Improving physical activity during hospital stay

Towards bridging the research-practice gap

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Chapter 1

General introduction

Mrs. Petersen, a 69-year old woman, is lying in bed with a fever in the nearby hospital. Five days ago she was admitted through the emergency ward with a mitral valve insufficiency. The mitral valve should be replaced, but due to a fever, surgery could not be performed. Instead, Mrs. Petersen was admitted to the Cardiology ward for antibiotic treatment.

A week went by as Mrs. Petersen's fever slowly diminished. During this time, breakfast, lunch, and dinner were all brought to Mrs. Petersen, and restraints such as IV-lines and the urinary catheter ensured that she didn't feel the need to get out of bed. Once a day, Mrs. Petersen had to get out of bed for at least half an hour, during which she used to sit next to bed staring out of the window. The longer her hospital stay took, the more help Mrs. Petersen needed to get out of bed and the more discussions with nurses it took to motivate her to ambulate. Based on these observations the nurses, physical therapists, and physicians started to wonder: What can we do to prevent such physical deconditioning in patients like Mrs. Petersen?

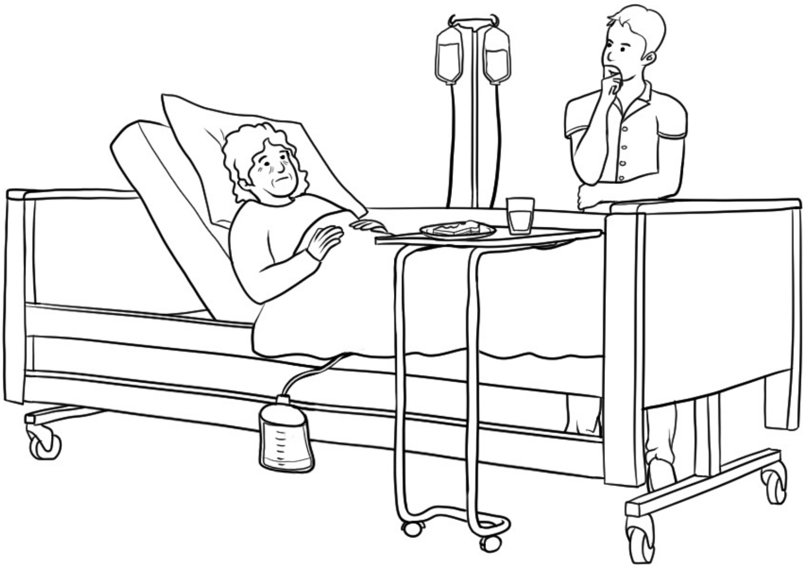

Figure 1. Mrs. Petersen during hospital stay

The studies in this thesis aim to better understand how routine hospital care can be changed in a way that patients like Mrs. Petersen stay physically active and thus avoid physical deconditioning during hospital stay.

In the Netherlands – as in the rest of the world – the general population is aging [1,2]. The number of adults aged 60 years and older is expected to double by 2050 [3]. The aging of the population is accompanied by an increase in prevalence of multi-morbidity and frailty [4-6], resulting in a larger number of adults who need to be admitted to a hospital when they become ill [7-9].

At the same time, advancements in healthcare and decentralization in the Dutch health sector have resulted in a substantial decrease in length of hospital stay while the number of hospital admissions remained stable [3,10]. Decreasing the length of hospital stay proved to be beneficial for improving functional performance, decreasing mortality, and reducing costs [11]. Nonetheless, hospitalization in adult patients continues to pose a high risk on adverse outcomes such as functional decline [12-14], with recent research showing that many of these adverse outcomes might be avoided by being physically active during hospital stay [15-19].

Physical (in)activity during hospital stay

Physical activity can be defined as 'any bodily movement produced by skeletal muscles that results in energy expenditure' [20]. Physical activity increases the physiological demands of the human body. For instance, regular physical activity causes the muscle capillary perfusion, muscle strength, muscular endurance, bone density, and exercise tolerance to increase, while it helps to decrease factors such as body weight and blood pressure [21]. Moreover, the cardiorespiratory system, muscle and bone metabolism, and various other metabolic processes are affected in a way that counteracts the negative effects caused by physical inactivity. These changes lead to better physical performance, more independence in activities of daily living (ADL), and better ability to participate in social activities. As a result, several national and international guidelines have been developed that advice adults, healthcare professionals, and policymakers on the frequency and content of physical activity in the general population [22,23]. There are no guidelines for adults who are hospitalized, but it is known that higher physical activity levels during hospital stay are associated with better outcomes, such as: better functional performance at discharge [24], better functional performance at 1-month follow-up [24], less impairments in instrumental ADL [24], shorter length of hospital stay [25], and lower readmission rates [26].

However, two recent reviews assessing the amount of physical activity in hospitalized adult patients revealed that patients rarely perform any physical activity during hospital stay [27,28]. The authors of one of these studies estimated that hospitalized patients spent 87-100% of their time during the day either lying in bed or sitting still in a chair [27]. When assessed for 24-hours using accelerometers, hospitalized patients were observed to be standing or walking for an estimated 70 minutes a day (95%CI = 57-83); however, this review also observed substantial heterogeneity between studies [27]. Although the exact amounts of physical activity highly depend on the measurement methods used and type of hospital ward, these reviews showed that there is consistent evidence that hospitalized patients are mostly physically inactive during their hospital stay [27,28]. Furthermore, very low levels of physical activity were found in hospitalized adult patients of all ages and despite their independence in mobility [29,30].

Hospitalization-associated physical deconditioning

In contrast to the positive health outcomes related to in-hospital physical activity, physical <u>in</u>activity is one of the three main reasons for acquiring hospitalization-associated physical deconditioning. The other two are the presenting illness and malnutrition. While the presenting illness results in a catabolic state with high amounts of inflammatory cytokines and glucocorticoids [31,32], physical inactivity ensures a mitochondrial dysfunction and lack of neural activation [33,34], both leading to muscle atrophy, which has been observed in healthy adults [35] and older hospitalized patients [36]. Malnutrition further aggravates the physical deconditioning and muscle atrophy by providing deficiencies in the energy and protein supply [37], causing bodies to start muscle wasting to support their need of energy and proteins. Moreover, the stress response caused by an acute illness, injury, trauma, and surgery may further derange these physiological processes related to physical deconditioning [38].

Although physical deconditioning can occur in all hospitalized patients, the consequences for certain patient groups are particularly significant. In adults with already compromised muscle mass and function – also referred to as sarcopenia [39] – hospitalization-associated physical deconditioning may superimpose and accelerate the process of muscle loss [40,41]. Furthermore, hospitalization-associated physical deconditioning in older patients can result in physical impairments that limit them in performing ADL, also described as hospitalization-associated disabilities (HADs) [42]. A recent systematic review showed that almost one in three hospitalized older patients leave the hospital with a HAD (prevalence = 30% [95%CI: 24-33%]) [14]. Acquiring such HAD has tremendous consequences for the older patient, as it often results in long-term adverse outcomes such as permanent physical impairments in ADL, increased length of hospital stay, increased risk of institutionalization, and increased mortality [43-45].

Physical activity as a modifiable factor

A recent study accounting for various patient-related risk factors revealed that physical inactivity during hospital stay is one of the strongest correlates to physical deconditioning in hospitalized patients [19]. Moreover, physical activity intervention studies showed that improving physical activity can be effective in decreasing the amount of time patients spent sedentary during hospital stay [46,47], improving physical performance [48,49], preventing HADs [50,51], preventing pulmonary complications [49,52], improving quality of life [48], decreasing length of hospital stay [49,53-56], increasing the number of discharges to home [46,47], and decreasing the number of readmissions [55]. Together, these findings suggest that physical activity during hospital stay is a modifiable factor that can prevent hospitalization-associated physical deconditioning and thereby many related negative patient outcomes [15-17]. Nevertheless, recent studies continue to report very low in-hospital physical activity levels [27,28], patients are still reflexively put to bed when admitted to a hospital [57], and the hospital bed remains to be a centerpiece in current clinical care [58-60]. There is therefore a discrepancy between what is known from the literature to be effective in preventing hospitalization-associated physical deconditioning and what actually happens in a hospital.

