possibly led to differences in physical activity levels and postoperative recovery between patient populations.

CONCLUSION

Physical functioning 3 months after oncological surgery is diminished in half of the patients emphasizing the high impact of oncological surgery on patients. Higher physically activity levels 1 month after discharge were associated with higher levels of physical functioning up to 3 months after discharge. Therefore, it is important to evaluate both physical activity levels and physical functioning levels after surgery to enable tailored postoperative mobility care to optimize recovery after oncological surgery.

REFERENCES

1. Neville A, Lee L, Antonescu I, Mayo NE, Vassiliou MC, Fried GM, et al. Systematic review of outcomes used to evaluate enhanced recovery after surgery. The British journal of surgery. 2014;101(3):159-70.
2. Miller TE, Mythen M. Successful recovery after major surgery: moving beyond length of stay. Perioper Med (Lond). 2014;3:4.
3. Lee L, Tran T, Mayo NE, Carli F, Feldman LS. What does it really mean to "recover" from an operation? Surgery. 2014;155(2):211-6.
4. Coster WJ, Haley SM, Jette AM. Measuring patient-reported outcomes after discharge from inpatient rehabilitation settings. J Rehabil Med. 2006;38(4):237-42.
5. Stewart CM, Wheeler TL, 2nd, Markland AD, Straughn JM, Jr., Richter HE. Life-space assessment in urogynecology and gynecological oncology surgery patients: a measure of perioperative mobility and function. J Am Geriatr Soc. 2009;57(12):2263-8.
6. Prue G, Rankin J, Allen J, Gracey J, Cramp F. Cancer-related fatigue: A critical appraisal. Eur J Cancer. 2006;42(7):846-63.
7. Jakobsson J, Idvall E, Kumlien C. Patient characteristics and surgery-related factors associated with patient-reported recovery at 1 and 6 months after colorectal cancer surgery. Eur J Cancer Care (Engl). 2017;26(6).
8. Lawrence VA, Hazuda HP, Cornell JE, Pederson T, Bradshaw PT, Mulrow CD, et al. Functional independence after major abdominal surgery in the elderly. J Am Coll Surg. 2004;199(5):762-72.
9. Castelino T, Fiore JF, Jr., Niculiseanu P, Landry T, Augustin B, Feldman LS. The effect of early mobilization protocols on postoperative outcomes following abdominal and thoracic surgery: A systematic review. Surgery. 2016;159(4):991-1003.
10. Abeles A, Kwasnicki RM, Pettengell C, Murphy J, Darzi A. The relationship between physical activity and post-operative length of hospital stay: A systematic review. Int J Surg. 2017;44:295-302.
11. Brown CJ, Friedkin RJ, Inouye SK. Prevalence and outcomes of low mobility in hospitalized older patients. J Am Geriatr Soc. 2004;52(8):1263-70.
12. Covinsky KE, Pierluissi E, Johnston CB. Hospitalization-associated disability: "She was probably able to ambulate, but I'm not sure". Jama. 2011;306(16):1782-93.
13. Zisberg A, Shadmi E, Sinoff G, Gur-Yaish N, Srulovici E, Admi H. Low mobility during hospitalization and functional decline in older adults. J Am Geriatr Soc. 2011;59(2):266-73.
14. van Zutphen M, Winkels RM, van Duijnhoven FJ, van Harten-Gerritsen SA, Kok DE, van Duijvendijk P, et al. An increase in physical activity after colorectal cancer surgery is associated with improved recovery of physical functioning: a prospective cohort study. BMC Cancer. 2017;17(1):74.
15. Carmichael H, Overbey DM, Hosokawa P, Goode CM, Jones TS, Barnett CC, Jr., et al. Wearable Technology-A Pilot Study to Define "Normal" Postoperative Recovery Trajectories. J Surg Res. 2019;244:368-73.
16. Jonker LT, Hendriks S, Lahr MM, van Munster BC, de Bock GH, van Leeuwen BL. Postoperative recovery of accelerometer-based physical activity in older cancer

patients. European journal of surgical oncology : the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology. 2020.

17. Jette AM, Haley, S.M., Coster, W.J., Ni, P. AM-PAC short form 2.0 - instruction manual 2016.

18. Beaton DE, Bombardier C, Guillemin F, Ferraz MB. Guidelines for the process of cross-cultural adaptation of self-report measures. Spine (Phila Pa 1976). 2000;25(24):3186-91.

19. Haley SM, Coster WJ, Andres PL, Ludlow LH, Ni P, Bond TL, et al. Activity outcome measurement for postacute care. Med Care. 2004;42(1 Suppl):I49-61.

20. Lee N, Thompson, N. R., Passek, S., Stilphen, M., Katzan, I. L. Minimally Clinically Important Change in the Activity Measure for Post-Acute Care (AM-PAC), a Generic Patient-Reported Outcome Tool, in People With Low Back Pain. Phys Ther. 2017;97(11):1094-102.

21. M. Alberts EMAS, J.H.M.M. Vercoulen, B. Garssen, G. Bleienberg 'Verkorte vermoeidheidsvragenlijst': een praktisch hulpmiddel bij het scoren van vermoeidheid Ned Tijdschr Geneeskd. 1997;2 augustus; 141(31)

22. Peel C, Sawyer Baker P, Roth DL, Brown CJ, Brodner EV, Allman RM. Assessing mobility in older adults: the UAB Study of Aging Life-Space Assessment. Phys Ther. 2005;85(10):1008-119.

23. Baker PS, Bodner EV, Allman RM. Measuring life-space mobility in community-dwelling older adults. J Am Geriatr Soc. 2003;51(11):1610-4.

24. Weggemans RM, Backx FJG, Borghouts L, Chinapaw M, Hopman MTE, Koster A, et al. The 2017 Dutch Physical Activity Guidelines. Int J Behav Nutr Phys Act. 2018;15(1):58.

25. Clavien PA, Barkun J, de Oliveira ML, Vauthey JN, Dindo D, Schulick RD, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250(2):187-96.

26. Groenwold RH, Donders AR, Roes KC, Harrell FE, Jr., Moons KG. Dealing with missing outcome data in randomized trials and observational studies. Am J Epidemiol. 2012;175(3):210-7.

27. Moons KG, Donders RA, Stijnen T, Harrell FE, Jr. Using the outcome for imputation of missing predictor values was preferred. J Clin Epidemiol. 2006;59(10):1092-101.

28. Ostir GV, Berges IM, Kuo YF, Goodwin JS, Fisher SR, Guralnik JM. Mobility activity and its value as a prognostic indicator of survival in hospitalized older adults. J Am Geriatr Soc. 2013;61(4):551-7.

29. Pedersen MM, Bodilsen AC, Petersen J, Beyer N, Andersen O, Lawson-Smith L, et al. Twenty-four-hour mobility during acute hospitalization in older medical patients. J Gerontol A Biol Sci Med Sci. 2013;68(3):331-7.

30. Brown CJ, Redden DT, Flood KL, Allman RM. The underrecognized epidemic of low mobility during hospitalization of older adults. J Am Geriatr Soc. 2009;57(9):1660-5.

31. Mudge AM, McRae P, McHugh K, Griffin L, Hitchen A, Walker J, et al. Poor mobility in hospitalized adults of all ages. J Hosp Med. 2016;11(4):289-91.

32. van der Meij E, van der Ploeg HP, van den Heuvel B, Dwars BJ, Meijerink W, Bonjer HJ, et al. Assessing pre- and postoperative activity levels with an accelerometer: a proof of concept study. BMC Surg. 2017;17(1):56.

33. Cortes OL, Delgado S, Esparza M. Systematic review and meta-analysis of experimental studies: In-hospital mobilization for patients admitted for medical treatment. J Adv Nurs. 2019;75(9):1823-37.

34. van der Leeden M, Balland C, Geleijn E, Huijsmans RJ, Dekker J, Paul MA, et al. In-Hospital Mobilization, Physical Fitness, and Physical Functioning After Lung Cancer Surgery. Ann Thorac Surg. 2019;107(6):1639-46.

35. Smart DA, Dermody G, Coronado ME, Wilson M. Mobility Programs for the Hospitalized Older Adult: A Scoping Review. Gerontol Geriatr Med. 2018;4:2333721418808146.

36. Kolovos P. Wearable Technologies in Post-Operative Recovery: Clinical Applications and Positive Impacts. International Journal of Caring Sciences. 2020;13(2):1474.

37. Cook DJ, Thompson JE, Prinsen SK, Dearani JA, Deschamps C. Functional recovery in the elderly after major surgery: assessment of mobility recovery using wireless technology. Ann Thorac Surg. 2013;96(3):1057-61.

38. Althubaiti A. Information bias in health research: definition, pitfalls, and adjustment methods. J Multidiscip Healthc. 2016;9:211-7.

39. Madley-Dowd P, Hughes R, Tilling K, Heron J. The proportion of missing data should not be used to guide decisions on multiple imputation. J Clin Epidemiol. 2019;110:63-73.

8

Chapter 9

Segmentation into different personas, the step to tailor care after major oncological surgery?

Petra Bor
Karin Valkenet
Sjaak Bloem
Richard van Hillegersberg
Cindy Veenhof

Submitted

ABSTRACT

Purpose: To evaluate the distribution of personas over time and evaluate differences in physical and mental functioning between personas.

Materials and methods: An observational cohort study was conducted in patients undergoing gastrointestinal or bladder oncological surgery. Personas were identified based on acceptance and perceived control of their subjective health experience and measured preoperative, 1 and 3 month after discharge. Differences in physical and mental functioning (anxiety and depression) were analyzed.

Results: In total, 98 patients were included. Preoperative, 31% of the patients were identified as persona 4 (low acceptance and perceived control), which increased to 47% and 45% after discharge. Patients in persona 4 (low acceptance and perceived control) showed to have significantly lower levels of physical functioning (preoperatively: 55 versus 61, p=0.030, 1 month: 47 versus 57, p=0.002, 3 months : 52 versus 62, p=0.006) and higher levels of anxiety and depression (preoperatively: 14 versus 9, p=0.000, 1 month: 11 versus 3, p=0.001, 3 months: 10 versus 3, p=0.009) compared to patients in persona 1 (high acceptance and perceived control).

Conclusion Frequent evaluation is important since patient change in persona over time. The segmentation of patients to different personas provides insight in different levels of physical and mental functioning.

INTRODUCTION

In patients who underwent major oncological surgery, literature shows that the majority of patients do not retain their preoperative physical functioning level within 3 months after surgery.[1-3] However, for patients it is important to return to their normal level of functioning as soon as possible after surgery.[4] Not all patients might need the same support for an optimal postoperative recovery. Increasing patient engagement improves the effectiveness and efficiency of care and thereby might enhance clinical outcomes and lower health care costs.[5, 6] Patient engagement can be increased when care is tailored to the patients' individual needs.[7-9] However, practical guidance how to tailor patient care after major oncological surgery is lacking.

Segmentation of patients is one way to tailor care. Segmentation divides patients into different personas, whereby for each persona intervention programs can be tailored to a persons' need.[10] For patients who are recovering from a major oncological surgery, health experience is an important outcome measure.[4, 11] Bloem & Stalpers developed a cross-disease segmentation model which divides persons in 4 personas based on their subjective health experience (SHE) and provides insight in different needs for support.[12, 13] SHE is defined as "an individual's experience of physical and mental functioning while living life the way he/she wants to, within the constraints and limitations of individual existence".[12, 13] The level of acceptance and perceived control constitute the theoretical basis to divide persons in 4 different personas.[14] These different personas showed to have different needs for support.[12]

9

It is unclear whether this way of segmentation can be applied to determine different personas and to tailor postoperative care in patients undergoing a major life event like oncological surgery. Therefore, the first step is to provide insight in the distribution of the personas from preoperative until 3 months after discharge. Second, it is important to get insight in the differences in physical and mental functioning between the different personas. This can be helpful for healthcare professionals to tailor care.

The primary research aim of this study was to explore the distribution of personas over time. The secondary research aim was to evaluate differences in physical and mental functioning between the different personas in patients who underwent major oncological surgery.

MATERIALS AND METHODS

Study design and population

A single center, observational cohort study was conducted at the University Medical Center Utrecht in the Netherlands between November 2020 and April 2022. Inclusion criterion was adult patients undergoing gastrointestinal (esophagus, stomach, colorectal, liver, pancreas) or bladder oncological surgery. Patients were excluded if they had a life expectancy of less than 3 months, if the patient was not able to fill in or sign the informed consent form due to cognitive problems like delirium (defined as an acute disorder of attention and cognition, estimated by the medical and nursing staff). The study protocol was assessed and approved by the medical ethics committee of University Medical Centre Utrecht (research protocol number 19/026). All participants signed informed consent and all methods were performed in accordance with the Declaration of Helsinki.

Subjective health experience

The primary outcome measure is the segmentation of patients to different personas based on the SHE model. Six questions were asked about the acceptance and perceived control of persons' current health condition, to divide patients in different personas. Of this six questions, three questions are about the level of acceptance (1. 'I am at peace with my health condition'; 2. 'The way in which I am functioning physically and mentally, is acceptable to me'; 3. 'I accept my health condition the way it is') and three questions about the perceived control (1. 'I have the feeling that I have grip on my health condition'; 2. 'My health condition is to a great extent in my own power'; 3. 'I have a lot of influence on my health condition'). Questions were answered on a scale 1= fully agree to 7 = fully disagree. The questionnaire is only available in Dutch. The mean score of the three questions was calculated. A high acceptance score is defined if the score is 4.96 or higher, and a high perceived control is defined if the score is 5.36 or higher.[13]. Additionally, two questions were asked about patients SHE: 'on which step do you feel you stand today and on average in the past month'. The questions were answered on a visual analogue scale (0-10) illustrated as a ladder, in which the lowest step represents the patients' worst day in the past month and the highest step represents the patients' best day in the past month.[12].

Based on the acceptance and perceived control score, patients were divided in four different personas which have different needs for support.(figure 1)[12, 15] In this study the term 'persona' is used instead of the term 'segment', since this is a more familiar term in healthcare and therefore adjusted in figure 1.

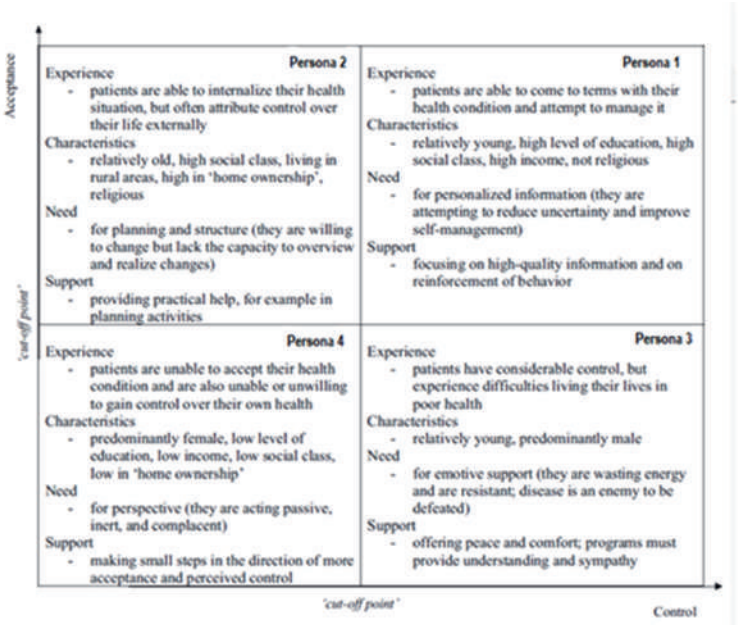


Figure 1. Updated Bloem & Stalpers segmentation model of SHE to divide patients in different personas and provide insight in the differences in need for support.[15] In the original model the term 'segment' was used, for this study the term 'segment' is adjusted to 'persona'

Persona 1: Persons with a high level of acceptance and a high perceived control. These persons have a high level of self-reliance. These persons need information, in order to strengthen a feeling of proudness.

Persona 2**:** Persons with a high level of acceptance and a low level of perceived control. These persons are seekers, they have the willingness to change, but lack the capacity and overview to realize changes. These patients need structure and planning, which can be realized by providing practical help.

Persona 3**:** Persons with a low level of acceptance and a high level of perceived control. These persons are resistant and waste energy and need emotive support.

Persona 4**:** Persons with a low level of acceptance and a low level of perceived control. These persons are passive and inert. These persons need personal guidance, which can be addressed by leading these persons by hand, in order to provide hope.

The SHE model in patients undergoing major surgery

Since the SHE model is validated in a cross-disease population, prior to this study it was evaluated if the SHE model can be applied in patients who underwent major oncological surgery. Therefore correlations were examined for the constructs 'acceptance' and 'perceived control' of the SHE model compared to well-established and validated questionnaires. For the construct acceptance, the acceptance subscale of the Illness Cognition Questionnaire was used as comparison.[16] For the construct perceived control, the General Self-Efficacy Scale was assessed.[17] [18] For the construct acceptance a correlation of r=0.622 was found and for the construct perceived control a correlation of r=0.347.

9

Physical functioning

Physical functioning was measured with the Boston University Measure for Post-Acute Care (AM-PAC) Basic Mobility Outpatients Routine Short Form.[19] Patients were asked 18 questions about the difficulty to perform specific activities in the outer setting on a scale form 1 (unable) to 4 (none). The total score ranged from 0 to 72 points, whereby a higher score represents less difficulty with performing daily activities. The AM-PAC has a minimal administration burden and excellent reliability, validity and sensitivity to changes.[20, 21] The minimal clinically important change lies between 3.9 and 5 points.[5]

Mental functioning

Mental functioning was measured with the Hospital Anxiety and Depression Scale (HADS). Patient were asked 14 questions about their perceived level of anxiety and depression. All items are equally weighted on a 4-pont scale, where 0 reflects the positive extreme and 3 reflects the negative extreme of the scale. The total score ranged from 0 to 42 points, whereby a higher score represent a higher level of anxiety and depression. The HADS showed to have an adequate internal consistency and is sensitive to change in patients with cancer.[22] The minimal clinically important differences was 1.7 points.[23]

Procedures

Within 72 hours after surgery patients received information about the research and were asked to participate. If patients were eligible for the study and signed informed consent, the participants were asked to retrospectively fill in the questionnaires within 1 week after surgery about their physical and mental status in the last week before surgery. At 1 and 3 months after discharge the participants received a digital questionnaire about their physical and mental functioning via e-mail.

Baseline and clinical data

Baseline and clinical data were retrieved from the electronic patient file. Baseline data included gender, age, body mass index (BMI), living situation, education level, comorbidities (pulmonary, cardiovascular disease and diabetes mellitus), American Society of Anesthesiologists classification of physical health (ASA classification), neoadjuvant treatment (radiotherapy, chemotherapy or chemoradiotherapy), tumor location, operation technique. Clinical data included the number of complications, length of stay and discharge destination.

Statistical analyses

All analyses were conducted using IBM-SPSS version 26. The sample size was set at at least 15 patients per persona based on earlier studies, leading to a sample size of >60. Categorical data are presented as numbers and percentage (%). Normally distributed continuous data are presented as mean with standard deviations (SD) and non-normally distributed continuous data as median with min-max. To explore the change of patients' SHE over time from preoperative to 3 months after discharge, a sankey diagram was plotted. Differences in physical and mental functioning between persona 1, 2, 3 and 4 were analysed preoperatively and 1 and 3 months after discharge. Patients identified as persona 1 were used as reference group. An independent sample t test was performed if data was normally distributed and an Man Whitney U test if data was not normally distributed.

RESULTS

In total, 98 patients were included. Patients had a mean±SD age of 63±12 years and 57% were male (Table 1). Preoperatively, 35% (n=33) of the patients were identified as persona 1, 17% (n=16) as persona 2, 18% (n=17) as persona 3, 31% (n=29) as persona 4. Three months after discharge, 27% (n=17) of the patients were identified as persona 1, 17% (n=11) as persona 2, 11% (n=7) as persona 3, 45% (n=29) as persona 4.(Table 2) Missing data occurred in 3 patients preoperatively, in 30 patients 1 month after discharge and in 34 patients 3 months after discharge. Figure 2 showed that missing data 1 and 3 months after discharge, occurred in all 4 personas identified preoperatively.

Change in personas over time

Table 2 provides an overview of the distribution per persona both preoperative, and 1 and 3 months after discharge. Preoperatively most patients were identified as persona 1 (35%). However, 1 and 3 months after discharge this decreased respectively to 22% and 27%. After discharge, the majority of the patients were identified as persona 4 with respectively 47% and 45%. Figure 2 provides an overview of the change in personas from preoperative to 3 months after discharge. Overall, patients who were preoperatively identified as persona 1 were most likely to change to persona 2, 3 or 4 after discharge. Patients who were preoperatively identified as persona 4, were after discharge mostly identified as persona 4 as well.

Table 1. Patients characteristics, surgical characteristics and postoperative outcomes in patients after oncological surgery

Patient characteristics		**n=98**
Male, n (%)		56 (57)
Age in years, mean±SD		63±12
BMI, mean±SD		26±4
Living alone, n (%)		16 (16)
Subjective health experience, mean±SD		
-	The day before surgery	6±3
-	1 month before surgery	7±2
Level of education, n (%)		
-	Low	11 (11)
-	Medium	24 (25)
-	High	30 (31)
Comorbidities, n (%)		
-	Pulmonary	20 (20)
-	Cardiovascular	34 (35)
-	Diabetes Mellitus	11 (11)
ASA-classification, n (%)		
-	I	11 (11)
-	II	42 (43)
-	III	39 (40)
-	Unknown	6 (6)
Pre-treatment, n (%)		
-	No	61 (62)
-	Chemotherapy	15 (15)
-	Radiotherapy	1 (1)
-	Chemoradiotherapy	21 (21)
Surgical characteristics		
Tumor location, n (%)		
-	Esophagus	20 (20)
-	Stomach	8 (8)
-	Colorectal	25 (26)
-	Liver	17 (17)
-	Bladder	24 (25)
-	Other	4 (4)
Operation technique, n (%)		
-	Laparoscopic	70 (71)
-	Open	26 (27)
-	Unknown	2 (2)
Postoperative outcomes		
Complications, n (%)		31 (32)
Length of stay in hospital, median (min-max)		9 (3-68)
Destination after discharge, n (%)		
-	Home	93 (95)
-	Rehabilitation center	4 (4)
-	Other	1 (1)

BMI = Body Mass Index, ASA classification= American Society of Anesthesiologists Classification of physical health, IQR = interquartile range

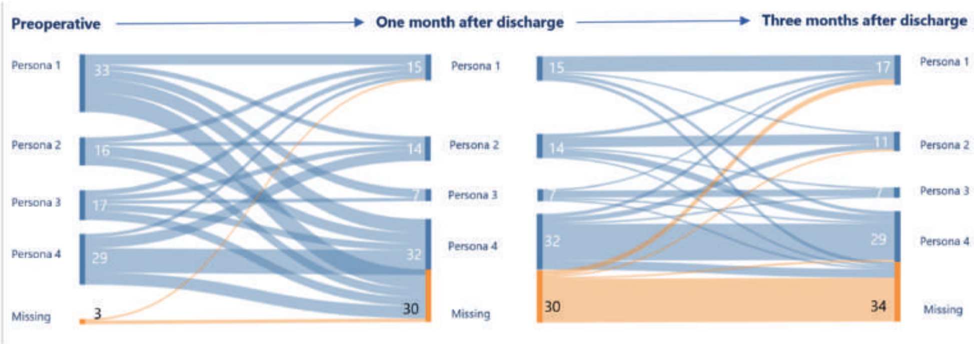


Figure 2. Change of personas from preoperative to 3 months after discharge

Table 2. Number of patients per persona preoperative and 1 and 3 months after discharge

	Preoperative n=95	1 month after discharge n=68	3 months after discharge n=64
Persona 1, n (%)	33 (35)	15 (22)	17 (27)
Persona 2, n (%)	16 (17)	14 (21)	11 (17)
Persona 3, n (%)	17 (18)	7 (10)	7 (11)
Persona 4, n (%)	29 (31)	32 (47)	29 (45)
Missing	*3*	*30*	*34*

Differences in physical and mental functioning between personas

Physical functioning

Patients in persona 4 showed to have significantly lower levels of physical functioning compared to patients in persona 1 during the perioperative period: preoperatively (persona 4: 55±12 versus persona 1: 61±9, p=0.030) 1 month after discharge (persona 4: 47±10 versus persona 1: 57±10, p=0.002) and 3 months after discharge (persona 4: 51±12 versus persona 1: 62±8, p=0.002).(Table 3) Patients in persona 3 showed to have significantly lower levels of physical functioning compared to patients in persona 1, at 3 month after discharge (persona 3: 53±2 versus persona 1: 62±8, p=0.033). No statistical differences in physical functioning were found between persona 2 and persona 1.

Mental functioning

Patients in persona 4 showed to have significantly higher levels of anxiety and depression compared to patients in persona 1 in the perioperative period: preoperatively (persona 4: 14 (0-28) versus persona 1: 9 (0-22), p=0.000), 1 month after discharge (persona 4: 11 (3-32) versus persona 1: 3 (0-8), p=0.001) and 3 months after discharge (persona 4: 10 (1-29) versus persona 1: 3 (0-15), p=0.009).(Table 4) No statistical differences in mental functioning were found between patients in persona 2 and 3 compared to patients in persona 1.

Table 3. Differences in physical functioning between personas

	Persona 1		Persona 2			Persona 3			Persona 4		
	n	mean ±SD	n	mean ±SD	P value*	n	mean ±SD	P value*	n	mean ±SD	P value*
Preoperatively	30	61±9	12	58±8	0.324	17	61±4	0.889	28	55±12	0.030
1 month after discharge	15	57±10	14	57±9	0.940	7	52±10	0.275	32	47±10	0.002
3 months after discharge	17	62±8	11	57±9	0.169	7	53±2	0.033	29	51±12	0.002

The physical functioning score ranged from 0-72 whereby a higher score represents a higher level of physical functioning.
*Patients identified as persona 1 were used as reference group.

Table 4. Differences in mental functioning between the personas

	Persona 1		Persona 2			Persona 3			Persona 4		
	n	median (min-max)	n	median (min-max)	P value*	n	median (min-max)	P value*	n	median (min-max)	P value*
Preoperatively	32	9 (0-22)	14	10 (3-20)	0.186	16	9 (3-24)	0.759	28	14 (0-28)	0.000
1 month after discharge	15	3 (0-8)	14	5 (0-18)	0.139	7	3 (0-18)	0.630	32	11 (3-32)	0.001
3 months after discharge	17	3 (0-15)	11	3 (1-20)	1.000	7	4 (1-13)	0.659	29	10 (1-29)	0.009

The mental functioning score ranged from 0-42 whereby a higher score represents a higher level of anxiety and depression.
*Patients identified as persona 1 were used as reference group.

9

DISCUSSION

This observational cohort study investigated the distribution of personas over time and examined differences in physical and mental functioning. In the perioperative period, patients showed to change in persona over time. Preoperative the majority of the patients (35%) were identified as persona 1, whereas 1 and 3 months after discharge this number decreased to respectively 22% and 27%. After discharge the majority of the patients were identified as persona 4 (47% 1 month after discharge and 45% 3 months after discharge). Significant differences in physical and mental functioning were found between persona 1 and persona 4 both preoperative and 1 and 3 months after discharge. Hereby patients in persona 4 showed to have significant lower level of physical functioning and higher levels of anxiety and depression compared to patient in persona 1.

This study showed that patients changed in persona over time when undergoing a major oncological surgery. Therefore, it seems important to frequently evaluate patients SHE, to tailor care to the patients' needs. Preoperative, the distribution between the different personas (35% persona 1 and 31% persona 4) was comparable with the distribution in the healthy population (32% persona 1 and 32% persona 4).[13] However, 1 and 3 month after discharge, the majority of the patients were identified as persona 4. Therefore, only preoperative measurement of SHE seems not appropriate to tailor postoperative care. The finding that patients can change in persona over time, is in line with a previous study in patients with inflammatory bowel disease.(unpublished results) However, the question remains if patients eventually retain preoperative SHE after major oncological surgery.

Postoperative recovery is characterized by an abrupt decline in function, followed by a progression toward the original state.[4, 24] From literature it is known that more than half of the patients undergoing major oncological surgery were not recovered in physical functioning 3 months after discharge.[1, 2] (Bor et al published) Therefore, it seems important to get insight in the patients who recover and not recover postoperatively. The current study showed significant differences in physical and mental functioning between the different personas. These findings are in line with a previous study showing an association between patients' perceived control and quality of life in patients who underwent radical prostatectomy.[25] Additionally, even in patients who underwent minor surgery, both physical and mental functioning seems important for postoperative recovery.[26] Considering the differences found in mental and physical functioning in this study between personas, this model might be useful to select the patients at risk (persona 4) for a delayed recovery. This may help to refer the right patients to the right place; advice to increase self-management when possible (i.e. persona 1) and postoperative guidance when needed (i.e. persona 4), to optimize postoperative recovery for all patients.[27]

For the usage and uptake of the SHE model in daily practice in patients undergoing major oncological surgery it is important that the discriminative ability of the SHE model is adequate. Prior to this study, correlations for the construct acceptance (r=0.622) and perceived control (r=0.347) were examined 1 month after discharge. In literature, different cut off point are used to determine a strong correlation.[28] McDowell and Newell (1996) stated that the correlation between questionnaires which measure health-related outcomes vary between 0.4 and 0.6.[29] Since both acceptance and perceived control is a health-related outcome, the correlations seems acceptable. Furthermore, clinically relevant differences in both physical and mental functioning were seen between patients in persona 1 and persona 4. Overall, the discriminative value of the SHE model for the segmentation to different personas seems acceptable and therefore might be a useful tool to define different personas in patients undergoing oncological surgery. The possibility to make a distinction between patients who require information to improve their self-management and patients who need personal guidance, can help to deliver tailored care.[30]

Strengths and limitations

This study is the first study presenting a segmentation model to identify different personas in patients who underwent a major oncological surgery. A longitudinal cohort study including different types of oncological surgery was conducted representing a wide variety of patients which might increase the generalizability to other populations. Furthermore, the longitudinal character makes it possible to provide insight in the change in personas from preoperatively until 3 months after discharge. Insight in the different personas could be the first step to guide healthcare professionals to refer the right patients to the right place to optimize postoperative recovery. This study also have some limitations. First, the SHE model is a cross-disease model and therefore not specifically validated in patients who underwent a major oncological surgery. This study provide insight in the discriminative value of the SHE model from preoperative until 3 months after discharge. Clinical relevant differences in both mental and physical functioning were found between persona 1 and 4. Further research is required within the different personas to provide rich data about their opinion and perspective about the need for support after major oncological surgery. Second, there was a large amount of missing data in the measurements 1 and 3 months after discharge. Therefore, the results must be interpret with caution.