Identifying hospitalized patients who are physically inactive

Identification of physically inactive patients during routine hospital care is the first step to improve physical activity in hospitalized patients. The best way to do this is to use measurement instruments that validly and reliably measure physical activity in terms of intensity, duration, and frequency, as well as activity type [61-63]. Various types of instruments to measure physical activity currently exist, including observations, questionnaires, diaries, calorimetry, and motion sensors (e.g., accelerometers, heart rate monitors, and pedometers) [64]. Of these instruments, tri-axial accelerometers have proven to be the most valid measurement tools to assess physical activity objectively, longitudinal, and continuously during hospital stay [65-67]. However, the downside of accelerometers is that they are difficult to implement in routine hospital care due to the relatively high costs, the high number of technical requirements that need to be accounted for (e.g., limited data storage or battery) [68], and the limited willingness of patients to wear them during hospital stay [65,69,70]. Thus, more knowledge on alternative, easier-to-implement methods to identify physically inactive patients during routine hospital care is currently needed.

One method is to systematically assess the factors associated with physical inactivity. Therefore, several studies have investigated the factors associated with physical activity in hospitalized older patients and identified a low level of pre-hospitalization cognitive functioning, low level of pre-hospitalization physical functioning, a history of falls, polypharmacy, use of medical equipment, and use of walking aids to be associated with physical inactivity [18,71-74]. Only one study assessed the factors associated in hospitalized adult patients of all ages, but was limited in their statistical model due to a small sample size [75]. Since hospitalization-associated physical deconditioning due to physical inactivity may affect hospitalized adult patients of all ages, more research incorporating larger sample sizes is indicated to examine more factors associated with physical inactivity.

Previous research highlighted that the degree to which patients are independent in basic mobility activities should be considered as one of these factors [71,75,76]. To systematically assess this factor in routine hospital care, the John Hopkins Hospital developed the Activity Measure for Post-Acute Care (AM-PAC) “6-clicks” Basic Mobility short form [77]. The advantage of this tool is that it is valid, reliable and easy-to-use by both nurses and physical therapists [77-79]. However, a Dutch version of this tool is currently lacking.

Another method to identify physically inactive patients during routine hospital care is to systematically assess the level of mobilization (i.e., what a patient has actually done). Therefore, the John Hopkins Hospital developed the 8-point ordinal John Hopkins Highest Level of Mobility (JH-HLM) scale. By implementing this valid and reliable scale as a tool to assess, document, and discuss mobilization on a daily basis in routine hospital care, the John Hopkins Hospital was able to increase the frequency of ambulation and reduce length of stay in two General Medicine Units [54,79]. Furthermore, the JH-HLM was not perceived as a burden by healthcare professionals and appears to be easy-to-implement using education, integration in the Electronic Medical Record (EMR), and low-cost tools such as whiteboards [80]. However, whether this tool can adequately be used in other patient groups such as surgical patients is unknown.

Understanding why hospitalized patients are physically inactive

The second step to improve physical activity in hospitalized patients is to understand why they are physically inactive. Many different factors influence physical activity behavior, making it a dynamic and complex process [81,82]. Factors perceived as limiting, or factors that negatively affect behavior are referred to as barriers [83,84]. Several studies have assessed the barriers to physical activity during hospital stay in various groups of hospitalized patients and showed that numerous barriers are being perceived by hospitalized patients [60,76,85-87]. Examples of such barriers are: feeling unwell, fear of falling, functional restraints, weakness, lack of assistive devices, and the inactivating hospital environment. In contrast, factors perceived as facilitating, motivating, or factors that positively affect behavior are often referred to as enablers [88]. Examples of such enablers in hospitalized patients are: an enabling environment, strong basic nursing care, more knowledge, and the ability to ambulate independently [85-87].

Moreover, as healthcare professionals have an important role in supporting and encouraging hospitalized patients to be physically active, it is also important to consider the healthcare professionals' perspectives to improving physical activity in hospitalized patients. Many studies have assessed these barriers and enablers in a wide variety of patient populations and revealed that numerous barriers and enablers might influence healthcare professionals on a daily basis [89-92].

Given the wide variety of barriers and enablers reported in the literature and the substantial number of articles that investigated the barriers and enablers to physical activity during hospital stay, it is difficult to determine which barriers need to be addressed and which enablers should be used when healthcare professionals aim to improve physical activity in hospitalized patients. Therefore, a comprehensive overview identifying all the factors influencing the behavior of hospitalized patients and healthcare professionals with regard to physical activity during hospital stay is needed. In addition, where the evidence on the various barriers to physical activity during hospital stay is substantial [60,76,86,87,89-92], there is little evidence which of these barriers might be key and what would help patients and healthcare professionals to overcome such barriers.

Improving physical activity in hospitalized patients through implementation of a multifaceted intervention

The third step is to implement a tailored intervention to improve physical activity in hospitalized patients who are physically inactive. Recent evidence suggested that interventions improving physical activity during hospital stay need to be multifaceted to be able to adequately address the complex phenomenon causing physical inactivity during hospital stay [93]. Such multifaceted interventions are interventions with two or more intervention components and are commonly viewed as more effective in changing behavior than single-component interventions [94]. The content of these intervention components strongly depends on the barriers and enablers perceived in local clinical care and are therefore ideally selected and implemented in close collaboration with local patient representatives and healthcare professionals [93]. Various multifaceted interventions reported positive effects regarding the time patients spent lying in bed and sitting [46,47], mobility levels [54], functional decline [51], length of hospital stay [47,54], and discharge home [46,47]. However, to date little is known as to whether and how such a multifaceted intervention might ultimately lead to improved physical activity levels during hospital stay and better patient outcomes.

In 2017, we received an innovation grant from the Amsterdam University Medical Centers (Amsterdam UMC) location Academic Medical Center – a tertiary university 1004-beds hospital in the Netherlands – to implement a multifaceted intervention, called "Better By Moving", to improve physical activity during hospital stay in collaboration with local patient representatives and healthcare professionals. We assumed that a comprehensive outcome and process evaluation would provide important information needed to understand whether and how such a multifaceted intervention might result in improved physical activity during hospital stay, less time spent lying in bed, shorter length of hospital stay, and more patients being discharged home.

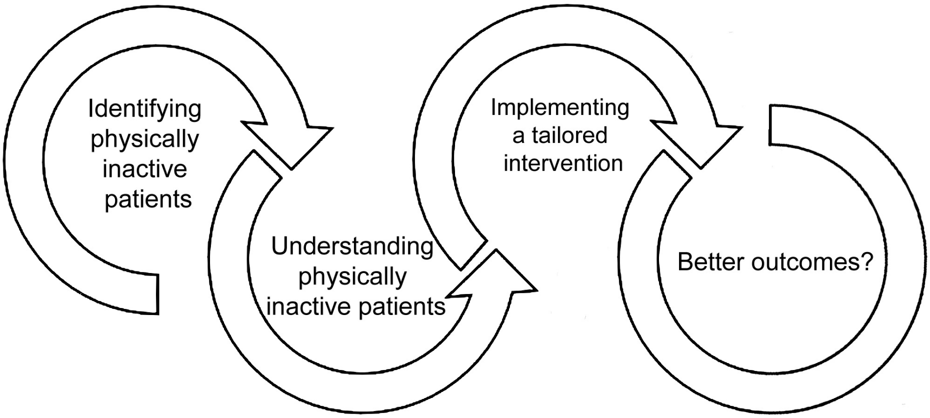

Figure 2. A summary of the step-by-step approach central to this thesis

Aim and outline of this thesis

The general aim of this thesis is to expand knowledge on how to improve physical activity in hospitalized patients. This knowledge contributes to bridging the gap between knowing that physical activity during hospital stay can help prevent hospitalization-associated physical deconditioning and current clinical practice. The studies in this thesis focus on the aforementioned three steps.

In **part I** of this thesis, the studies aim to expand knowledge on how to identify physically inactive patients during routine hospital care. Two easy-to-implement methods will be explored: systematically assessing the factors associated with physical inactivity and systematically assessing the level of mobilization.

Chapter 2 describes the association between factors that can be systematically assessed during routine hospital care and physical inactivity in a large sample of hospitalized adults of all ages.

Chapter 3 outlines how we translated the Activity Measure for Post-Acute Care (AM-PAC) “6-clicks” Basic Mobility short form from English to Dutch. Moreover, chapter 3 describes the construct validity and inter-rater reliability of the Dutch AM-PAC “6-clicks” Basic Mobility short form in assessing the level of independence in basic mobility in Dutch hospitalized adult patients. The level of independence in basic mobility should be considered as a factor associated with physical inactivity, but no tools to systematically assess this factor for patient identification are yet available in routine Dutch hospital care.

Chapter 4 describes our experience with the use of the John Hopkins Highest Level of Mobility (JH-HLM) scale to systematically assess the level of mobilization after gastrointestinal and oncological surgery.

In **part II** of this thesis, the studies aim to expand our understanding why patients are physically inactive during hospital stay.

Chapter 5 contains a scoping review of all patient- and healthcare professional-reported barriers and enablers to physical activity during hospital stay published in previous literature.

Chapter 6 describes the healthcare professionals' perspectives on key barriers to improving physical activity in hospitalized patients and on solutions to overcome these key barriers.

In **part III** of this thesis, the studies aim to better understand whether and how multifaceted interventions might result in improved physical activity levels during hospital stay and better patient outcomes

Chapter 7 describes the study protocol of Better By Moving (BBM), a multifaceted intervention to improve physical activity in adults admitted to the Amsterdam UMC in the Netherlands.

Chapter 8 describes the implementation of BBM on two gastrointestinal and oncological surgery, one hematology, one infectious diseases, and one cardiology hospital ward of the Amsterdam UMC in the Netherlands. Through the use of a mixed-methods evaluation study design, the effectiveness and process will be evaluated.

Chapter 9 describes the main findings, methodological considerations, clinical recommendations and future perspectives. A summary in English and Dutch will conclude this thesis.

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Part I

Identifying hospitalized patients who are physically inactive

Chapter 2

Physical dependence and urinary catheters both strongly relate to physical inactivity in adults during hospital stay: a cross-sectional, observational study

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Abstract

Purpose

To determine which factors are associated with physical inactivity in hospitalized adults of all ages.

Methods

A cross-sectional sample of 114 adults admitted to a gastrointestinal surgery, internal medicine or cardiology hospital ward (median age 60, length of stay 13 days) were observed during one random day from 8 am to 8 pm using wireless accelerometers and behavioral mapping protocols. Factors (e.g., comorbidities, self-efficacy, independence in mobility, functional restraints) were collected from medical records, surveys, and observations.

Results

Patients were physically active for median (IQR) 26 (13-52.3) min and were observed to lie in bed for 67.3%, sit for 25.2%, stand for 2.5%, and walk for 5.0% of the time. Multivariable regression analysis revealed that physical inactivity was 159.87% (CI = 89.84; 255.73) higher in patients dependent in basic mobility, and 58.88% (CI = 10.08; 129.33) higher in patients with a urinary catheter (adjusted $R^2 = 0.52$). The fit of our multivariable regression analysis did not improve after adding hospital ward to the analysis ($p > 0.05$).

Conclusions

Independence in mobility and urine catheter presence are two important factors associated with physical inactivity in hospitalized adults of all ages, and these associations do not differ between hospital wards. Routine assessments of both factors may therefore help to identify physically inactive patients throughout the hospital.

Keywords

Hospital; exercise; mobility; physical activity; behavioral mapping; factors

Implications for rehabilitation

- Healthcare professionals should be aware that physical inactivity during hospital stay may result into functional decline.
- Regardless of which hospital ward patients are admitted to, once patients require assistance in basic mobility or have a urinary catheter they are at risk of physical inactivity during hospital stay.
- Implementing routine assessments on the independence of basic mobility and urine catheter presence may therefore assist healthcare professionals in identifying physically inactive patients before they experience functional decline.

Introduction

Physical inactivity during hospital stay is a large problem, and in elderly patients this has been associated with hospitalization-associated functional decline [1-4]. In turn, hospitalization-associated functional decline leads to prolonged length of hospital stay and increased mortality [5]. Given that hospitalization-associated functional decline occurs frequently and is not limited to adults aged 60 and older [6-9], more emphasis on preventing functional decline is paramount.

Interventions that increase in-hospital physical activity have proven to be effective in preventing hospitalization-associated functional decline [10-12]. These interventions have also proven to be effective in reducing the length of stay [13,14], improving the level of independence in daily activities [15,16], and improving the likelihood of returning home [5,15]. Still, many hospitalized patients continue to spend the most time in bed and barely spend time physically active [13,17-20]. If we can identify these physically inactive patients, we might be able to better translate effective interventions increasing in-hospital physical activity into local intervention strategies.

Previous studies have identified a history of falls [13], use of medical equipment [19], use of walking aids [19], low level of pre-admission mobility [13], low level of pre-admission cognitive function [18], and low level of physical function during admission [16,18] to be associated with physical inactivity in hospitalized patients; however, these studies solely focused on older hospitalized patients. Two recent studies quantified the physical activity levels of hospitalized adults of all ages admitted to a variety of hospital wards [17,21], and only one of those studies also examined the factors associated with physical inactivity in adults [21]. This study identified in a sample of n = 39 that pain levels, functional independence and functional restraints are related to time lying in bed during the day [21]. If, however, the factors associated with physical inactivity are assessed in a larger sample of hospitalized adults of all ages, we may be able to examine more factors related to physical inactivity. This might provide healthcare professionals with more guidance on how to optimally identify physically inactive adults of all ages in clinical care.

To our knowledge, no larger studies have investigated the factors associated with physical inactivity in hospitalized adults of all ages while taking into account the case mix of gastrointestinal surgery, internal medicine and cardiology hospital wards. To this end, this study conducted a thorough assessment of the physical activity levels at five hospital wards at a university hospital in Amsterdam and aimed to answer the following primary research question: Which factors are associated with physical inactivity in hospitalized adults of all ages?

Materials and methods

Study design

This cross-sectional, observational study was conducted in five hospital wards – two gastrointestinal surgery, internal medicine haematology, internal medicine infectious diseases, and cardiology – at Amsterdam University Medical Centres (Amsterdam UMC) - location Academic Medical Centre, a 1002-bed tertiary university hospital in Amsterdam. Each hospital ward had nursing-to-patient ratios of 1:3 or 1:4, depending on the patients' acuity. Allied health staffing consisted of 0.5-1 physiotherapists to each hospital ward. The Medical Ethical Review Committee of the Amsterdam UMC assessed and approved this study (reference number W17_479 # 18.003), and this study has been conducted according to the principles of the Declaration of Helsinki. Participants gave verbal and written informed consent to participate in the study. The study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.

Participants

Patients in this study were admitted at the gastrointestinal surgery ward for acute or elective gastrointestinal surgery (including re-admissions due to postoperative complications), at the haematology ward for investigations and treatment of blood or bone marrow disorders, at the infectious diseases ward for a variety of medical conditions (e.g., pneumonia, complicated infections), and at the cardiology ward for the diagnostics and treatment of heart disorders. Patients were included during an audit at the two gastrointestinal surgery wards between 15 January 2018 and 11 February 2018, at the haematology and infectious diseases wards between 13 August 2018 and 9 September 2018, and at the cardiology ward between 29 April 2019 and 26 May 2019. Inclusion criteria were: aged 18 and older, able to make an active independent bed-chair transfer before hospitalization, Dutch or English speaking and reading proficiency, and admission for more than 24 h. Patients with obligatory bed rest, expected to be discharged before noon on the day of observation, delirious on either the day of inclusion or observation and those receiving end-of-life care were excluded. Patients were observed from 8 am to 8 pm on either a weekday or a weekend day. One or two days before each day of observation, a random sample of hospitalized patients was approached to participate. The selection of potential participants was performed using a computer-generated list based on the room number. In the case of refusal, the investigator approached the patient in the next hospital room on the computer-generated list.