CONCLUSION

In patients who underwent major oncological surgery, the segmentation to different personas based on SHE provides insight in different levels of physical and mental functioning. This way of segmentation may guide tailored care. However, since patients can change in persona over time during the perioperative period, it is important to frequently evaluate patients' subjective health experience. Furthermore, postoperatively most patients were identified as persona 4 (low acceptance and perceived control), which indicate that these patients are unable to gain control over their own health and therefore might need guidance for an optimal recovery.

REFERENCES

1. van Zutphen, M., et al., An increase in physical activity after colorectal cancer surgery is associated with improved recovery of physical functioning: a prospective cohort study. BMC Cancer, 2017. 17(1): p. 74.
2. Lawrence, V.A., et al., Functional independence after major abdominal surgery in the elderly. J Am Coll Surg, 2004. 199(5): p. 762-72.
3. Bor, P., et al., Physical functioning and physical activity after gastrointestinal or bladder oncological surgery: An observational cohort study. Eur J Cancer Care (Engl), 2022: p. e13739.
4. Lee, L., et al., What does it really mean to "recover" from an operation? Surgery, 2014. 155(2): p. 211-6.
5. Lee, D.J., et al., Patient engagement in the design and execution of urologic oncology research. Urol Oncol, 2017. 35(9): p. 552-558.
6. Hibbard, J.H. and J. Greene, What the evidence shows about patient activation: better health outcomes and care experiences; fewer data on costs. Health Aff (Millwood), 2013. 32(2): p. 207-14.
7. Higgins, T., E. Larson, and R. Schnall, Unraveling the meaning of patient engagement: A concept analysis. Patient Educ Couns, 2017. 100(1): p. 30-36.
8. Tew, G.A., et al., Community-based prehabilitation before elective major surgery: the PREP-WELL quality improvement project. BMJ Open Qual, 2020. 9(1).
9. Fournier, B., et al., Interest and preferences for physical activity programming and counselling among cancer patients aged over 70 years receiving oncological treatments. Eur J Cancer Care (Engl), 2022. 31(1): p. e13527.
10. Vuik, S.I., E.K. Mayer, and A. Darzi, Patient Segmentation Analysis Offers Significant Benefits For Integrated Care And Support. Health Aff (Millwood), 2016. 35(5): p. 769-75.
11. Allvin, R., et al., Postoperative recovery: a concept analysis. Journal of Advanced Nursing, 2007. 57(5): p. 552-558.
12. Bloem, S. and J. Stalpers, Subjective experienced health as a driver of healthcare behaviour. Nyenrode Research Papers Series, 2012. 12(01):1.
13. Bloem, S., et al., Segmentation of health-care consumers: psychological determinants of subjective health and other person-related variables. BMC Health Serv Res, 2020. 20(1): p. 726.
14. Stalpers, J., Psychological Determinants of Subjective health. Doctoral dissertation, Nyenrode Business Universiteit, 2009
15. Broekharst, D.S.E., et al., Differences between expert reported and patient reported burden of disease rankings. Sci Rep, 2022. 12(1): p. 895.
16. Evers, A.W., et al., Beyond unfavorable thinking: the illness cognition questionnaire for chronic diseases. J Consult Clin Psychol, 2001. 69(6): p. 1026-36.
17. Scherbaum, C.A., Y. Cohen-Charash, and M.J. Kern, Measuring General Self-Efficacy:A Comparison of Three Measures Using Item Response Theory. Educational and Psychological Measurement, 2006. 66(6): p. 1047-1063.

18. Schwarzer, R. and M. Jerusalem, Generalized Self-Efficacy Scale. Measures in health psychology: A user's portfolio. Causal and control beliefs, ed. S.W. In J. Weinman, & M. Johnston. 1995, Windsor, UK: NFER-NELSON.

19. Jette, A.M., Haley, S.M., Coster, W.J., Ni, P., AM-PAC short form 2.0 - instruction manual 2016.

20. Coster, W.J., S.M. Haley, and A.M. Jette, Measuring patient-reported outcomes after discharge from inpatient rehabilitation settings. J Rehabil Med, 2006. 38(4): p. 237-42.

21. Haley, S.M., et al., Activity outcome measurement for postacute care. Med Care, 2004. 42(1 Suppl): p. I49-61.

22. Vodermaier, A., W. Linden, and C. Siu, Screening for emotional distress in cancer patients: a systematic review of assessment instruments. J Natl Cancer Inst, 2009. 101(21): p. 1464-88.

23. Lemay, K.R., et al., Establishing the Minimal Clinically Important Difference for the Hospital Anxiety and Depression Scale in Patients With Cardiovascular Disease. J Cardiopulm Rehabil Prev, 2019. 39(6): p. E6-e11.

24. Feldman, L.S., L. Lee, and J. Fiore, Jr., What outcomes are important in the assessment of Enhanced Recovery After Surgery (ERAS) pathways? Can J Anaesth, 2015. 62(2): p. 120-30.

25. Kawaguchi, K., et al., Effect of general self-efficacy on promoting health-related quality of life during recovery from radical prostatectomy: a 1-year prospective study. Int J Clin Oncol, 2020. 25(12): p. 2122-2129.

26. Nilsson, U., K. Dahlberg, and M. Jaensson, Low Preoperative Mental and Physical Health is Associated with Poorer Postoperative Recovery in Patients Undergoing Day Surgery: A Secondary Analysis from a Randomized Controlled Study. World J Surg, 2019. 43(8): p. 1949-1956.

27. Jakobsson, J., E. Idvall, and C. Kumlien, Patient characteristics and surgery-related factors associated with patient-reported recovery at 1 and 6 months after colorectal cancer surgery. Eur J Cancer Care (Engl), 2017. 26(6).

28. Akoglu, H., User's guide to correlation coefficients. Turk J Emerg Med, 2018. 18(3): p. 91-93.

29. McDowell, I. and C. Newell, Measuring health: A guide to rating scales and questionnaires, 2nd ed. Measuring health: A guide to rating scales and questionnaires, 2nd ed. 1996, New York, NY, US: Oxford University Press. xix, 523-xix, 523.

30. Hibbard, J.H., J. Greene, and V. Overton, Patients with lower activation associated with higher costs; delivery systems should know their patients' 'scores'. Health Aff (Millwood), 2013. 32(2): p. 216-22.

Chapter 10

General discussion

GENERAL DISCUSSION

Optimizing care in the entire patient journey

The Dutch healthcare system is facing a major challenge as result of the aging population and increasing number of patients with a chronic illness or multi-morbidity.[1] Healthcare costs increase rapidly and there is a lack of healthcare professionals to provide care. In order to reduce costs and provide high quality of care in the future, the Dutch ministry of Health, Welfare and Sports together with healthcare partners initiated the 'Integral Care Agreement' (in Dutch called 'Integraal Zorg Akkoord').[2] The Integral Care Agreement stated 4 principles; 'value-driven care', 'appropriate care is established together with and around the patient', 'care takes place in the right place' and 'care is about health instead of illness'. The aim of this agreement is to deliver good, accessible and affordable healthcare in the future.

In line with these principles, it is important to lower the impact of hospital admission, to prevent negative outcomes like functional decline and to improve recovery afterwards. Especially since patients stated that not the number of complications, but the return to daily functioning as soon as possible is most important.[3-5] However, this thesis showed that half of the patients is still diminished in physical functioning 3 months after discharge.(Chapter 8) If patients do not recover well, this might lead to higher costs for the society, for example if patients stay dependent of care to perform activities in daily living or if they are not able to return to work.[6, 7]

To optimize care in the patient journey, 3 main themes will be discussed. First, there is a need for *structural change in the immobility culture in the hospital* to lower the risk of negative outcomes and improve patients' health. Second the added value of the *use of technology* like activity trackers both during the hospital stay and within the entire patient journey is discussed. Third, since not every patient needs the same support to achieve full recovery there is a need to *identify the right patients, to deliver the right care*.

Changing the immobility culture in the hospital

The main findings of this thesis indicate that inpatients' physical activity is a modifiable factor, however changing the immobility culture in the hospital is still challenging. Within the project Hospital in Motion patients changed their bed for a chair, however they were not getting more active. Therefore, the increased time spend sitting is seen as a first step in counteracting the immobility culture during hospital stay. However, interventions which increase the level of physical activity like the GOAL-intervention seem more important, especially since literature shows that higher levels of physical activity are important to reduce the risk of functional decline during admission and lower the risk of complications.[8-10]

Multidimensional approach

Both Hospital in Motion and the GOAL-intervention included multimodal interventions covering several levels of the Social Ecological Model (e.g. patient, healthcare professional, environment). To change physical activity in the hospital, this thesis confirmed the importance of multimodal interventions which is therefore recommended in further projects.[11-15] However, since immobility in the hospital is deeply rooted in the culture, next to multimodal interventions to increase physical activity levels on the

ward, there is also a need for more structural changes in both the build environment and within the entire organization of the hospital.[14-18]
During the projects Hospital in Motion and the GOAL intervention some adjustments were made to the environment. However more effort is needed to achieve structural changes in the build environment. Renovation of wards or new building projects in the hospital should consider the integration of normal daily activities within the hospital environment to stimulate physical activity. For example to make it normal to eat at the table, create spaces to go to (to spend time with family and friends, to exercise or to read a book) and provide a day schedule including an appointment with the physician (where the patient can walk to, instead of waiting for the physician to come through). Hereby, care delivered within the hospital should change from 'bed-centred care' to more 'function-focused care'.[19] In the long-term these changes might safe costs, for example if less patients need to be discharged to a nursing home or rehabilitation centre.(Chapter 3)[20]

Physical activity as standard outcome measure in the hospital

One of the mechanisms of impact found in the process evaluation of Hospital in Motion was the continuous awareness of physical activity, which is a never-ending process to maintain sustained changes of inpatients' movement behaviour. Continuous awareness of physical activity levels can be realized when the use of activity trackers are used as standard outcome in daily care. Activity trackers can deliver continuous objective physical activity data. Hereby both patients and healthcare professionals get insight in physical activity levels and it offers the possibility to provide more tailored advice to stimulate physical activity.[21-23] If physical activity becomes a structural outcome measure, like heart rate and blood pressure, this might help to achieve a common language between the entire team of healthcare professionals. Achieving a common language about physical activity might enhance responsibility in the entire team regarding physical activity.[14] Therefore, structural implementation of the use of activity trackers on all wards of the hospital might be the next step to achieve sustainable physical activity behaviour. Hereby it is recommended that the intervention with the activity tracker covers multiple dimensions and is tailored to the ward in co-creation with patients and healthcare professionals.[24] Furthermore, it is important to evaluate the effectiveness of interventions using an activity tracker on both short-term (i.e. physical activity level, level of functioning, discharge destination) and long-term outcomes (i.e. patients' recovery). Additionally, to improve uptake in daily practice, implementation outcomes like the acceptability and adoption should be evaluated on a regular basis.[24, 25]

Use of technology around major oncological surgery

In the past years the usage of technology in healthcare has extensively increased. In the perioperative period, technology can be a useful tool to replace or supplement daily care.[26-29] The use of technology can help to deliver care to a large amount of patients at relatively low cost and can stimulate self-management. An example of technology which can replace or supplement daily care in the perioperative period is the use of mobile applications and activity trackers.[21-23, 30]

Interventions using an activity tracker seem to increase the level of physical activity during or/and after an inpatients' period.(Chapter 5) Therefore, the use of technology like activity trackers around major oncological surgery is seen as the next step to stimulate self-management and improve recovery, with relatively low costs. Especially since this thesis showed that half of the patients undergoing major oncological surgery do not retain baseline functioning of physical functioning within 3 months after discharge.(Chapter 8) Promoting physical activity early after surgery and to continue this promoting after discharge with the use of activity trackers might enhance postoperative recovery.[31-33]

To optimize the effectiveness of interventions using activity tracker in the perioperative period it is recommended to start using the activity tracker prior to surgery and continue use both during and after hospital stay.(Chapter 5)[33, 34] Start using the activity tracker prior to surgery, enables the patient to get used to the application and activity tracker and provide insight in their activity level in normal daily life. Continuing the use of the activity tracker both during hospital stay and after discharge, might support early mobilization after surgery and might help patients to improve physical activity levels after discharge.[21, 22, 35, 36] This is important since from literature it is known that many patients do not reach their preoperative activity levels after major oncological surgery.[37, 38] Additionally, this thesis showed that the effectiveness of interventions using activity trackers increased when more behavioral change techniques were used and included coaching from a healthcare professional. Therefore, this should be taken into consideration when implementing activity trackers in the perioperative period.

Next to physical activity, risk behaviors such as smoking, use of alcohol, poor nutritional status and mental status are associated with negative outcomes and poor recovery after surgery.[39, 40] Therefore, next to physical activity, there should be attention to other risk behaviors as well. The use of mobile applications might be an effective approach to deliver multimodal content, reach many patients, enhance self-management and achieve changes in risk behavior.[30] However, nowadays the use of technology in the perioperative care is most of the time fragmented in the preoperative period, hospital admission or recovery phase, with limited coordination of care among involved healthcare professionals. Therefore, there is a need to integrate the use of technology within the entire perioperative period, covering multiple risk behaviors.