Outcome measures

Physical activity

Wireless accelerometers (Physical Activity Monitor (PAM) AM400, PAM BV, Oosterbeek, The Netherlands, 2018) were used to measure the total amount of physical activity in minutes objectively ($>$ 1.4 Metabolic Equivalent Tasks (METs) [22]) between 8 am and 8 pm. Also, the PAM compares each second of physical activity with the following three pre-defined intensity zones: light physical activity intensity (1.4-3.0 MET), moderate physical activity intensity (3.0-7.0 MET), and vigorous physical activity intensity ($>$7.0 MET), and measures the derivative of calculated energy expenditure for 24 h physical activity (PAM-score). The PAM is a 2 cm wide coin, water-proof, and was attached to the ankle. The PAM contains a sensor with sensitive elements in all three directions (x, y, and z), measures accelerations 10 times per second and integrates it to one second. The number of time accelerations were measured above $>$ 1.4 MET were accumulated to the total amount of physical activity in minutes. Each of these accelerations was also converted to the PAM-score, representing the ratio of the energy spent according to METs compared resting metabolism (PAM-score $=$ (METs – 1) $\times$ 100 averaged over the day). The validity and reliability of the PAM in healthy adults is moderate-to-good in assessing the estimate of energy expenditure [23,24].

Behavioural mapping protocols were used in which structured observations revealed the percentage of time patients spent at each type of activity (i.e., lying, sitting, standing, walking) and location in the hospital (i.e., hospital room, hallway, not observed) [17]. In detail, participants in each room were observed for a 1-min period every 10 min. This way, every participant was observed 72 times. The observations were performed by trained physical therapy graduate students using a predetermined set of mutually exclusive levels of activity (lying in bed, sitting on the edge of the bed or chair, making a transfer from bed to chair or standing, walking, or using the ergometer) and locations (patient room, toilet/bathroom, hallway, lounge, other). For an equal amount of time during the minute of observation, the activity with the highest intensity was recorded. The observations were directly recorded in the online Castor Electronic Data Capture database (Ciwit BV, Amsterdam, The Netherlands, 2018).

Factors

We collected demographic information from medical records. In addition, we used the medical records to assess the type of admission (i.e., acute or elective), to identify whether the participant had surgery during current hospital admission, to assess the number of comorbidities using the Charlson Comorbidity Index (CCI) [25], and to calculate the number of days between the day of admission and observation (i.e., as a derivative of length of hospital stay). We also extracted the Katz-ADL score, which describes the level of independence in ADL 2-weeks preadmission and ranges from 0 (completely ADL dependent) to 6 (completely ADL independent) [26]. On the day of observation, we used the Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility short form to assess the level of independence in basic mobility and the AM-PAC "6-clicks" Daily Activity short form to assess the level of independence in ADL [27,28]. Both contain six items, which are scored on a scale of 1 (unable to do or total assistance required) to 4 (no assistance required). The first five questions of the AM-PAC "6-clicks" Basic Mobility were used to distinguish between patients not requiring any help (score = 20/20) with basic mobility activities and patients requiring assistance (score < 20). Muscle strength was assessed by measuring handgrip strength using the JAMAR handheld-dynamometer [29,30]. Using a survey, we assessed the patients' perceived self-efficacy related to mobility using seven questions (i.e., getting out of bed, getting out of a chair, showering, walking stairs, walking in the neighbourhood, doing the groceries and going to a social activity) which was be scored using a five-point Likert scale (0 to 4) and ranged from 0 (minimal) to 28 (maximal). We used the Short Falls Efficacy Scale-International (Short FES-I) to derive these seven mobility-related self-efficacy questions [31]. Lastly, the number of functional restraints (i.e., drains, urine catheter, IV-lines, hospital isolation precautions) was assessed by direct observation.

Data analysis

All analyses were conducted using IBM-SPSS Statistics version 25 (IBM Corp, Armonk, New York). Descriptive data are given as means with standard deviations (SD) or medians with interquartile ranges (IQRs). Normality was evaluated by visually inspecting histograms and Q-Q plots. Multiple imputations was used to impute missing factors. Frequency distributions and summary statistics were used to summarize the accelerometer data of all participants and for each hospital ward individually. Data of patients who wore the PAM during the entire observation period (8 am-8 pm) was used. Frequency distributions and summary statistics were also used to calculate the number of times a patient was observed at each possible location and type of activity. We used these to calculate percentages of time spent patients spent between 8 am and 8 pm per observed item.

To explore which factors were associated with physical inactivity, a univariable linear regression analysis was used to evaluate the relationship between the total number of minutes of physical activity and patient factors (e.g., age, type of admission), hospital ward, physical performance measures, and functional restraints. Based on the univariable linear regression analyses results, we performed a multivariable regression model to test if age, surgery, IV-lines, urine catheter, independence in basic mobility, and mobility-related self-efficacy were associated with physical inactivity. Independence in ADL was omitted from the multivariable regression model due to collinearity with independence in basic mobility. In addition, the influence of the hospital ward was evaluated using a mixed linear model; however, no improved fit ($p > 0.05$) was observed. All parameter estimates were expressed with a 95% confidence interval (CI). Because of the residuals' non-normally distribution, we performed a natural logarithmic transformation of the dependent variable before performing the regression models. To be able to interpret the amount of change for each variable within the multivariable regression model, we transformed the regression coefficients (β), to change percentages using: change percent = 100(e ^ (β) – 1).

Results

One hundred and forty-eight patients were considered for inclusion. Of those, 16 patients did not meet the inclusion criteria, and 18 patients declined to participate. This resulted in 114 patients divided over the 5 wards (Figure 1).

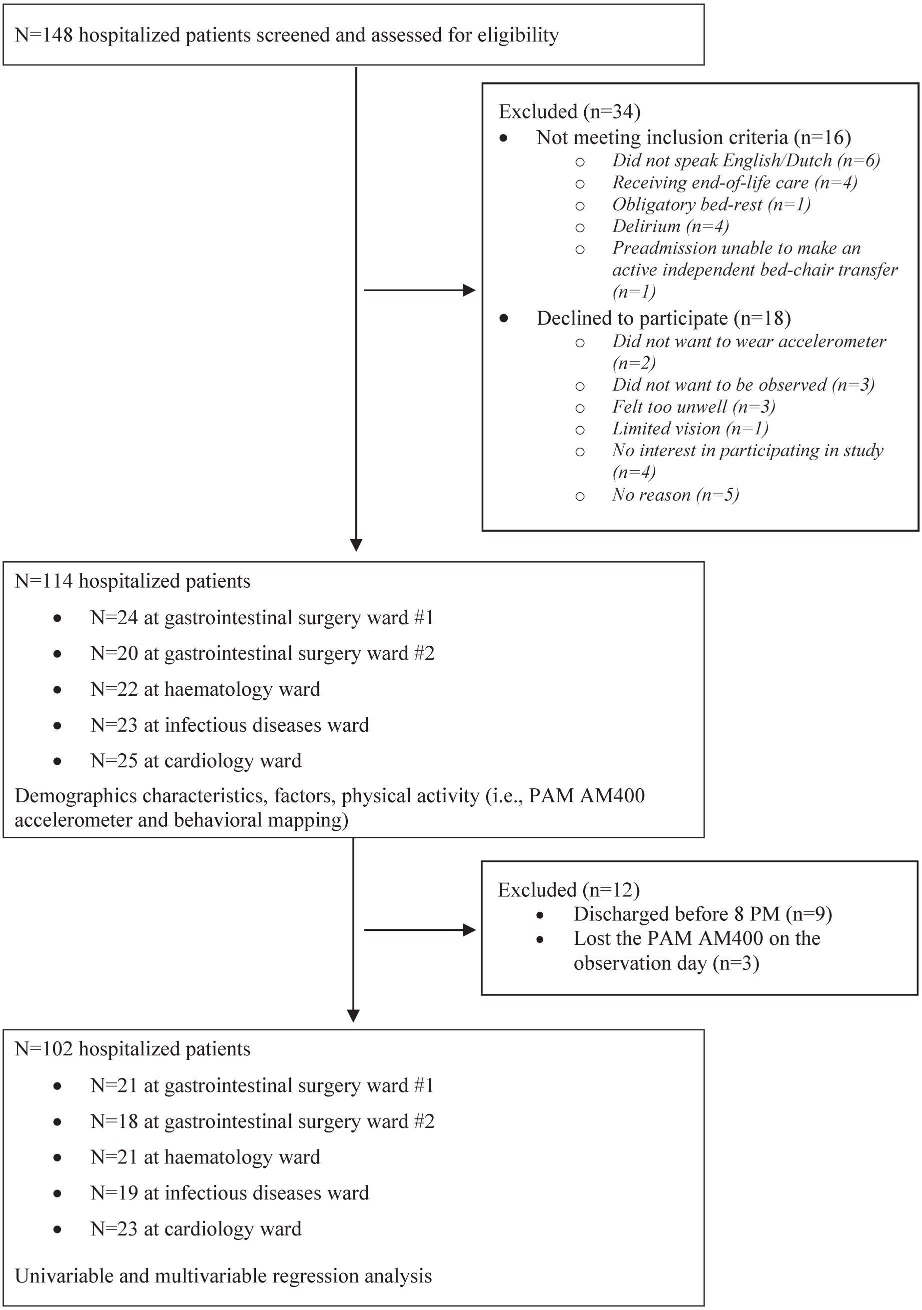

Figure 1. Flow diagram showing inclusion of participants

Nine patients were discharged before 8 pm, and three patients lost the accelerometer during the day of observation. Eighty-three patients were observed on a weekday and 31 patients on a weekend day. The median (IQR) age of the included sample was 60 (46.8-70.3), and 72 (63.2%) were male. The median (IQR) length of stay was 13 days (8-25) days. The observation day was performed at median (IQR) 8 (3-14.5) days after admission to the hospital. Of the 114 patients, 96 (84.2%) patients were completely independent in basic ADL (Katz-ADL score = 0/6) before hospitalization. One hundred-and-three (90.4%) had at least one tether (i.e., IV-line, drain). Seventy-four (64.9%) patients were observed to be independent in basic mobility (AM-PAC "6-clicks" Basic Mobility short form questions 1-5 = 20). All demographics and factors are presented in Table 1. Hospital ward specific presentation of the demographics and factors can be found in Supplemental Online Material S1.

Table 1. Demographic characteristics and factors

	All hospitalized patients n = 114
Demographic characteristics	
Age (years), median (IQR)	60 (47-70)
Length of stay (days), median (IQR)	13 (8-25)
Female, n (%)	42 (36.8%)
Pre-admission living situation, n (%)	
Alone	42 (36.8%)
Partner	67 (58.7%)
Caregiver	1 (0.9%)
Rehab center	1 (0.9%)
Nursing home	1 (0.9%)
Missing	2 (1.8%)
Discharge destination, n (%)	
Home	101 (88.6%)
Rehab center	4 (3.6%)
Nursing home	1 (0.9%)
Secondary hospital	5 (4.4%)
End-of-life care center	1 (0.9%)
Died	2 (1.8%)
Unplanned readmission < 3 months, n (%)	34 (30.4%)

Factors	
Admission-day of observations[a], median (IQR)	8 (3-14.5)
Acute admission, n (%)	68 (59.6%)
Surgery during admission, n (%)	48 (42.9%)
Charlson Comorbidity Index, median (IQR)	3 (1-6)
Preadmission ADL-impairment[b], n (%)	16 (14%) (missing n = 5)
Muscle strength (kg)[c], mean (SD)	30.89 (14.18)
AM-PAC Basic Mobility[d], median (IQR)	24 (21.5-24)
Independent in basic mobility[e], n (%)	40 (35.1%)
AM-PAC Daily Activity[f], median (IQR)	24 (21-24) (missing n = 1)
Mobility-related self-efficacy score[g], median (IQR)	23 (18.75-27) (missing n = 6)
IV-lines, n (%)	
0	12 (10.5%)
1	68 (59.6%)
2	21 (18.4%)
3	10 (8.8%)
4	3 (2.6%)
Drains, n (%)	
0	79 (69.3%)
1	19 (16.7%)
2	12 (10.5%)
3	3 (2.6%)
4	1 (0.9%)
Presence of urine catheter, n (%)	30 (26.3%)
Hospital isolation precautions, n (%)	
None	99 (86.8%)
Contact	12 (10.5%)
Contact + airborne	3 (2.7%)

IQR: Interquartile range; SD: standard deviation; kg: kilograms; [a]Number of days between the day of admission and day of observation; [b]Measured using the Katz-ADL; [c]Hand-held dynamometer; [d]Activity Measure for Post-Acute Care “6-clicks” Basic Mobility score; [e]Using questions 1-5 AM-PAC Basic Mobility short form; [f]Activity Measure for Post-Acute Care “6-clicks” Daily Activity short form; [g]maximal self-efficacy score = 28.

Level of physical activity

Patients were physically active for a total number of median (IQR) 26 (13-52) min during the 12-h observation period. When divided over the three intensity zones, patients were physically active with light intensity for median (IQR) 21 (11-36) min, moderate for 4 (2-13) min, and vigorous for 0 (0-0) min. The median (IQR) PAM-score was 2.34 (1.30-5.40). The total number of minutes physical activity in patients observed on a weekday was median (IQR) 24 (12-50), compared to 27 (14-62) on a weekend day. Hospital ward specific presentation of the accelerometer data can be found in Supplemental Online Material S2.

There were 7095 observations of a type of activity and location (median 67 per patient, IQR 62-70). Patients were observed to lie in bed for mean (SD) 67.3% (23.5), sitting 25.2% (19.9), standing/transfer 2.5% (2.6), and walking/ergometer 5.0% (5.6) of the time. Additionally, patients were observed to spend 92.7% (11.3) of their time at the patient room, 1.6% (2.0) at the toilet/bathroom, 2.7% (4.2) at the hallway, 2.6% (7.3) at the patient lounge and 0.4% (1.6) at unspecified locations (e.g., medical examination rooms). Hospital ward specific presentation of the behavioural mapping data can be found in Supplemental Online Material S3.

Factors associated with physical inactivity

In the univariable regression analyses, higher age, being admitted to surgery ward #2, having surgery during admission, more IV-lines, a urine catheter, dependence in basic mobility and ADL on the day of observation and less mobility-related self-efficacy were all significantly ($p < 0.05$) associated with more physical inactivity. Multivariable regression analysis revealed that being dependent on basic mobility on the day of observation and having a urinary catheter were the only two predictors that were significantly associated with physical inactivity (Table 2).

The overall fit of the multivariable regression model was adjusted $R^2 = 0.52$ ($p < 0.001$). We found that physical inactivity is 159.87% (CI 89.84-255.73) higher in patients who are dependent on basic mobility. We also found that physical inactivity is 58.88% (CI 10.08-129.33) higher in patients with a urinary catheter.

Table 2. Linear regression with factors associated with physical inactivity (ln[physical activity in minutes]) using the imputed dataset.