Identifying the right patients, to deliver the right care

Selecting patients at risk

Selecting patients at risk is about identifying patients with low adaptive capacity and resilience to stressors like surgery (e.g. the frail patient).[41, 42] Preoperatively, literature shows that patients' physical fitness is an important determinant for identifying patients at risk for complications and successful recovery in patients undergoing abdominal surgery.[43-46] Furthermore, in patients undergoing esophagectomy due to esophageal cancer, this thesis showed that patients who decline in physical fitness during neoadjuvant chemoradiation, have the highest risk of developing postoperative pneumonia. However, since frailty is described as a complex, multidimensional and cyclical state of diminished physiological reserve, continuing efforts to identify patients and promote multidisciplinary decision making is recommended. [41, 42](Figure 1)

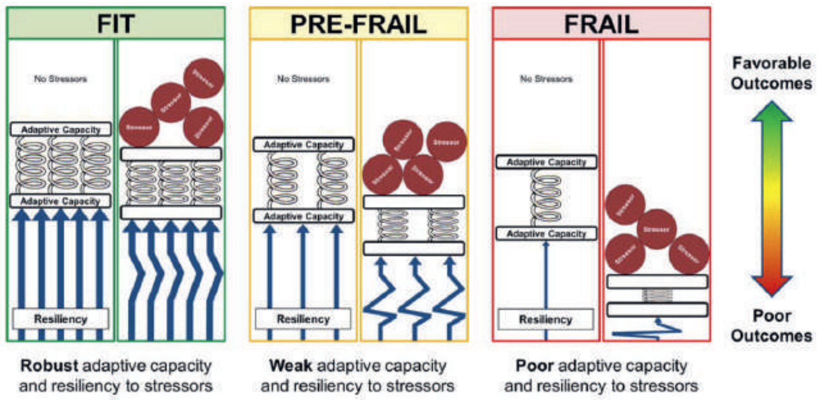


Figure 1. A Model for Defining Frailty. Fit patients have robust adaptive capacity and resiliency to stressors, which leads to more favorable outcomes.[41, 42]

In literature there is growing evidence about the potential benefits of prehabilitation programs.[47-53] Hereby, multimodal prehabilitation programs seem to be more effective compared to unimodal prehabilitation programs.[40, 49, 51, 54] However, since there is a wide variety in the content of interventions and most studies delivered the same intervention to all patients, conflicting results are found. Selecting the high-risk patients might help to improve the effectiveness of prehabilitation programs in the future.[44, 47, 55, 56]

10

Also during hospital admission it is important to identify patients with a high-risk of functional decline, immobility-related complications such as pneumonia, decubitus and deep venous thrombosis.[8-10, 57-59] Although many studies have shown that higher physical activity levels contribute to the prevention of negative outcomes, the optimal dose-response relationship is still unknown.[60] Therefore, it remains unclear how much physical activity is needed to prevent unwanted outcomes like functional decline and improve patients' health after an hospital admission. However, monitoring patterns of change in physical activity levels might be useful for the prediction and early detection of postoperative complications.[61]

Furthermore, also after discharge it is important to identify patients with a delayed recovery, especially since the majority of patients do not recover within 3 months.(Chapter 8)[62, 63] When activity trackers become part of the entire patient journey, this offers the opportunity to identify patients showing signs of inadequate progress of recovery in the home-situation.[35] Additionally, since patients stated that the return to baseline function is most important, this should also be an important outcome measure to evaluate recovery.[3-5] In chapter 9 the identification of different personas based on patients' subjective health experience showed to provide insight in different trajectories of both mental and physical functioning. Therefore, this could help to early detect the patients at risk for a delayed recovery.

Deliver care tailored to the patients' needs

If patients at risk could be identified, the next step is to evaluate what a patient needs to achieve behavioral change and prevent negative outcomes like complications, functional decline or delayed recovery. Tailoring care to the patients' individual needs is important since it leads to increased patient engagement and thereby improves the effectiveness and efficiency of care. [64-67] However, there is a lack of practical guidance to tailor care. This thesis provides a possible way to identify personas and to tailor care to the patients' needs. This might be useful to refer the right patients to the right place; advice to increase self-management when possible (i.e. patients with high acceptance and perceived control) and postoperative guidance when needed (patients with low acceptance and perceived control), to optimize postoperative recovery for all patients.(Chapter 9)[68] However, more research is needed to investigate if interventions based on these personas are effective to improve patients' health. Furthermore, there could be other factors of influence to achieve changed behavior. A recent scoping review about factors of influence to participate in prehabilitation shows that it is important to take into account patients' capability, opportunity and motivation to tailor care.[69] These are the 3 key elements of the COM-B model, a framework for understanding behavior.[70] Since the identification of different personas based on subjective experiences health is mainly based on patients' capability, other factors like the motivation and opportunity should also be taken into consideration when delivering interventions.

Methodological considerations

Measuring physical activity

To evaluate the effect of Hospital in Motion, the behavioural mapping method was used.[71] Providing insight in both objective physical activity data in combination with contextual data makes this method very useful to map the mobility culture in the hospital. Even so, this information was used as a starting point for the development and tailoring interventions to the ward. For example, this method provides insight in the number of patients who were lying in bed during lunch time or during visiting hours, highlighting the possibility to involve visitors to get patients active.[72] Nevertheless, the behavioural mapping method also has downsides. In our study patients were only monitored during working hours (9 AM – 4 PM) due to feasibility reasons. Hereby important information about what happened in the evening hours was missed. Another outcome measure to evaluate physical activity is the use of activity trackers. Activity trackers can gather objective and continuous data of physical activity levels. At the University Medical Center Utrecht, the PAM AM400 was used, which is a small, lightweight sensor, worn around the ankle. The PAM AM400 showed to be a suitable tool to measure active minutes in hospitalized patients.[73] The sensor has a lifetime of 1 year and good usability (patient report not noticing the device during the day and the device is always ready to use). Having an inexpensive, user-friendly and easy-to-use tool were important considerations to take into account to achieve adoption in daily care. A downside of the PAM AM400 is that the sensor cannot make a distinction between lying and sitting. However during hospital stay, getting out of bed and sitting in the chair might be a relevant change and might reduce the risk of pneumonia. For patients who are not able to walk (yet), the activity tracker might be less suitable. Since both measures have advantages and disadvantages, the level of agreement between an activity tracker and the behavioural mapping method was evaluated in an additional study.[74] A strong level of agreement on group level was found in classifying inpatient physical activity into time spend 'lying', 'sitting' and 'moving' on group level.[74] However, on individual level a wide variation was seen between the behavioural mapping method and the activity tracker. This emphasizes the importance of selecting the right measure for the right purpose.

Study design

The choice of study design in implementation science requires balancing between scientific, pragmatic and ethical issues.[75] To evaluate the effectiveness of Hospital in Motion and the GOAL-intervention a pragmatic pre- post evaluation was chosen. This enables us to follow an iterative an dynamic process, whereby the intervention was adapted to the local context of the ward within the study design. Furthermore, the intervention was implemented in daily care, whereby a real-world reflection is given of actual change in daily practice instead of a controlled research environment. However a downside of a pre-post design is that it is not possible to investigate a true intervention effect, since the intended effect might also been caused by the time, variation in treatments and patients (i.e confounders).[76] Therefore, future research which aimed to evaluate the effectiveness should consider other designs like a clustered randomized trial, interrupted time series or stepped-wedge design as well. However, since all designs have their strengths and weaknesses, the chosen design should fit the context.

Furthermore, from literature it is known that establishing the effectiveness does not guarantee uptake in daily care.[77] It is indicated that it takes 17-20 years to get clinical innovations into practice and less than 50% of clinical innovations ever make it into general usage.[78] Therefore, the use of a hybrid design, whereby next to the effectiveness also the implementation is evaluated, seems important to enhance uptake of interventions in daily practice.[79, 80] Both within the Hospital in Motion and GOAL-intervention, both outcomes on the effectiveness and on the implementation were evaluated. However, in both studies it remains unclear to what extent the interventions were adopted in daily practice. To improve uptake of interventions in the long-term it is recommended to evaluate the adoption in daily practice more extensively.

Implications for clinical practice

This thesis showed that physical activity in the hospital is a modifiable factor, emphasizing the need for structural changes within the hospital to prevent negative outcomes due to inactivity and lower the impact of an hospital on patients' health. Based on this thesis a few recommendations can be given to change the immobility culture in the hospital:

- Multidisciplinary and multimodal interventions tailored to the ward are needed to change the immobility culture in the hospital
- Physical activity measured with an activity tracker should be a standard outcome measure just like heart rate and blood pressure
- Standard use of activity trackers in daily care could stimulate patients' self-management, can create a common language between healthcare professionals, creates continuous awareness regarding physical activity and could help to select the patients at risk for functional decline or complications

In the future, whenever possible, care will move from the hospital into the community and the patients' home.[81] More care will be delivered at home and patients are getting more responsibility about their own health. Therefore, patients should get a central role in their treatment. Based on this thesis a few recommendations can be made to optimize care in the future:

- Integrate the use of activity trackers and mobile applications within the entire patient journey to facilitate self-management

- Select patients at risk for unwanted outcomes like complications or delayed recovery at several time points (i.e preoperative, during hospital and in the home-situation)
- If patients are at risk, deliver more extensive care tailored to the patient's needs

To create structural changes within the healthcare system, there is a need for implementation. After the conduction of this thesis, a few recommendations could be made about important aspects of implementation to optimize patients health:

- Extensively engage all stakeholders involved in the patient journey
- Use a structured approach and a site-specific analysis per ward or healthcare pathway
- Do not underestimate implementation, implementation takes time and many factors could be of influence during the process

Future perspectives

Nowadays different devices to measure physical activity are used, with all different outcomes (i.e. steps, active minutes per day, posture) and worn on different places (arm, waist, ankle), all having advantages and disadvantages. Further projects should explore the different outcomes of physical activity and the beneficial value to improve patientcare with developing insights. Additionally, next to rapid development of different activity trackers, there are developments of technology to measure vital signs like heart rate, oxygen saturation and blood pressure in daily hospital care with wireless health patches.[82] The combination of measuring vital signs and physical activity with one sensor could enhance uptake in daily care and help interpret data (i.e different interpretation is required in patients with increased heart rate if the patients is climbing the stairs or lying down in bed). However, the validity of health patches to make a distinction between different postures like lying, sitting/standing and walking showed conflicting results.[83, 84] Therefore, more research is needed to evaluate the validity to measure physical activity as new vital sign in the future.

The use of artificial intelligence and machine learning will change healthcare in the future.[85] Artificial intelligence and machine learning involves algorithms that draw on big data to learn to make predictions.[86] The opportunity to translate big data into clinical relevant decision making, is therefore seen as the next step.[85] In this thesis, continuous data was mainly used in a descriptive way. In the future, the use of artificial intelligence and machine learning might help to improve the prediction of patients at risk. However, since the optimal dose-response relationship between physical activity level and the risk of negative outcomes is still unknown, this should be established first.

This thesis highlights the importance to deliver the right care to the right patients. Stimulation self-management when possible and more extensive care when needed. To stimulate self-management, technology seems important. However, more research is needed about the optimal content and delivery of technology. Furthermore, for patients who are at risk, more extensive care should be delivered tailored to the patients' needs. Further projects should investigate the optimal way to tailor care to patients' needs and evaluate the effectiveness on patients' recovery, to optimize care in the future.

REFERENCES

1. CBS, C.B.v.S. Projectie van (gezonde) levensverwachting 2018-2040. 2018.
2. Integraal Zorg Akkoord Samen werken aan gezonde zorg 2022.
3. Lee, L., et al., What does it really mean to "recover" from an operation? Surgery, 2014. 155(2): p. 211-6.
4. Miller, T.E. and M. Mythen, Successful recovery after major surgery: moving beyond length of stay. Perioper Med (Lond), 2014. 3: p. 4.
5. Rajabiyazdi, F., et al., Understanding the Meaning of Recovery to Patients Undergoing Abdominal Surgery. JAMA Surgery, 2021. 156(8): p. 758-765.
6. Loor, M.M., et al., Postoperative Work and Activity Restrictions After Abdominal Surgery: A Systematic Review. Ann Surg, 2021. 274(2): p. 290-297.
7. Covinsky, K.E., E. Pierluissi, and C.B. Johnston, Hospitalization-associated disability: "She was probably able to ambulate, but I'm not sure". Jama, 2011. 306(16): p. 1782-93.
8. Nevo, Y., et al., Activity Tracking After Surgery: Does It Correlate With Postoperative Complications? Am Surg, 2022. 88(2): p. 226-232.
9. Pavon, J.M., et al., Accelerometer-Measured Hospital Physical Activity and Hospital-Acquired Disability in Older Adults. J Am Geriatr Soc, 2020. 68(2): p. 261-265.
10. Cohen, Y., et al., Walking for Better Outcomes and Recovery: The Effect of WALK-FOR in Preventing Hospital-Associated Functional Decline Among Older Adults. J Gerontol A Biol Sci Med Sci, 2019. 74(10): p. 1664-1670.
11. Mudge, A.M., P. McRae, and M. Cruickshank, Eat walk engage: an interdisciplinary collaborative model to improve care of hospitalized elders. Am J Med Qual, 2015. 30(1): p. 5-13.
12. Koenders, N., et al., Multifaceted interventions are required to improve physical activity behaviour in hospital care: a meta-ethnographic synthesis of qualitative research. J Physiother, 2021. 67(2): p. 115-123.
13. Prior, M., M. Guerin, and K. Grimmer-Somers, The effectiveness of clinical guideline implementation strategies--a synthesis of systematic review findings. J Eval Clin Pract, 2008. 14(5): p. 888-97.
14. Stutzbach, J., et al., Systems Approach Is Needed for In-Hospital Mobility: A Qualitative Metasynthesis of Patient and Clinician Perspectives. Arch Phys Med Rehabil, 2021. 102(5): p. 984-998.
15. Dijkstra, F., et al., Facilitators and barriers to enhancing physical activity in older patients during acute hospital stay: a systematic review. Int J Behav Nutr Phys Act, 2022. 19(1): p. 99.
16. Czaplijski, T., et al., Creating a culture of mobility: an interdisciplinary approach for hospitalized patients. Hosp Top, 2014. 92(3): p. 74-9.
17. Golden, S.D. and J.A. Earp, Social ecological approaches to individuals and their contexts: twenty years of health education & behavior health promotion interventions. Health Educ Behav, 2012. 39(3): p. 364-72.
18. Geelen, S.J.G., et al., Barriers and enablers to physical activity in patients during hospital stay: a scoping review. Syst Rev, 2021. 10(1): p. 293.

19. Resnick, B., E. Galik, and M. Boltz, Function focused care approaches: literature review of progress and future possibilities. J Am Med Dir Assoc, 2013. 14(5): p. 313-8.

20. Koenders, N., et al., Ban Bedcentricity: A Multifaceted Innovation to Reduce Sedentary Behavior of Patients During the Hospital Stay. Physical Therapy, 2021. 101(7).

21. Wells, C.I., et al., Wearable devices to monitor recovery after abdominal surgery: scoping review. BJS Open, 2022. 6(2).

22. Amin, T., et al., Wearable devices for patient monitoring in the early postoperative period: a literature review. Mhealth, 2021. 7: p. 50.

23. Low, C.A., Harnessing consumer smartphone and wearable sensors for clinical cancer research. NPJ Digit Med, 2020. 3: p. 140.

24. van Grootel, J.W.M., et al., Development of a goal directed movement intervention (GOAL) using a movement sensor for hospitalized patients: an Intervention Mapping approach. under review.

25. Proctor, E., et al., Outcomes for implementation research: conceptual distinctions, measurement challenges, and research agenda. Adm Policy Ment Health, 2011. 38(2): p. 65-76.

26. van der Meij, E., et al., The Effect of Perioperative E-Health Interventions on the Postoperative Course: A Systematic Review of Randomised and Non-Randomised Controlled Trials. PLoS One, 2016. 11(7): p. e0158612.

27. Bouwsma, E.V.A., et al., Effectiveness of an internet-based perioperative care programme to enhance postoperative recovery in gynaecological patients: cluster controlled trial with randomised stepped-wedge implementation. BMJ Open, 2018. 8(1): p. e017781.

28. Bowyer, A. and C. Royse, The future of recovery - Integrated, digitalised and in real time. Best Pract Res Clin Anaesthesiol, 2018. 32(3-4): p. 295-302.

29. Panda, N., et al., Enhancing Patient-Centered Surgical Care With Mobile Health Technology. Journal of Surgical Research, 2022. 274: p. 178-184.