	Univariable			Multivariable		
	Regression coefficient (β)			Regression coefficient (β)		
Independent variable	Estimate	95% CI	*p* value	Estimate	95% CI	*p* value
Age	0.011	0.000 to 0.022	0.041	0.004	-0.004 to 0.012	0.359
Hospital ward						
Gastrointestinal surgery #1	0.297	-0.227 to 0.822	0.263	-	-	-
Gastrointestinal surgery #2	0.762	0.216 to 1.309	0.007	-	-	-
Haematology	-0.221	-0.745 to 0.303	0.405	-	-	-
Infectious diseases	0.344	-0.195 to 0.882	0.209	-	-	-
Cardiology[a]	-	-	-	-	-	-
Number of days already admitted before observation	0.011	0.000 to 0.022	0.051	-	-	-
Acute admission	0.155	-0.219 to 0.529	0.416	-	-	-
Surgery during admission	0.445	0.084 to 0.807	0.016	-0.019	-0.343 to 0.306	0.910
Comorbidities[b]	0.022	-0.045 to 0.088	0.523	-	-	-
Preadmission ADL-impairment[c]	0.400	-0.097 to 0.898	0.155	-	-	-
Muscle strength[d]	-0.011	-0.024 to 0.001	0.084	-	-	-
Independent in basic mobility[e]	-1.250	-1.539 to -0.961	< 0.001	-0.955	-0.641 to -1.269	< 0.001
Independence in ADL[f]	-0.162	-0.207 to -0.117	< 0.001	-	-	-
Mobility-related self-efficacy score	-0.054	-0.082 to -0.026	< 0.001	-0.023	-0.047 to 0.002	0.067
Number of IV-lines	0.306	0.105 to 0.507	0.003	0.157	-0.046 to 0.315	0.144
Number of drains	0.197	-0.007 to 1.931	0.058	-	-	-
Presence of urine catheter	0.887	0.525 to 1.250	< 0.001	0.463	0.096 to 0.830	0.014
Presence of hospital isolation precautions	0.423	-0.140 to 0.985	0.141	-	-	-

CI: Confidence interval; [a]Cardiology hospital ward has been used as reference; [b]Using the Charlson Comorbidity Index; [c]Using the Katz-ADL; [d]Using the hand-held dynamometer; [e]Using questions 1-5 Activity Measure for Post-Acute Care (AM-PAC) Basic Mobility; [f]Activity Measure for Post-Acute Care (AM-PAC) Daily Activity short form.

Discussion

This cross-sectional observational study illustrated that adults of all ages admitted to gastrointestinal surgery, internal medicine or cardiology hospital wards were physically active for only 26 min (13-53) and spent most of their time during the day lying in bed (67.3%). Using a multivariable regression model, we determined that (1) dependence in basic mobility and (2) urine catheter presence were significantly associated with physical inactivity. These two factors were the only remaining factors in our multivariable regression analysis, indicating that they may be of more importance in identifying physically inactive patients than age, self-efficacy, IV-lines, and surgery. Additionally, we observed that the fit of our multivariable regression model did not significantly change after adding hospital ward to the analysis, indicating that the associations found within our study did not differ between hospital wards.

The amounts of objectively assessed physical activity in our study were considerably lower than reported in comparable studies [15,16,18]. Possible explanations may be the difference in patient population or the accelerometers used to measure physical activity. For example, previous studies defined physical activity as the time that patients stand or walk via the patient's postural position, while the PAM AM400 accelerometer solely measures physical activity via three-dimensional accelerations and, therefore, will not include the time patients stand till in the total amount of physical activity [15,16,18]. Only one study measured the time patients walk separately from the time that patients standstill and observed elderly patients to be walking for only median 4-10 min a day [20]. Considering that slow walking (± 2 mph / 3.2 kph) would be classified as physical activity when using the PAM, we may assume that patients on our hospital wards are relatively more physically active than patients aged 65 years and older who have been admitted to an acute geriatric ward.

We also found that patients were lying in bed for considerably higher amounts of time when we compared the results of our behavioural mapping data with comparable hospital wards from other studies [17,32]. For example, Mudge et al. described that patients were in bed for 53.3-65.1% of the time, whereas we observed patients lie in bed on comparable wards for 67.5-79.6% of the time [17]. These differences might result from the considerably longer observation period (8 am-8 pm versus 10 am-6 pm). However, they may also reflect a difference in case mix, culture, or ward environment. Despite the differences in percentages, our study emphasizes that the same pattern occurs in adults of all ages admitted to gastrointestinal surgery, internal medicine, and cardiology wards: patients remain largely in bed during hospitalization, but the exact amounts vary between hospital wards.

The importance of the association between independence in basic mobility and in-hospital physical activity has been highlighted by many authors [18,19,21]. In addition to the previous studies, we observed in our sample adults of all ages requiring assistance in basic mobility is by far the strongest factor associated with physical inactivity. This finding suggests that routine assessments of independence in basic mobility are the starting point to identify physically inactive patients of all ages before a functional decline occurs. Previous research in the John Hopkins Hospital has shown that mobility assessments in routine clinical practice can best be performed using the valid and reliable AMPAC “6-clicks” inpatient Basic Mobility short form [27,28,33].

In addition, our findings also revealed that patients who have urine catheters are significantly more physically inactive than patients who do not have a urine catheter. These findings may suggest that by registering urinary catheters in addition to the routine assessments of mobility, the accuracy of identifying physically inactive patients can be improved. This finding is in line with the study of Koenders et al. [21], who showed that both urine catheter use and drain use were significantly associated with time spent lying in bed. Although both studies indicate that functional restraints can be used to identify physically inactive patients, we were unable to conclude that these functional restraints are the impeding causes. Interventions should therefore not only consider removing functional restraints but also should look more broadly at what is needed to counter physical inactivity. This is substantiated by a recent synthesis of qualitative evidence showing that physical inactivity during hospital stay is primarily caused by a multifaceted and complex phenomenon, whereby multiple issues should be tackled at the same time to be able to counter physical inactivity in hospitalized patients effectively [34].

Finally, the finding that both associations do not differ between hospital wards is new and suggests that routine assessments in clinical care have added value across an entire hospital. Assuming that many hospitals already register the urine catheter presence in their electronic medical record, implementing the AM-PAC “6-clicks” inpatient Basic Mobility short form in the electronic medical record may offer healthcare professionals and policymakers with new opportunities to systematically identify physically inactive patients throughout the hospital.

Strengths and limitations of the study

The strengths of this research is the comprehensive assessment of physical activity through both behavioural mapping and accelerometers, the random selection of participants on each hospital ward and the extensive inclusion of factors which may be associated with in-hospital physical activity. We also recognize some limitations of this study. First, data were collected on one random day during the patients' admission. The physical activity data may therefore not reflect overall physical activity during the entire hospital stay. However, we included the number of days that patients were admitted until physical activity measurement as a factor and determined that other factors were more strongly associated with physical inactivity. Second, concerns remain present regarding the most appropriate criterion measure to define light, moderate, and vigorous physical activity. Considering that the PAM AM400 has been validated in healthy adults, our description of the absolute physical activity intensities might be underestimated in hospitalized adults [23,24]. Third, independence in ADL was omitted from the multivariable regression model due to collinearity with independence in basic mobility. This choice was based on the results of the univariable regression analysis and the applicability of the measure in clinical practice. Still, readers should note that the variance explained with independence in basic mobility might also be largely explained by assessing independence in ADL.

Conclusions

The results of this study show that physical inactivity in hospitalized adults of all ages is significantly associated with dependence on basic mobility and urine catheter presence. And, furthermore, that both associations do not differ between hospital wards. These findings imply that regardless of which hospital ward patients are admitted to, once patients require assistance in basic mobility or have a urinary catheter they are at risk of physical inactivity. Also, these results imply that through routine assessments of basic mobility and urine catheter presence, healthcare professionals may be able to identify physically inactive patients before these patients experience a functional decline. A possible next step would be to translate the effective interventions from the literature into local intervention strategies to improve physical activity in the identified physically inactive patients. Future research is particularly needed to investigate the relationship between (1) social (e.g., family, visitors, healthcare professionals) and environmental context and (2) physical inactivity. Understanding how the social and environmental context influences the patient's physical activity behaviour may offer healthcare professionals new interventions to sustainably prevent physical inactivity during hospital stay. Furthermore, future research should focus on identifying normative values for physical activity during hospital stay, so that hospital wards can more easily include physical activity as a goal in clinical practice.