30. van der Velde, M., et al., Usability and Preliminary Effectiveness of a Preoperative mHealth App for People Undergoing Major Surgery: Pilot Randomized Controlled Trial. JMIR Mhealth Uhealth, 2021. 9(1): p. e23402.

31. Cortes, O.L., S. Delgado, and M. Esparza, Systematic review and meta-analysis of experimental studies: In-hospital mobilization for patients admitted for medical treatment. J Adv Nurs, 2019. 75(9): p. 1823-1837.

32. Kolovos, P., Wearable Technologies in Post-Operative Recovery: Clinical Applications and Positive Impacts. International Journal of Caring Sciences, 2020. 13(2): p. 1474.

33. van der Meij, E., et al., Personalised perioperative care by e-health after intermediate-grade abdominal surgery: a multicentre, single-blind, randomised, placebo-controlled trial. Lancet, 2018. 392(10141): p. 51-59.

34. van der Leeden, M., et al., In-Hospital Mobilization, Physical Fitness, and Physical Functioning After Lung Cancer Surgery. Ann Thorac Surg, 2019. 107(6): p. 1639-1646.

35. Carmichael, H., et al., Wearable Technology-A Pilot Study to Define "Normal" Postoperative Recovery Trajectories. J Surg Res, 2019. 244: p. 368-373.

36. van der Meij, E., et al., Assessing pre- and postoperative activity levels with an accelerometer: a proof of concept study. BMC Surg, 2017. 17(1): p. 56.

37. Jonker, L.T., et al., Postoperative recovery of accelerometer-based physical activity in older cancer patients. Eur J Surg Oncol, 2020.

38. Hara, T. and A. Kubo, Relationship between physical activity and function in elderly patients discharged after surgical treatment for gastrointestinal cancer. J Phys Ther Sci, 2015. 27(9): p. 2931-4.

39. McDonald, S., et al., Exploring patient attitudes to behaviour change before surgery to reduce peri-operative risk: preferences for short- vs. long-term behaviour change. Anaesthesia, 2019. 74(12): p. 1580-1588.

40. Scheede-Bergdahl, C., E.M. Minnella, and F. Carli, Multi-modal prehabilitation: addressing the why, when, what, how, who and where next? Anaesthesia, 2019. 74 Suppl 1: p. 20-26.

41. Ethun, C.G., et al., Frailty and cancer: Implications for oncology surgery, medical oncology, and radiation oncology. CA Cancer J Clin, 2017. 67(5): p. 362-377.

42. Robinson, T.N., et al., Frailty for Surgeons: Review of a National Institute on Aging Conference on Frailty for Specialists. J Am Coll Surg, 2015. 221(6): p. 1083-92.

43. Argillander, T.E., et al., Preoperative physical performance as predictor of postoperative outcomes in patients aged 65 and older scheduled for major abdominal cancer surgery: A systematic review. Eur J Surg Oncol, 2022. 48(3): p. 570-581.

44. Moran, J., et al., Role of cardiopulmonary exercise testing as a risk-assessment method in patients undergoing intra-abdominal surgery: a systematic review. Br J Anaesth, 2016. 116(2): p. 177-91.

45. Steffens, D., et al., Preoperative Cardiopulmonary Exercise Test Associated with Postoperative Outcomes in Patients Undergoing Cancer Surgery: A Systematic Review and Meta-Analyses. Ann Surg Oncol, 2021. 28(12): p. 7120-7146.

46. West, M.A., et al., Validation of preoperative cardiopulmonary exercise testing-derived variables to predict in-hospital morbidity after major colorectal surgery. Br J Surg, 2016. 103(6): p. 744-752.

47. Berkel, A.E.M., et al., Effects of Community-based Exercise Prehabilitation for Patients Scheduled for Colorectal Surgery With High Risk for Postoperative Complications: Results of a Randomized Clinical Trial. Ann Surg, 2022. 275(2): p. e299-e306.

48. Heger, P., et al., A Systematic Review and Meta-analysis of Physical Exercise Prehabilitation in Major Abdominal Surgery (PROSPERO 2017 CRD42017080366). J Gastrointest Surg, 2020. 24(6): p. 1375-1385.

49. Hughes, M.J., et al., Prehabilitation Before Major Abdominal Surgery: A Systematic Review and Meta-analysis. World J Surg, 2019. 43(7): p. 1661-1668.

50. Moran, J., et al., The ability of prehabilitation to influence postoperative outcome after intra-abdominal operation: A systematic review and meta-analysis. Surgery, 2016. 160(5): p. 1189-1201.

51. Thomas, G., et al., Prehabilitation before major intra-abdominal cancer surgery: A systematic review of randomised controlled trials. Eur J Anaesthesiol, 2019. 36(12): p. 933-945.

52. van Rooijen, S.J., et al., Systematic review of exercise training in colorectal cancer patients during treatment. Scand J Med Sci Sports, 2018. 28(2): p. 360-370.

53. Waterland, J.L., et al., Efficacy of Prehabilitation Including Exercise on Postoperative Outcomes Following Abdominal Cancer Surgery: A Systematic Review and Meta-Analysis. Front Surg, 2021. 8: p. 628848.

54. Jain, S.R., et al., The Role and Effect of Multimodal Prehabilitation Before Major Abdominal Surgery: A Systemic Review and Meta-Analysis. World J Surg, 2022.

55. Barberan-Garcia, A., et al., Personalised Prehabilitation in High-risk Patients Undergoing Elective Major Abdominal Surgery: A Randomized Blinded Controlled Trial. Ann Surg, 2018. 267(1): p. 50-56.

56. van Wijk, L., et al., Improved preoperative aerobic fitness following a home-based bimodal prehabilitation programme in high-risk patients scheduled for liver or pancreatic resection. Br J Surg, 2022. 109(11): p. 1036-1039.

57. Epstein, N.E., A review article on the benefits of early mobilization following spinal surgery and other medical/surgical procedures. Surg Neurol Int, 2014. 5(Suppl 3): p. S66-73.

58. Hanada, M., et al., Effect of early mobilization on postoperative pulmonary complications in patients undergoing video-assisted thoracoscopic surgery on the esophagus. Esophagus, 2018. 15(2): p. 69-74.

59. Ramos Dos Santos, P.M., et al., Effects of early mobilisation in patients after cardiac surgery: a systematic review. Physiotherapy, 2017. 103(1): p. 1-12.

60. Ley, L., et al., The dose of physical activity to minimise functional decline in older general medical patients receiving 24-hr acute care: A systematic scoping review. J Clin Nurs, 2019. 28(17-18): p. 3049-3064.

61. Iida, H., et al., Usefulness of measuring temporal changes in physical activity levels using an accelerometer for prediction and early detection of postoperative complications after hepatectomy. HPB (Oxford), 2022. 24(1): p. 57-64.

62. van Zutphen, M., et al., An increase in physical activity after colorectal cancer surgery is associated with improved recovery of physical functioning: a prospective cohort study. BMC Cancer, 2017. 17(1): p. 74.

63. Lawrence, V.A., et al., Functional independence after major abdominal surgery in the elderly. J Am Coll Surg, 2004. 199(5): p. 762-72.

64. Higgins, T., E. Larson, and R. Schnall, Unraveling the meaning of patient engagement: A concept analysis. Patient Educ Couns, 2017. 100(1): p. 30-36.

65. Tew, G.A., et al., Community-based prehabilitation before elective major surgery: the PREP-WELL quality improvement project. BMJ Open Qual, 2020. 9(1).

66. Fournier, B., et al., Interest and preferences for physical activity programming and counselling among cancer patients aged over 70 years receiving oncological treatments. Eur J Cancer Care (Engl), 2022. 31(1): p. e13527.

67. Lee, D.J., et al., Patient engagement in the design and execution of urologic oncology research. Urol Oncol, 2017. 35(9): p. 552-558.

68. Jakobsson, J., E. Idvall, and C. Kumlien, Patient characteristics and surgery-related factors associated with patient-reported recovery at 1 and 6 months after colorectal cancer surgery. Eur J Cancer Care (Engl), 2017. 26(6).

69. van der Velde, M., et al., What moves patients to participate in prehabilitation before major surgery? A mixed methods systematic review. Under review

70. Michie, S., M.M. van Stralen, and R. West, The behaviour change wheel: a new method for characterising and designing behaviour change interventions. Implement Sci, 2011. 6: p. 42.

71. Bernhardt, J., et al., Inactive and alone: physical activity within the first 14 days of acute stroke unit care. Stroke, 2004. 35(4): p. 1005-9.

72. Valkenet, K., et al., Inpatient physical activity across a large university city hospital: a behavioral mapping study. Physiother Theory Pract, 2022: p. 1-8.

73. Valkenet, K., et al., Physical activity monitoring during hospital stay: a validation study. Disabil Rehabil, 2022: p. 1-6.

74. Valkenet, K., et al., Measuring physical activity levels in hospitalized patients: a comparison between behavioural mapping and data from an accelerometer. Clin Rehabil, 2019. 33(7): p. 1233-1240.

75. Miller, C.J., S.N. Smith, and M. Pugatch, Experimental and quasi-experimental designs in implementation research. Psychiatry Research, 2020. 283: p. 112452.

76. Goodacre, S., Uncontrolled before-after studies: discouraged by Cochrane and the EMJ. Emergency Medicine Journal, 2015. 32(7): p. 507-508.

77. Bauer, M.S. and J. Kirchner, Implementation science: What is it and why should I care? Psychiatry Res, 2020. 283: p. 112376.

78. Morris, Z.S., S. Wooding, and J. Grant, The answer is 17 years, what is the question: understanding time lags in translational research. Journal of the Royal Society of Medicine, 2011. 104(12): p. 510-520.

79. Bernet, A.C., D.E. Willens, and M.S. Bauer, Effectiveness-implementation hybrid designs: implications for quality improvement science. Implementation Science, 2013. 8(1): p. S2.

80. Curran, G.M., et al., Effectiveness-implementation hybrid designs: combining elements of clinical effectiveness and implementation research to enhance public health impact. Med Care, 2012. 50(3): p. 217-26.

81. Zimlichman, E., et al., Health Care 2030: The Coming Transformation. Catalyst non-issue content, 2021. 2(2).

82. Chan, P.Y., et al., Novel wearable and contactless heart rate, respiratory rate, and oxygen saturation monitoring devices: a systematic review and meta-analysis. Anaesthesia, 2022. 77(11): p. 1268-1280.

83. Koenders, N., et al., Validation of a wireless patch sensor to monitor mobility tested in both an experimental and a hospital setup: A cross-sectional study. PLoS One, 2018. 13(10): p. e0206304.

84. Chan, A.M., et al., Wireless patch sensor for remote monitoring of heart rate, respiration, activity, and falls. Annu Int Conf IEEE Eng Med Biol Soc, 2013. 2013: p. 6115-8.

85. Shreve, J.T., S.A. Khanani, and T.C. Haddad, Artificial Intelligence in Oncology: Current Capabilities, Future Opportunities, and Ethical Considerations. Am Soc Clin Oncol Educ Book, 2022. 42: p. 1-10.

86. Chui M., Manyika J., and Bughin J. Big Data's Potential for Businesses. . 2011; Available from: https://www.mckinsey.com/mgi/overview/in-the-news/big-data-potential-for-businesses.

Summary

KEEP ON MOVING

Promoting physical activity during hospital stay and enhance recovery - focused on patients with cancer

Yearly many new patients are diagnosed with cancer. The risk of death from cancer decreases continuously. Due to the 'success' of new cancer therapies, cancer survivors life longer and experience new issues including physical and physiological side effects of treatment. Counteracting the side-effects seem important to optimize recovery after cancer treatment. An example which helps to counteract the side-effects is physical activity. However, cancer survivors show to have low levels of physical activity. Patients who underwent treatment like surgery or chemotherapy are frequently admitted to the hospital. However, within the hospital, sedentary behavior is deeply rooted in the hospital culture. In order to prevent functional decline during admission and to enhance recovery of physical functioning, it is necessary that patients remain as physical active as possible during their hospital stay. To change the culture of inactivity during hospital stay, there is a need for effective interventions promoting inpatients physical activity. Next to promoting physical activity during hospital stay, it is important to optimize patients recovery in the entire patient journey. Especially since the return to daily functioning as soon as possible after surgery is most important for patients.

In this thesis, we investigated physical activity and physical functioning levels during and after hospitalization, with a special focus on patients with cancer. In **part I** (chapter 2, 3, 4, 5, 6) we investigated the effect of interventions promoting physical activity during hospital stay. In **part II** (chapter 7, 8, 9) the role of physical activity and functioning around major oncological surgery is described and a possible way to tailor care is provided.

Part I: Interventions to promote inpatients' physical activity

The first 3 chapters focus on the implementation of the project Hospital in Motion, a multidimensional implementation project, which aimed to promote inpatients' physical activity. In **chapter 2** the research protocol for a mixed-method study on the evaluation of the effectiveness and implementation process of Hospital in Motion is described. Per ward, a multidisciplinary team followed a step-by-step approach including the development and implementation of a ward-specific action plan. The action plan consisted of 6 general topics including education, physical activity as part of usual care, involving third parties, stimulation environment, mobilization milestones and technology support. Per ward, interventions were implemented within multiple dimensions to improve movement behavior. The implementation of change model, developed by Grol and Wensing, was used for the development and implementation of the action plan. The primary outcome measure was the percentage of the time spend lying, measured with the behavioral mapping method. Secondary outcome measures were the time spend sitting and moving, immobility related complications, length of stay, discharge destination, mortality and 30-day readmissions. In addition, a process evaluation was performed including semi-structured interviews.

The effectiveness of Hospital in Motion was evaluated in **chapter 3**, using a pre-post design. Hospital in Motion was conducted at 4 wards of the University Medical Center Utrecht; cardiology, cardiothoracic surgery, medical oncology and hematology. Inpatient movement behavior was assessed before the start of the project and 1 year later, using the behavioral mapping method, whereby patients were observed between 9:00 am and 4:00 pm. Movement behavior of approximately 160 patients (40 per ward) was observed before and after the implementation of Hospital in Motion. Patient observations demonstrated that the primary outcome, the time spend lying, changed significantly from 60% to 52%. For the secondary outcomes, the time spend sitting increased significantly from 32% to 38%. No significant changes were found in the time spend moving (8% to 10%). At discharge, the number of patients who went to a rehabilitation setting reduced significantly from 6 (4%) to 1 (1%). No statistical differences were found in the other secondary outcome measures. The results of this study indicate that inpatients' movement behavior can be improved by implementing multidimensional interventions, however more effort is needed to get patients more active.

In **chapter 4** a process evaluation was conducted, including an in-dept analysis on all perceived factors of influence of the project Hospital in Motion. At the end of the implementation of Hospital in Motion, 28 semi-structured interviews were conducted with 16 healthcare professionals and 12 patients. The framework of the Medical Research Council for complex interventions, was used as guidance for the identification of categories and themes. The results were represented into 3 key components; implementation, mechanisms of impact and the context. Factors of influence within the theme 'implementation' were the iterative and multidisciplinary approach. Within the theme 'mechanisms of impact' continuous attention and interaction of multiple interventions, tailored to the target group and targeting multiple dimensions were perceived as important. Within the theme 'context' the intrinsic motivation and inter-professional, community and societal culture towards physical activity was perceived to be a factor of influence. These results confirmed the importance of a multidisciplinary approach and implementing a set of tailored interventions targeting multiple dimensions. However, to maintain enough focus on individual interventions, the amount of activities should be limited. These findings emphasize the complexity of changing inpatients' movement behavior.

Within Hospital in Motion, patients exchanged their bed for the chair, however more effort is needed to get patients more active during hospital stay. To increase focus on the interventions and to achieve continuous attention of physical activity, the use of activity trackers seems promising. Interventions with an activity tracker can cover multiple dimensions (individual, ward and hospital) and thereby help to create more sustainable change in hospital care processes. Therefore, in **chapter 5** a systematic review and meta-analysis was conducted to evaluate the effectiveness of physical activity interventions using activity trackers on improving physical activity and physical functioning in patients during and/or after inpatient care. Additionally, it was determined whether intervention characteristics like the number of behavioural change techniques, the use of a theoretical model or the addition of coaching by a healthcare professional, increase the effectiveness of the intervention. Overall, 21 Randomized Controlled Trials, with in total 2355 patients were included. The results showed that interventions using activity trackers during and/or after inpatient care are heterogeneous, but in generally more effective in increasing the level of physical activity compared to usual care. However, this does not necessarily translate into an improvement of physical functioning. The intensity and quality of interventions seem to improve when the intervention was provided both during and after the inpatient period, included more behavioral change techniques, used a theoretical model and coaching from a healthcare professional.

To develop an intervention using an activity tracker to promote physical activity during hospital stay, the steps of intervention mapping were followed. In co-creation with healthcare professionals and patients, important aspects of the interventions were identified and implementation strategies were selected. After following the steps of intervention mapping, the GOAL-intervention consisted of 1) self-monitoring of patients' physical activity 2) setting daily movement goals and 3) posters with exercises and walking routes. The GOAL-intervention was implemented at two medial wards (pulmonology and nephrology/gastro-enterology wards) of the University Medical Center Utrecht. In **chapter 6** the effectiveness of the GOAL-intervention was evaluated with a pre-post design. The primary outcome measure was active minutes per day. Secondary outcomes were hospital length of stay, discharge destination, immobility-related complications, physical functioning, difficulty to move, 30-day re-admission, 30-day mortality and the adoption of the intervention. The results showed that post-implementation the mean level of physical activity was 12 minutes (32%) higher compared to pre-implementation. Perceived difficulty to move at discharge decreased significantly from 3.4 to 1.7 points. There were no statistically significant changes in other secondary outcomes. The adoption of both patients and healthcare professionals was considered as "good/acceptable".

Part II: Optimizing recovery after major oncological surgery

In patients with esophageal cancer, curative treatment involves esophagectomy and is often preceded with neoadjuvant chemoradiotherapy. However, after esophagectomy, patients have a relatively high risk of postoperative complications. Change scores might provide more insight in the patients' adaptive capacity and resilience to stressors. Therefore, in **chapter 7** a longitudinal retrospective observational cohort study was conducted to evaluate whether changes in physical fitness, weight and fat-free mass index can predict the risk of postoperative pneumonia. Physical fitness (handgrip strength, leg extension strength and exercise capacity), weight and fat-free mass index were measured before and after chemoradiotherapy. A decrease in handgrip strength and exercise capacity during neoadjuvant chemoradiotherapy was associated with an increased risk of postoperative pneumonia after esophagectomy for cancer. Even so, all pneumonias occurred in patients with declined physical fitness during neoadjuvant chemoradiotherapy. Measuring physical fitness before and after chemoradiotherapy might identify patients at risk for unwanted postoperative events and is therefore being suggested as standard practice.

Nevertheless, for patients who undergo major surgery, the recovery to perform daily activities afterwards is most important. One of the factors of influence on physical functioning might be the level of physical activity. Therefore in **chapter 8** a prospective observational cohort study was conducted to investigate recovery of physical functioning and the association with objective physical activity levels. Patient who underwent gastrointestinal or bladder oncological surgery were included in this study. Physical functioning was measured preoperatively at 1 and 3 months after discharge. Physical activity was objectively measured with an activity tracker both during hospitalization at 1 and 3 months after discharge. In total 68 patients were included. Half of the patients (49%) were not recovered in physical functioning 3 months after surgery. Higher levels of physical activity 1 month after discharge were associated with higher level of physical functioning up to 3 months after discharge. Therefore, it seems important to evaluate both physical activity and physical functioning levels after surgery to enable tailored postoperative mobility care to optimize recovery after major oncological surgery.

Not all patients might need the same support to optimize postoperative recovery. However, practical guidance on how to tailor patient care after major oncological surgery is lacking. A possible way to tailor care is segmentation. Segmentation divides patients in different personas, whereby for each persona intervention programs can be tailored to the patients' need. A previous developed cross-disease segmentation model divides persons in 4 personas based on acceptance and perceived control of their subjective health experience. However, it is unclear whether this way of segmentation can be applied to determine different personas and to tailor postoperative care in patients undergoing a major life event like oncological surgery. Therefore, in **chapter 9** the distribution of personas over time was evaluated and differences in physical and mental functioning between the personas were explored. Personas were identified preoperative and 1 and 3 month after discharge. Preoperative the majority of the patients (35%) were identified as persona 1 (high acceptance and perceived control), whereas 1 and 3 months after discharge this number changed to respectively 22% and 27%. After discharge the majority of the patients were identified as persona 4 (low acceptance and perceived control), 47% 1 month after discharge and 45% 3 months after discharge. Patients in persona 4 showed to have significant lower levels of physical functioning and higher levels of anxiety and depression compared to patients in persona 1. The segmentation to different personas based on subjective health experience provides insight in different levels of physical and mental functioning, which may guide tailoring care.

In **chapter 10** the main findings of this thesis are discussed, focusing on 3 main themes: 1) structural change in the immobility culture, 2) the use of technology and 3) the identification of patients at risk, to deliver tailored care. This thesis showed that inpatients' physical activity is a modifiable factor, however changing the immobility culture is challenging. Therefore, multimodal interventions covering several levels of the social ecological model are needed to change the immobility culture. Furthermore, physical activity measured with an activity tracker should be a standard outcome measure, just like heart rate and blood pressure. Standard use of activity trackers in daily hospital care could facilitate patients' self-management, can create a common language between healthcare professionals, creates continuous awareness regarding physical activity and could help to select the patients at risk for functional decline or complications. The use of technology could also be a useful tool to replace or supplement care in the perioperative period. Especially since patients get more responsibility about their own health, due to changes in the healthcare system. Integration of the use of activity trackers and mobile applications within the entire patient journey might help to reach many patients with relatively low costs. However, it is important to select the patients at risk for unwanted outcomes like complications or delayed recovery at several time points (i.e. preoperatively, during hospital stay and in the home situation) to deliver more extensive care to the patients who benefit most.

Samenvatting

BLIJF IN BEWEGING

Het verbeteren van fysieke activiteit tijdens ziekenhuisopname om herstel te bevorderen – gericht op patiënten met kanker

Jaarlijks worden er veel nieuwe patiënten gediagnosticeerd met kanker. Door het 'succes' van nieuwe behandelingen tegen kanker is de overleving toegenomen. Echter als gevolg van de behandeling kunnen patiënten nieuwe problemen ervaren op fysiek en mentaal vlak. Het verminderen van deze nadelige effecten lijkt belangrijk om herstel na de behandeling tegen kanker te verbeteren. Fysieke activiteit kan helpen om achteruitgang als gevolg van de behandeling te verminderen. Toch zien we dat patiënten met kanker een laag activiteitenniveau hebben. Daarnaast worden patiënten die behandeling moeten ondergaan zoals chemotherapie of een operatie, regelmatig opgenomen in het ziekenhuis. In het ziekenhuis is inactiviteit echter diep geworteld in de ziekenhuiscultuur. Om achteruitgang in dagelijks functioneren als gevolg van de ziekenhuisopname te voorkomen en herstel te bevorderen, is het belangrijk dat patiënten zo actief mogelijk blijven tijdens de ziekenhuisopname. Daarom is het belangrijk om effectieve interventies te ontwikkelen om beweeggedrag tijdens de ziekenhuisopname te verbeteren. Daarnaast is het van belang dat patiënten na de opname weer op hun oude niveau van dagelijks functioneren kunnen terugkeren. Daarom is het belangrijk om niet alleen naar de periode tijdens de ziekenhuisopname te kijken maar ook naar de periode voorafgaand aan de opname en naar het herstel nadien.

In dit proefschrift hebben we onderzoek gedaan naar verschillende interventies om het beweeggedrag tijdens ziekenhuisopname te verbeteren en het herstel nadien te optimaliseren. In **deel I** (hoofdstuk 2, 3, 4, 5 en 6) hebben we gekeken naar het effect van verschillende interventies gericht op het stimuleren van bewegen tijdens de ziekenhuisopname. In **deel II** (hoofdstuk 7, 8 en 9) hebben we gekeken naar de invloed van fysieke activiteit en functioneren rondom een grote oncologische operatie en inzicht gegeven in een mogelijke manier om zorg in de toekomst meer op maat te leveren.

Deel I: Interventies gericht op het verbeteren van fysieke activiteit tijdens ziekenhuisopname

De eerste 3 hoofdstukken van dit proefschrift zijn gericht op de implementatie van het project UMC Utrecht in Beweging (in het engels: 'Hospital in Motion'), een multidimensionaal implementatie project dat als doel heeft om beweeggedrag tijdens ziekenhuisopname te stimuleren. **Hoofdstuk 2** beschrijft het onderzoeksprotocol voor een mixed-method studie waarin de effectiviteit en het implementatieproces van UMCU in Beweging wordt geëvalueerd. Per afdeling volgt een multidisciplinair team een stapsgewijs proces waarbij interventies worden ontwikkeld en geïmplementeerd, gericht op het verbeteren van beweeggedrag. Voor het ontwikkelen van de interventies en de implementatie is gebruik gemaakt van het implementatiemodel van Grol en Wensing. De interventies zijn gericht op 6 generieke thema's van het actieplan, bestaande uit: educatie, fysieke activiteit als standaard onderdeel van de zorg, betrekken van derden, doelen stellen en de inzet van technologie. De primaire uitkomstmaat is het percentage dat patiënten in bed liggen, gemeten met observaties. De secondaire uitkomstmaten zijn de tijd dat patiënten zitten en bewegen, complicaties als gevolg van inactiviteit, opnameduur, ontslagbestemming, overlijden en heropnames. Daarnaast is een proces evaluatie uitgevoerd aan de hand semi-gestructureerde interviews met patiënten en zorgverleners.

De effectiviteit van het project UMC Utrecht in Beweging is geëvalueerd in **hoofdstuk 3** aan de hand van een pre-post design. Het project is uitgevoerd op 4 afdelingen van UMC Utrecht; cardiologie, cardio thoracale chirurgie, medische oncologie en de hematologie. Het beweeggedrag was gemeten voor de start van het project en 1 jaar later, met behulp van observaties. Patiënten werden geobserveerd gedurende een opnamedag van 9:00 tot 16:00. Het beweeggedrag van ongeveer 160 patiënten (40 per afdeling) is in kaart gebracht, zowel voor als na de implementatie van het project. Resultaten laten zien dat na implementatie van UMC Utrecht in Beweging, patiënten significant minder tijd in bed liggen (pre-implementatie 60%, post-implementatie 52%). Daarnaast is de tijd dat patiënten zitten in de stoel significant toegenomen van 32% naar 38%. Geen significante verschillen zijn gevonden in de tijd dat patiënten actief waren (8% naar 10%). Bij ontslag werden wel significant minder patiënten doorverwezen naar een revalidatiecentrum van 6 (4%) pre-implementatie naar 1 (1%) post-implementatie. De resultaten laten zien dat beweeggedrag tijdens opname kan verbeteren door de implementatie van multidimensionale interventies, maar dat er meer inspanningen nodig zijn om patiënten daadwerkelijk meer in beweging te krijgen.

In **hoofdstuk 4** is de proces evaluatie uitgevoerd, waarbij een verdiepende analyse is gedaan op alle factoren die van invloed waren op het project UMC Utrecht in Beweging. Na implementatie zijn 28 semigestructureerde interviews afgenomen met 16 zorgverleners en 12 patiënten. Het model van de Medical Research Council voor complexe interventies is gebruikt als leidraad voor de identificatie van categorieën en thema's. De resultaten zijn weergegeven in 3 hoofdthema's; de implementatie, het mechanisme van impact en de context. Beinvloedbare factoren binnen het thema 'implementatie' zijn de iteratieve en multidisciplinaire benadering. Binnen het thema 'mechanisme van impact' waren continue aandacht, de interactie tussen meerdere interventies, het op maat maken en multidimensionale interventies geduid als belangrijke factoren. Binnen het thema 'context' zijn karakteristieken van het individu (patiënt en zorgverleners), de afdeling, het ziekenhuis en de maatschappij aangegeven als beïnvloedbare factoren. De resultaten bevestigen het belang van een multidisciplinaire aanpak en het implementeren van meerdere interventies, gericht op meerdere dimensies. Daarentegen om focus op de individuele interventies te behouden, moet het aantal interventies beperkt blijven. Daarnaast benadrukken deze resultaten de complexiteit van het veranderen van beweeggedrag tijdens ziekenhuisopname.

Tijdens het project UMC Utrecht in Beweging zagen we dat patiënten meer uit bed kwamen en in de stoel zaten, maar niet meer in beweging kwamen. Om meer focus te krijgen op de interventies en om continue aandacht en bewustwording te creëren ten aanzien van fysieke (in)activiteit, lijkt het gebruik van beweegsensoren veelbelovend. Interventies met een beweegsensor kunnen meerdere dimensies omvatten (individu, afdeling, ziekenhuis) en daarmee helpen om duurzame verandering te bewerkstelligen ten aanzien van fysieke activiteit binnen de zorgprocessen. Daarom hebben we in **hoofdstuk 5** een systematische review en meta-analyse uitgevoerd waarbij we gekeken hebben naar het effect van interventies met een beweegsensor op fysieke activiteit en fysiek functioneren tijdens of na een opname periode. Daarnaast is gekeken naar welke interventie karakteristieken zoals het aantal gedragsveranderingstechnieken, het gebruik van een theoretisch model of het toepassen van coaching door een zorgverlener invloed heeft op het effect van de interventie. In totaal zijn 21 'randomized controlled trials' geïncludeerd, met in totaal 2355 patiënten. De resultaten laten zien dat er veel verschil zit tussen de interventies met een beweegsensor tijdens of na een opnameperiode, maar dat het over het algemeen effectief is om fysieke activiteit te stimuleren in vergelijking met standaard zorg.

Desalniettemin vertaalt zich dit niet automatisch in een hoger niveau van functioneren. De intensiteit en kwaliteit van interventies lijken te verbeteren als de interventie toegepast wordt zowel tijdens als na de opname periode, meerdere gedragsveranderingstechnieken bevat, een theoretisch model wordt gebruik en er coaching plaats vindt van een zorgverlener.