Supplementary Information

Supplemental Online Material S1, S2 and S3 can be found online: https://doi.org/10.1080/09638288.2021.1970257

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Chapter 3

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

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Abstract

To evaluate the construct validity and the inter-rater reliability of the Dutch Activity Measure for Post-Acute Care “6-clicks” Basic Mobility short form measuring the patient’s mobility in Dutch hospital care. First, the “6-clicks” was translated by using a forward-backward translation protocol. Next, 64 patients were assessed by the physiotherapist to determine the validity while being admitted to the Internal Medicine wards of a university medical center. Six hypotheses were tested regarding the construct “mobility” which showed that: Better “6-clicks” scores were related to less restrictive pre-admission living situations ($p = 0.011$), less restrictive discharge locations ($p = 0.001$), more independence in activities of daily living ($p = 0.001$) and less physiotherapy visits ($p < 0.001$). A correlation was found between the “6-clicks” and length of stay ($r = -0.408$, $p = 0.001$), but not between the “6-clicks” and age ($r = -0.180$, $p = 0.528$). To determine the inter-rater reliability, an additional 50 patients were assessed by pairs of physiotherapists who independently scored the patients. Intraclass Correlation Coefficients of 0.920 (95%CI: 0.828-0.964) were found. The Kappa Coefficients for the individual items ranged from 0.649 (walking stairs) to 0.841 (sit-to-stand). The Dutch “6-clicks” shows a good construct validity and moderate-to-excellent inter-rater reliability when used to assess the mobility of hospitalized patients.

Keywords
Hospitalization; mobility; physiotherapy; validity; reliability; measuring; tool

Implications for rehabilitation

- Even though various measurement tools have been developed, it appears the majority of physiotherapists working in a hospital currently do not use these tools as a standard part of their care.
- The Activity Measure for Post-Acute Care “6-clicks” Basic Mobility is the only tool which is designed to be short, easy to use within usual care and has been validated in the entire hospital population.
- This study shows that the Dutch version of the Activity Measure for Post-Acute Care “6-clicks” Basic Mobility form is a valid, easy to use, quick tool to assess the basic mobility of Dutch hospitalized patients.

Introduction

The percentage of people older than 65 years increases by the year. It is estimated that in The Netherlands the amount of elderly will rise from 13% in 2005 to 24% in 2030 [1]. The aging of the population will be accompanied with an increase in multimorbidity and frailty, resulting in a higher number of patients at greater risk of being admitted to a hospital when they become ill [2,3]. When admitted to a hospital, a relatively high proportion of these older patients with an acute musculoskeletal, neurological, or cardiopulmonary injury or disease, experience new limitations in mobility and activities of daily living (ADL) [4].

A loss in mobility and ADL during admission may have profound consequences, such as prolonged length of stay, increased risk of mortality and increased risk for institutionalization after discharge [5,6]. When the loss in mobility and ADL persist up to three months, the probability of "complete recovery" of function decreases [7]. After six months, these impairments rarely reverse [7,8]. Consequently, some patients experience permanent limitations in their ADL and participation in the community after hospitalization.

To counteract this loss in mobility and ADL, various hospital care models are aimed at stimulating the patient's physical activity during hospitalization [9-11]. These care models regularly involve physiotherapy and are often evaluated by surrogate outcomes, such as length of stay and hospital complications, while these outcome measures do not fully represent the intended functional changes [12]. By actually using the patient's mobility as a standardized outcome measure, it will be possible to better evaluate such care models. Additionally, it will be possible to better display the progress of recovery in regular care and provide clinically relevant insight into a patient's physical capabilities during hospitalization.

So far, various measurement tools have been developed to assess and monitor the independent mobility of hospitalized patients [13-19], but it appears that the majority of physiotherapists working in hospitals currently do not use these tools as a standard part of their care [20]. Underlying reasons for not adopting the available instruments are that they are too time consuming to complete during usual care, too time-consuming to analyze or they have been designed for only a small part of the total hospital population [20]. The Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility is the only tool which is designed to be short, easy to use within usual care and has been validated in the entire hospital population [14].

Also, physiotherapists are able to score the AM-PAC "6-clicks" Basic Mobility not only by using the observations made during an assessment, but also by using their clinical judgment as a physiotherapist about patient's probable capabilities [14]. Up to now, a Dutch version of the AM-PAC "6-clicks" Basic Mobility is not yet available.

To enable the use of the AM-PAC "6-clicks" Basic Mobility in clinical practice and research in the Netherlands, we aimed to translate this instrument to the Dutch language and investigate the construct validity and inter-rater reliability of the Dutch AM-PAC "6-clicks" Basic Mobility in patients admitted to a hospital setting.

Materials and methods

Phase 1 – Translation

The first step was to translate the AM-PAC "6-clicks" Basic Mobility version 2.0 from English to Dutch (supplementary Table S1) [21]. Permission to translate and validate the AM-PAC "6-clicks" Basic Mobility Short Form has been received prior to this study from the original research team. A forward-backward translation method was used as described in Figure 1 [22,23].

In stage 1 of the translation process, two independent translators translated all 6 items, introductory texts, response options and the footnote of the AM-PAC "6-clicks" Basic Mobility. Both translators were bilingual, with Dutch as their native language. One translator worked as a clinician and was aware of the purpose of the AM-PAC "6-clicks" Basic Mobility. The second translator had no medical background and was not aware of the purpose of the AM-PAC "6-clicks" Basic Mobility.

In stage 2, both translators and an independent observer sat down to synthesize the results. During this meeting, the original AM-PAC "6-clicks" Basic Mobility, both translations and the notes were used to derive one combined translation. Any disagreements were discussed until consensus on the combined translation had been reached.

In stage 3, two different independent translators translated the preliminary Dutch version back to English. Both translators had no medical background, had English as their native language and Dutch as their second language. They were unaware of the original version of the AM-PAC "6-clicks" Basic Mobility. Both backward translations were compared with the original version by two additional independent reviewers to ensure a consistent and adequate translation. Any inconsistencies or conceptual errors in the translation process were changed.

In stage 4, an expert committee reviewed all versions of the translation process. The role of the expert committee was to consolidate all the versions into a pre-final version, ready for pre-testing as described in stage 5. A methodologist, a language professional, one forward translator, one backward translator and health professionals were part of the expert committee.

In stage 5, the pre-final version of the Dutch AM-PAC "6-clicks" Basic Mobility was field tested in a sample of physiotherapists. Three physiotherapists were asked to read the pre-final version. They were then asked about their thoughts on the meaning of each item and related answer options. These field tests were examined in order to look for any consistent misinterpretations or room for discussion. If needed, the pre-final version was adjusted accordingly.

The translation process resulted in a final Dutch AM-PAC "6-clicks" Basic Mobility version that was used within this study and has been added to this report in Supplementary Table S2.