Om beweeggedrag tijdens ziekenhuisopname te stimuleren is een interventie met een beweegsensor ontwikkeld, passend bij de afdeling, middels de stappen van intervention mapping. In samenwerking met zorgverleners en patiënten is per afdeling gekeken wat belangrijke aspecten van de interventie moeten zijn en implementatie strategieën geselecteerd. Op basis hiervan is de GOAL-interventie ontwikkeld, bestaande uit: 1) inzichtelijk maken van beweeggedrag 2) doelen stellen 3) aanpassingen aan de omgeving door middel van oefeningen en looproutes. De interventie is geïmplementeerd op 2 afdeling (longziekten en nefrologie/gastro-enterologie) van het UMC Utrecht. In **hoofdstuk 6** is de effectiviteit van de GOAL-interventie geëvalueerd met behulp van een voor- en nameting. De primaire uitkomst is het aantal actieve minuten per dag. De secundaire uitkomsten zijn de opname duur, ontslagbestemming, complicaties als gevolg van inactiviteit, fysiek functioneren, moeite met bewegen, heropname, mortaliteit en de adoptie van de interventie. De resultaten laten zien dat na de implementatie patiënten significant actiever waren (12 minuten per dag, 32%). De ervaren moeite om te bewegen was significant afgenomen van 3.4 naar 1.7 punten. Er zijn geen statistische verschillen gevonden in de overige uitkomstmaten. De adoptie van de interventie was “goed/acceptabel” vanuit zowel patiënt- als zorgverlenersperspectief.

Deel II: Het optimaliseren van herstel na een grote oncologische operatie

Voor patiënten met slokdarmkanker bestaat de behandeling uit slokdarmkankerresectie, aangevuld met neoadjuvante chemoradiotherapie. Echter is er na een slokdarmkankerresectie een hoog risico op het krijgen van postoperatieve complicaties. Verander scores van fysieke fitheid zijn mogelijk van toegevoegde waarde gezien dit inzicht geeft in het adaptieve vermogen en veerkracht van de patiënt bij impactvolle gebeurtenissen zoals een operatie of chemoradiotherapie. Daarom is in **hoofdstuk 7** een longitudinale retrospectieve observationele cohort studie uitgevoerd om te evalueren of verander scores van fysieke fitheid, gewicht en vetvrije massa index voorspellend zijn voor het risico op postoperatieve complicatie zoals een longontsteking. Fysieke fitheid (handknijpkracht, spierkracht en uithoudingsvermogen), gewicht en vetvrije massa index was gemeten voor en na de chemoradiotherapie. Een afname van handknijpkracht en uithoudingsvermogen tijdens neoadjuvante chemoradiotherapie was geassocieerd met een verhoogd risico op postoperatieve longontsteking. Alle longontstekingen ontstonden bij patiënten die achteruit gingen in fysieke fitheid tijdens de neoadjuvante chemoradiotherapie. Het meten van fysieke fitheid voor en na de chemoradiotherapie lijkt belangrijk om patiënten met een verhoogd risico op longontsteking te identificeren.

Desalniettemin, voor patiënten die een grote oncologische operatie ondergaan, is met name het herstel naar hun ‘normale niveau’ van dagelijks functioneren belangrijk. Een factor die mogelijk van invloed is op het herstel van fysiek functioneren is fysieke activiteit. Daarom hebben we in **hoofdstuk 8** een observationele cohort studie uitgevoerd om het herstel van functioneren in kaart te brengen. Hierbij hebben we gekeken of het activiteitenniveau tijdens en na de ziekenhuisopname geassocieerd is met het niveau van fysiek functioneren 3 maanden na ontslag. Patiënten die een grote gastro-intestinale (maag, slokdarm, lever, darm) of blaas operatie ondergaan in verband met kanker waren geïncludeerd in de studie. Fysiek functioneren was gemeten voor de operatie en 1 en 3 maanden na ontslag uit het ziekenhuis. Fysieke activiteit was gemeten met een beweegsensor gedurende opname en 1 en 3 maanden na ontslag. In totaal zijn 68 patiënten geïncludeerd. De resultaten laten zien dat de helft van de patiënten (49%) niet hersteld is qua fysiek functioneren 3 maanden na ontslag uit het ziekenhuis. Een hoger activiteitenniveau 1 maand na ontslag was geassocieerd met een hoger niveau van functioneren 3 maanden na ontslag. Het evalueren van fysieke activiteit en fysiek functioneren rondom de operatie lijkt daarom belangrijk om patiënten die extra ondersteuning nodig hebben te identificeren en daarmee het postoperatieve herstel te bevorderen.

Niet alle patiënten hebben dezelfde begeleiding nodig om het postoperatieve herstel te bevorderen. Desondanks zijn er geen praktische handvatten om zorg op maat te bieden na een grote operatie. Een mogelijke manier om zorg op maat te bieden is segmentatie. Segmentatie verdeeld patiënten in verschillende persona's, waarbij voor elke persona de zorg aangepast kan worden aan de behoefte van de patiënt. Een al eerder ontwikkelde ziekte-overstijgend segmentatiemodel maakt een indeling naar 4 persona's gebaseerd op de mate van acceptatie en de mate van controle over zijn/haar ervaren beleefde gezondheid. Echter is onduidelijk in hoeverre dit model toepasbaar is bij patiënten die een levensingrijpende gebeurtenis meemaken zoals een oncologische operatie. Daarom is in **hoofdstuk 9** gekeken wat de verdeling is van der persona's gedurende het perioperatieve traject en of er verschillen zijn in het mentaal en fysiek functioneren tussen de persona's. De persona's zijn geïdentificeerd voor de operatie en 1 en 3 maanden na ontslag. In totaal zijn 98 patiënten geïncludeerd die een gastro-intestinale of blaas operatie ondergaan in verband met kanker. Voor de operatie was het grootste gedeelte van de patiënten (35%) geïdentificeerd als persona 1 (hoge acceptatie en ervaren controle), wat veranderd naar 22% en 27% na 1 en 3 maanden ontslag uit het ziekenhuis. Na ontslag zijn de meeste patiënten geïdentificeerd als persona 4 (lage acceptatie en ervaren controle)(47% 1 maand na ontslag 45% 3 maanden na ontslag). Patiënten die geïdentificeerd zijn als persona 4 hebben een significant lager niveau van functioneren en meer last van angst en depressieklachten in vergelijking met persona 1. De segmentatie naar verschillende persona's gebaseerd op de ervaren gezondheid geeft inzicht in verschillende niveau van fysiek en mentaal functioneren, wat kan helpen om zorg meer op maat te leveren.

In **hoofdstuk 10** zijn de belangrijkste bevindingen van dit proefschrift bediscussieerd, ingedeeld in 3 thema's; 1) structurele veranderingen in de ziekenhuiscultuur 2) het gebruik van technologie 3) het identificeren van patiënten die een hoog-risico hebben en het leveren van passende zorg. Dit proefschrift laat zien dat beweeggedrag een modificeerbare factor is, maar dat het veranderen van de beweegcultuur in het ziekenhuis een uitdaging is. Multi-dimensionele interventies die verschillende niveaus van het sociaal ecologische model bevatten lijken belangrijk om cultuurverandering te bewerkstelligen. Daarnaast lijkt het standaard meten van fysieke activiteit belangrijk om van bewegen een objectieve uitkomstmaat te maken, net zoals hartslag en bloeddruk. Standaard gebruik van een beweegsensor tijdens ziekenhuisopname kan zelfmanagement van patiënten ten aanzien van fysieke activiteit vergroten, kan een gemeenschappelijke taal bewerkstelligen tussen zorgverleners, creëert continue bewustwording ten aanzien van fysieke activiteit en kan helpen om patiënten die inactief zijn en daardoor een hoog risico hebben op functionele achteruitgang en complicaties te identificeren. Daarnaast kan het gebruik van technologie zinvol zijn om zorg in het gehele perioperatieve traject te ondersteunen of te vervangen indien mogelijk. Dit lijkt belangrijker te worden gezien patiënten steeds meer verantwoordelijkheid krijgen over zijn/haar gezondheid. De integratie van het gebruik van beweegsensoren en mobiele applicaties in het gehele perioperatieve traject kan helpen om veel patiënten te bereiken met relatief lage kosten. Desalniettemin blijft het belangrijk om de patiënten met een hoog risico op complicaties of vertraagd herstel te identificeren op meerdere momenten in het traject (voor operatie, tijdens opname en in de herstelfase) om meer uitgebreide zorg te leveren aan de patiënten die het het meeste nodig hebben.

About the author

ABOUT THE AUTHOR

Petra Bor was born in Oldemarkt, the Netherlands on the 10th of February 1990. After graduating from secondary school in Wolvega, she obtained her bachelor degree in Physical Therapy at the Hanze Hogeschool Groningen, in 2011. She started working as physical therapist with different patient populations in both a private practice and a general hospital. Next to her work as physical therapist, she completed the master Clinical Health Sciences, direction Physiotherapy Sciences, at the University Utrecht in 2016.

In 2017 Petra started working at the department Rehabilitation, Physiotherapy Sciences and sports of the University Medical Center Utrecht (UMC Utrecht) as a hospital-based physical therapist on the oncology wards, which is still her focus. Short after she started working at the UMC Utrecht she had the opportunity to start in a PhD position on the topic 'promoting physical activity levels during hospital stay' at the same department. An important topic whose consequence she witness in daily practice every day. Next to that, she was project leader to develop a guideline for the perioperative physiotherapy care in patients' who underwent abdominal surgery as an assignment for the Royal Dutch Society for Physical Therapy, in the period of September 2022 until March 2023. In the summer of 2023 she completed her PhD project.

After completing her PhD, Petra will continue her work as physical therapist on the oncology wards of the UMC Utrecht, combined with a fellowship of *implementation science practitioner*, subsidized by ZonMw. In this role she continues her work with a special focus on the translation of research findings into daily practice to optimize healthcare in the future. During this fellowship she pursues the implementation of the activity tracker in and around daily hospital care to enhance patients' recovery in the future.

Petra lives together with Marco in Amersfoort and they are proud parents of Lea (2019) and Fien (2021).

List of publications

LIST OF PUBLICATIONS

Peer reviewed publications

Valkenet, K., **Bor, P**., van Delft, L., & Veenhof, C. (2019). Measuring physical activity levels in hospitalized patients: a comparison between behavioural mapping and data from an accelerometer. *Clin Rehabil, 33*(7), 1233-1240. doi:10.1177/0269215519836454

van Delft, L. M. M., **Bor, P.**, Valkenet, K., & Veenhof, C. (2019). Hospital in Motion, a Multidimensional Implementation Project to Improve Patients' Physical Behavior During Hospitalization: Protocol for a Mixed-Methods Study. *JMIR Res Protoc, 8*(4), e11341. doi:10.2196/11341

van Delft, L., **Bor, P**., Valkenet, K., Slooter, A., & Veenhof, C. (2020). The Effectiveness of Hospital in Motion, a Multidimensional Implementation Project to Improve Patients' Movement Behavior During Hospitalization. *Phys Ther*. doi:10.1093/ptj/pzaa160

Bor, P., Kingma, B. F., Kerst, A., Steenhagen, E., Ruurda, J. P., van Hillegersberg, R., Valkenet, K, Veenhof, C.(2021). Decrease of physical fitness during neoadjuvant chemoradiotherapy predicts the risk of pneumonia after esophagectomy. *Dis Esophagus, 34*(12). doi:10.1093/dote/doab008

Bor, P., van Delft, L., Valkenet, K., & Veenhof, C. (2021). Perceived Factors of Influence on the Implementation of a Multidimensional Project to Improve Patients' Movement Behavior during Hospitalization: A Qualitative Study. *Phys Ther*. doi:10.1093/ptj/pzab260

Bor, P., de Leeuwerk, M. E., Valkenet, K., van Hillegersberg, R., & Veenhof, C. (2022). Physical functioning and physical activity after gastrointestinal or bladder oncological surgery: An observationalcohort study. *Eur J Cancer Care (Engl)*, e13739. doi:10.1111/ecc.13739

Valkenet, K., McRae, P., Reijneveld, E., Jans, M., **Bor, P**., van Delft, L., . . . Veenhof, C. (2022). Inpatient physical activity across a large university city hospital: a behavioral mapping study. *Physiother Theory Pract*, 1-8. doi:10.1080/09593985.2022.2112116

de Leeuwerk, M. E., **Bor, P**., van der Ploeg, H. P., de Groot, V., van der Schaaf, M., & van der Leeden, M (2022). The effectiveness of physical activity interventions using activity trackers during or after inpatient care: a systematic review and meta-analysis of randomized controlled trials. *Int J Behav Nutr* Phys Act, 19(1), 59. doi:10.1186/s12966-022-01261-9

Reijneveld, E. A. E., **Bor, P**., Dronkers, J. J., Argudo, N., Ruurda, J. P., & Veenhof, C. (2022). Impact of curative treatment on the physical fitness of patients with esophageal cancer: A systematic review and meta-analysis. *Eur J Surg Onco*l, 48(2),391402.doi:10.1016/j.ejso.2021.08.015

Valkenet, K., **Bor, P**., Reijneveld, E., Veenhof, C., & Dronkers, J. (2023). Physical activity monitoring during hospital stay: a validation study. *Disabil Rehabil*, 1-6. doi:10.1080/09638288.2022.2034995

Submitted manuscripts

Bor, P. Valkenet, K. Bloem, S. van Hillegersberg, R. Veenhof, C. Segmentation into different personas, the step to tailor care after major oncological surgery? *2023 submitted* van Grootel, J. W. M., **Bor, P**., Veenhof, C., & Valkenet, K. Development of a goal directed movement intervention (GOAL) using a movement sensor for hospitalized patients: an Intervention Mapping approach. *2023 under review*

Van Grootel, J. W.M., **Bor, P**. Netjes, J.A., Veenhof, C. Valkenet, K. Improving physical activity in hospitalized patients: the impact of the GOAL-intervention. *2023 under review*

Other publications

Jaap Dronkers, Karin Valkenet, **Petra Bor**, Elja Reijneveld, Anne de Hoop, Cindy Veenhof. Fysiek fit de operatie in. *Oncologica Jaargang 36, Nummer 4 2019*

Lotte van Delft, Karin Valkenet, **Petra Bor** en Cindy Veenhof. UMC Utrecht in Beweging, *fysiopraxis oktober 2019*

Rennen voor de dokter, ziekenhuispatiënten liggen veel te veel in bed. *NRC Handelsblad 2019*

Wetenschappers in Beweegziekenhuizen, een succesvolle samenwerking. *Fysiopraxis mei 2021*

Petra Bor, Ad Kerst, Floor van Baren, Karin Valkenet, Richard van Hillegersberg, Cindy Veenhof. Meten van bewegen in de klinische zorg. *Oncologica jaargang 39 Nummer 2 2022*

Handreiking perioperatieve fysiotherapeutische zorg bij buikchirurgie, Koninklijk Nederlands Genootschap voor Fysiotherapie. *In progress*

Authors' contributions

AUTHORS’ CONTRIBUTIONS

Chapter 2 Hospital in Motion, a Multidimensional Implementation Project to Improve Patients’ Physical Behavior During Hospitalization: Protocol for a Mixed-Methods Study

Study concept and design	PB, LvD, KV, CV
Draft the manuscript	PB, LvD
Manuscript editing and review	PB, LvD, KV, CV

Chapter 3 The effectiveness of Hospital in Motion, a multidimensional implementation project to improve patients' movement behavior during hospitalization

Data collection	LvD, PB
Study concept and design	LvD, PB, KV, CV
Data analysis and interpretation	LvD, PB, KV, CV
Draft the manuscript	LvD, PB
Manuscript editing and review	LvD, PB, KV, AS, CV

Chapter 4 Perceived factors of influence on the implementation of a multidimensional project to improve patients’ movement behavior during hospitalization: A qualitative study

Data collection	PB, LvD
Study concept and design	PB, LvD, KV, CV
Data analysis and interpretation	PB, LvD, KV, CV
Draft the manuscript	PB, LvD,
Manuscript editing and review	PB, LvD, KV,CV

Chapter 5 The effectiveness of physical activity interventions using activity trackers during or after inpatient care: a systematic review and meta-analysis of randomized controlled trials

Data collection	MEL, PB, MvdL
Study concept and design	MEL, MvdL
Data analysis and interpretation	MEL, MvdL, MvdS
Draft the manuscript	MEL
Manuscript editing and review	PB, MvdL, MvdS, HvdP, VdG

Chapter 6 Improving physical activity in hospitalized patients: the impact of the GOAL-intervention

Data collection	JvG, PB, JN
Study concept and design	JvG, PB, CV, KV
Data analysis and interpretation	JvG, PB, CV, KV
Draft the manuscript	JvG, PB, KV
Manuscript editing and review	JvG, PB, JN, CV, KV

Chapter 7 Decreased physical fitness during neoadjuvant chemoradiotherapy predicts the risk of pneumonia after esophagectomy

Data collection	PB, BFK, AK, ES
Study concept and design	PB, JPR, RvH, KV, CV
Data analysis and interpretation	PB, BFK, RvH, KV, CV
Draft the manuscript	PB
Manuscript editing and review	PB, BFK, AK, ES, JPR, RvH, KV, CV

Chapter 8 Physical functioning and physical activity after oncological surgery: an observational cohort study

Data collection	PB, MEL
Study concept and design	PB, KV, RvH, CV
Data analysis and interpretation	PB, KV, RvH, CV
Draft the manuscript	PB, KV
Manuscript editing and review	PB, MEL, KV, RvH, CV

Chapter 9 Segmentation into different personas, the step to tailor care after major oncological surgery?

Data collection	PB
Study concept and design	PB, KV, SB, RvH, CV
Data analysis and interpretation	PB, KV, SB, RvH, CV
Draft the manuscript	PB
Manuscript editing and review	PB, KV, SB, RvH, CV

PhD Portfolio

PHD PORTFOLIO

PhD period: 15-9-2017 – 31-5-2023

Name of PhD Supervisors: K. (Karin) Valkenet

C. (Cindy) Veenhof

R. (Richard) van Hillegersberg

Training activities	Year	Workload (ECTS)*
Courses		
Academic Writing in English course	2017	2.0
Basic course on Regulation and Organization for Clinical Investigators (BROK)	2018	1.5
John Hopkins workshop: implementing an inter-professional culture of mobility across the hospital	2018	0.6
Prognostic research	2020	1.5
BCT taxonomy training	2020	1.0
Multilevel modellen en longitudinale data-analyse	2021	4.0
Qualitative research	2022	0.5
National and international conferences		
International Congress of Physical Therapy and Oncology, Amsterdam – poster presentation	2018	0.5
Dag van de fysiotherapeut, Den Bosch – poster presentation	2018	0.3
Dag van de Fysiotherapeut, Den Bosch – poster presentation	2019	0.3
International Congress of Physical Therapy and Oncology, online – poster presentation and oral presentation	2020	0.5
European Implementation Event, online poster presentation	2021	0.3
Dag van de Fysiotherapeut, Den Bosch – oral presentation	2022	0.5
NVZF congres, Deventer – oral presentation	2022	0.5
2^{e} National prehabilitation congress, Eindhoven – poster presentation	2022	0.5
EndPJparalysis Global Summit, online - oral presentation	2022	0.3
World Physiotherapy Congres, Dubai– oral and poster presentation	2023	1.0
International Congress of Physical Therapy and Oncology, Amsterdam – focused symposium and poster pitch	2023	0.5

Meetings		
Weekly research meeting physiotherapy sciences	2017-2023	0.2
Expert and research meeting (Beweegziekenhuizen, promovendi)	2017-2023	1.0
Teaching / supervising		
Supervising students Hogeschool Utrecht (Physical Therapy, Cesar Therapy, Nursing, Art)	2017-2023	5.0
NVZF symposium ‘Ziekenhuis fysiotherapie van de toekomst’, Groningen – oral presentation	2018	0.5
Lecture NVZF-cursus Beweegziekenhuizen	2018-2020	1.0
Supervising students Avans Plus (master Oncology Physical Therapy)	2019	1.0
Supervising students University Utrecht (Physial therapy sciences)	2019-2023	5.0
Lecture Master Geriatric Physical Therapy at Hogeschool Utrecht	2019-2023	0.5
Lecture AIOS rehabilitation at De Hoogstraat	2020-2022	0.5
Lecture nurses gastro-enterology at UMC Utrecht	2023	0.1

*ECTS = 28 hours, based on the European Credit Transfer system

Dankwoord

Dankwoord

De afgelopen jaren heb ik met veel plezier gewerkt aan het project UMC Utrecht in Beweging en dit proefschrift 'Keep on Moving'. Ondanks dat promoveren en het schrijven van dit proefschrift niet mijn primaire doel was, ben ik onwijs trots op het eindresultaat. De afgelopen jaren heb ik veel geleerd van de projecten die uitgevoerd zijn op de afdelingen, op onderzoeksgebied maar vooral ook op persoonlijk vlak. Het was een mooi en leerzaam traject! Veel mensen hebben bijgedragen aan de totstandkoming van dit proefschrift, zowel patiënten, collega's, familie en vrienden. Ik ben jullie enorm dankbaar. Een aantal mensen wil ik graag in het bijzonder bedanken.

Allereerst mijn promotoren. Beste **Cindy**, dank voor je fijne begeleiding. Het vertrouwen dat je mij hebt gegeven in de afgelopen jaren maakt dat ik dit bereikt hebt. Je oprechte interesse op zowel persoonlijk- en onderzoekvlak en je waardering waren ontzettend fijn en heeft enorm bijgedragen in de ontwikkeling en groei die ik afgelopen jaren heb doorgemaakt, dank daarvoor! Beste **Richard,** dank voor je fijne begeleiding en deskundige inbreng aan mijn proefschrift. Jouw kritische vragen hebben geholpen om dit proefschrift naar een hoger niveau te brengen.

Uiteraard wil ik ook **Karin**, mijn copromotor, bedanken voor de fijne dagelijkse samenwerking in de afgelopen jaren. Je pragmatische aanpak en oplossingsgerichtheid waren ontzettend helpend als ik even niet wist hoe het verder moest. Ik heb onwijs veel van jou geleerd op allerlei fronten; van het uitvoeren van de projecten binnen UMC Utrecht in Beweging tot het doen van wetenschappelijk onderzoek. Onwijs mooi om de zorg te verbeteren in combinatie met onderzoek doen en goed om te zien wat er afgelopen jaren bereikt is in het UMC Utrecht. Ik ben daarom blij dat ik ook in de toekomst kan blijven bijdragen aan dit belangrijke onderwerp.

Daarnaast wil ik **Lotte** bedanken, wat was het fijn om gezamenlijk van start te gaan aan het avontuur van ons promotieonderzoek eind 2017. Ik vond het erg fijn samenwerken en jouw enthousiasme en voortvarendheid waren heel prettig om in de beginfase als promovendi de eerste projecten van UMC Utrecht in Beweging op te starten. Dank daarvoor! **Juul,** jij startte in 2022 als onderzoeker op het GOAL project. Super knap om te zien wat je in een jaar voor elkaar hebt gekregen. Je enthousiasme en positiviteit maken dat dit gelukt is. Dank voor de fijne samenwerking in het afgelopen jaar! **Marijke**, ook jij bedankt voor je samenwerking en openheid de afgelopen jaren. Het begon toen ik je begeleider was tijdens de afstuderen van Fysiotherapiewetenschap. Dit is overgegaan in een mooie samenwerking nu je met je eigen promotieonderzoek al een eind op weg bent, binnen hetzelfde onderwerp. Je bent altijd bereid om ideeën uit te wisselen, iets samen op te pakken of kennis uit te wisselen. Dank daarvoor!

Aan alle collega's van de **onderzoeksgroep Fysiotherapiewetenschap Utrecht**, dank voor de fijne samenwerking. In het bijzonder **Miriam, Elja en Anne,** of het nu een gezamenlijk onderzoek, congresbezoekje, lesgeven of de patiënten op de afdeling als gemeenschappelijke deler was, ik heb onze overleggen en samenwerking altijd als zeer prettig ervaren.

Beste mede promovendi 'Beweegziekenhuizen', **Hanneke, Sven, Niek, Emily en Lotte,** wat was het een fijne samenwerking met elkaar. Passie voor hetzelfde onderwerp, interesse in elkaars werk en projecten, het delen van kennis maar ook de struggels. Ieders openheid en bereidheid om samen te werken hierin is bewonderingswaardig. Ik hoop dat we elkaar nog vaak tegen komen op congressen, borrels of andere plekken en dat we elkaar mogen blijven inspireren!

Afdeling Revalidatie, Fysiotherapiewetenschap en Sport dank voor het mogelijk maken van mijn ambities om onderzoek en zorg te combineren. Het was niet altijd de makkelijkste weg, maar wel een hele waardevolle! **Folkert**, dank voor je betrokkenheid in mijn traject! De combinatie van de patiëntenzorg, onderzoek doen en een gezin thuis was soms een uitdaging, maar mede dankzij jou steun en waardering is het gelukt. Natuurlijk ons DGD team (ik schrijf het niet uit, want na al die jaren weet ik nog steeds niet waar het voor staat), dank voor fijne samenwerking de afgelopen jaren! En speciaal voor ons onco-team **Ad, Yvonne en Martine**, wat hebben we een fijn en vertrouwd clubje waar ik me in thuis voel. Ik ben trots op wat we met z'n allen allemaal doen (heel veel) en ik ben jullie erg dankbaar voor jullie flexibiliteit (ook al kwam het soms onhandig uit..), waardering en fijne samenwerking. Op nog vele fijne jaren samen!

Teamies; **Laura, Marije, Kim, Eveline, Lianne, Tessa, Elke, Rianne, Inge,** ook al volleyballen we bijna allemaal niet meer en zijn we ondertussen veranderd naar een eetclub (waar ging het mis..), hoe wij naast de serieuze dingen, met z'n allen kunnen lachen blijft ongekend. Dank voor alle leuke avondjes, of het nu beachen, padellen, eten, borrelen of wat anders was wat we bedacht hebben! Dat er nog veel gezellige avondjes mogen volgen met zijn allen!

Buurtjes, dank voor alle gezelligheid in de straat! Van uitwisseling van kleding en speelgoed tot een 'straatbootcampclubje' en borrels, er wordt van alles verzonnen. Dank voor de gezelligheid en het creëren van een plek waar ik me thuis voel.

Sanne, jeetje wat vliegt de tijd voorbij; van teammatties in Groningen tot samen weer aan de studie bij Fysiotherapiewetenschap. Nu ik dit dankwoord schrijf besef ik hoeveel we hebben meegemaakt samen en hoe dankbaar ik ben voor onze vriendschap! Mede dankzij jou begon ik aan de opleiding Fysiotherapiewetenschap. Je bent altijd ontzettend positief en ruimdenkend ingesteld en het is ontzettend fijn om samen avonturen te beleven! Dank dat je ook op deze dag, achter me wilt staan als paranimf!

Thijs en Geke, iedere woensdag staan jullie weer voor de deur om Lea en Fien alle liefde van de hele wereld te geven; er wordt oneindig geknuffeld, gepuzzeld en boekjes gelezen! Ik vind het prachtig om te zien hoe gek jullie zijn op al jullie kleinkinderen en vol overgave meegaan in het spelen en ontdekken! Jullie zijn super flexibel en staan altijd voor iedereen klaar. Heel veel dank daarvoor, ik waardeer dat enorm! **Lisette, Michel, Robert Jan en Tessa** ook jullie bedankt voor alle gezelligheid als we met het hele spul bij elkaar zijn.

Mama, dank voor je steun de afgelopen jaren. Het was soms een beetje abstract wat dat 'promoveren' en 'onderzoek doen' nou eigenlijk is, toch was je altijd geïnteresseerd en wilde je weten waar ik mee bezig was. De podcast gaf het meeste inzicht en de hits zijn waarschijnlijk verdubbeld doordat je het met iedereen deelde! Dank voor je luisterend oor en dat je altijd klaar staat en zelfs 's ochtends vroeg in de auto sprong om op Lea en Fien te passen als ze ziek waren. **Papa en Marleen** ook jullie wil ik bedanken voor jullie steun. Altijd geïnteresseerd en trots op waar ik mee bezig ben. Dat er naast een dokter Bor nu ook een doctor Bor in de familie is, is toch bewonderingswaardig. **Bart,** jou positivisme en doorzettingsvermogen is ongekend. Jij laat je niet uit het veld slaan, ook al zit het niet altijd mee. Je bent altijd in voor gezelligheid en altijd overal bij, dat waardeer ik enorm! **Herma,** de enige echte dokter Bor natuurlijk, ook al zijn we erg verschillend, toch begrijpen we elkaar. Ik ben trots op wat je hebt bereikt en hoe je in het leven staat samen met je gezin. Wanneer jullie lekker kunnen omrommelen met elkaar, zijn jullie op je best. Dank voor je steun in de afgelopen jaren en ik ben trots dat je achter me wilt staan deze dag!

Oma Bor, ook al ben je er niet meer, toch ben en blijf je een voorbeeld voor mij met je oprechte interesse, openheid en hartelijkheid. Bij jou stond voor iedereen de deur altijd wagenwijd open en voelde iedereen zich thuis.

Marco, liefste, you're simply the best! Wat een geluk heb ik met jou. Ik kan je niet genoeg bedanken voor je steun de afgelopen jaren. Bedankt dat je elke ochtend mijn ontbijt maakt. Bedankt dat je altijd bereid bent om me te helpen, of het nu een excelletje bouwen of een spelling check of 's-jes' is. Maar vooral bedankt voor je steun en luisterend oor als ik het even niet meer zag zitten of kwijt was waar ik mee bezig was. Je wist het altijd weer te relativeren. Je geloof en oneindige vertrouwen in mij maakt dat ik dit allemaal heb bereikt. Je bent mijn stabiele basis, fijnste thuis en samen zijn we op ons best. Ik waardeer enorm wat je allemaal doet en je bent de allerliefste papa van de hele wereld. Ik hou van jou!

Lieve **Lea** en **Fien**, wat ben ik dankbaar dat jullie mijn meisjes zijn. Jullie zien opgroeien en ontwikkelen maakt me onwijs trots. Heerlijk en zeer relativerend om jullie te horen kletsen en zingen en te zien hoe jullie de wereld ontdekken! Op nog heel veel mooie avonturen met zijn 4-tjes. Jullie zijn het allerbelangrijkste!

UMC Utrecht

Universiteit Utrecht

ISBN 978-94-6469-644-8