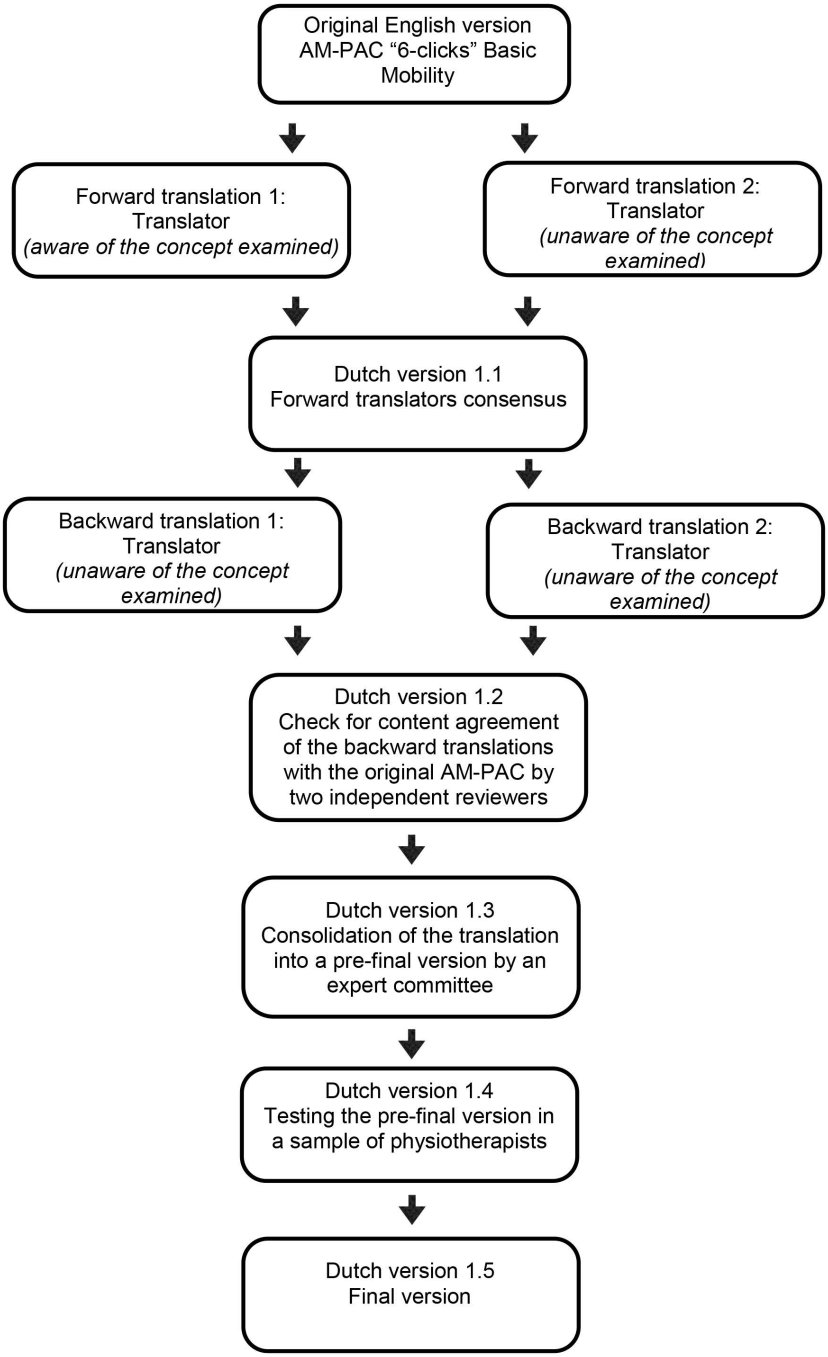

Figure 1. Forward-backward translation process

Phase 2 – Validation and inter-rater reliability

Study design

A single-center, cross-sectional study design was used to investigate the construct validity and inter-reliability of the Dutch AM-PAC “6-clicks” Basic Mobility. The study was approved by the Medical Research Ethics Committee and has been conducted according to the principles of the Declaration of Helsinki. All patients gave oral informed consent to collect the data.

Study population

The AM-PAC “6-clicks” Basic Mobility was first introduced to the physiotherapists working on the internal medicine wards: rheumatology, nephrology, gastroenterology, oncology (including hematology), urology, infection diseases, internal medicine and geriatrics. The physiotherapists received an explanation of the background, rationale and use of the AM-PAC “6-clicks” Basic Mobility. They were asked to use the AM-PAC “6-clicks” Basic Mobility within the regular care to assess patient mobility. For both the validity and the reliability sample, all patients above 18 years who were admitted to one of these internal medicine wards, were eligible for inclusion. The patients who were medically unstable, underwent surgery during admission, or when mobilization was contraindicated by the medical team were excluded. For the validity sample, patients were also only included when they had been assessed by the physiotherapist using the AM-PAC “6-clicks” Basic Mobility in the first visit.

The AM-PAC “6-clicks” basic mobility

The AM-PAC “6-clicks” Basic Mobility assesses the basic mobility activities, which represent the functional activities of most interest to post-acute rehabilitation providers [14]. It contains six items: rolling in bed, transfers in bed, transfers out of bed, standing, walking and climbing stairs, which are the six most important activities to determine a patient’s basic mobility level [14,24]. All activities are scored on a scale of 1 (unable to do or 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). Because the AM-PAC “6-clicks” Basic Mobility was drawn from the calibrated AM-PAC Basic Mobility item bank [14,21], all scores can be converted to a standardized score, the t-scale score, for analysis (with a mean of 50 and standard deviation (sd) of 10) [21,25]. The t-scale score offers the health care professional to compare the AM-PAC “6-clicks” Basic Mobility scores with other AM-PAC mobility questionnaires via a single reporting scale, assessing different target populations (e.g. inpatient vs. outpatient) and different mobility levels (ranging from very low to high level of function). Also, it offers the option to gain insight into the level of functioning of individual patients in the entire construct “mobility”, with lower scores being equal to a higher degree of limitation [21]. The physiotherapists scored the AM-PAC “6-clicks” Basic Mobility without changing their assessment or treatment. They were asked to score each item by observing the patient’s physical performance or by using their clinical judgment about patient’s probable capabilities. The English AM-PAC “6-clicks” Basic Mobility has been validated and found reliable within a diverse population of American hospitalized patients [14,26].

Assessment of validity

The construct that needed to be validated within the AM-PAC “6-clicks” Basic Mobility was “the patients’ mobility” [27]. The research team decided to investigate the construct by testing hypotheses related to the construct, due to the absence of a gold standard [23]. To test construct validity, the following six hypotheses were defined: (1) lower age correlates moderately with higher AM-PAC “6-clicks” Basic Mobility scores registered during the first physiotherapeutic visit, (2) the patients’ length of stay is inversely moderately correlated with the AM-PAC “6-clicks” Basic Mobility score on the first visit, (3) patients living independently at home before being admitted to a hospital have significantly higher AM-PAC “6-clicks” Basic Mobility scores during the first visit of a physiotherapist than those living in more restrictive settings such as nursery homes, (4) patients score significantly higher during the first visit of a physiotherapist when they were more independent in their ADL prior to admission (as measured by the Katz-ADL[28]), (5) patients returning home independently after hospital admission have significantly higher AM-PAC “6-clicks” Basic Mobility scores during the first visit of a physiotherapist than patients returning to more restrictive settings such as nursery homes and (6) patients who only needed a single physiotherapy visit during their hospital stay have a mean difference of at least 7.36 (standardized score, minimal detectable difference [26]) compared to patients who needed more visits. The following criteria were used for labelling correlations: small/weak ($0.1 < r < 0.3$), medium/moderate ($0.3 < r < 0.5$) and large/strong ($0.5 < r$) [29]. These hypotheses have been posed using the original study [14], the input of the research team and two involved physiotherapists. A positive rating of the construct validity is present when at least 75% of the results are in correspondence with these hypotheses [30].

The AM-PAC “6-clicks” Basic Mobility scores, information regarding the patients’ age, gender, type of diagnosis at admission, length of stay, pre-admission living situation, discharge location and the pre-admission Katz-ADL score [28] were collected by the physiotherapist and delivered anonymously to the research team. The Katz Index of Independence in Activities of Daily Living (ADL) describes the level of independence in ADL and contains six dichotomous questions which can be scored from 0 (completely ADL dependent) to 6 (completely ADL independent) [28].

Inter-rater reliability

In daily care hospital practice, clinometric instruments are often used by several health care providers. Therefore, the inter-rater reliability was assessed of the AM-PAC “6-clicks” Basic Mobility Short Form. The procedure used to assess the inter-rater reliability has been described in earlier research [26,31]. Participating physiotherapists visited hospitalized patients in pairs. One physiotherapist was responsible for the direct care of the patient and performed treatment as usual and additionally recorded the Dutch AM-PAC “6-clicks” Basic Mobility scores. The second physiotherapist solely observed the patient and also scored the tool. Both physiotherapists were unaware of the other therapist’s AM-PAC “6-clicks” Basic Mobility assessment. The physiotherapists did not communicate with each other during the assessment.

Data analysis

All analyses were conducted using IBM-SPSS Statistics version 24 (IBM Corp, Armon, New York).

For the construct validity, a sample size of at least 64 patients was needed, as calculated with a $(1 - \beta)$ of 80%, an α of 5% and a one-tail correlation of at least 0.3 based on the original validation study of Jette et al. [14]. For the inter-rater reliability, a sample of at least 50 patients was needed to calculate an Intraclass Correlation Coefficient (ICC) between two raters of at least 0.8 with a 95% confidence interval of $\pm$ 0.1 [23,32].

Descriptive statistics were derived to describe the patients who were observed during the study. Normality was evaluated by using histograms and Q-Q plots. Homogeneity of variances was evaluated by Levene’s test. The following data analyses were used to test the six hypotheses: a one-tailed Spearmen’s correlation coefficient was used to determine the relationship between (1) the first visit score and age, and (2) the first visit score and length of stay. Kruskal-Wallis analysis of variance (ANOVA) was used to examine differences in mean first visit scores across (3) six types of pre-admission living situations (home alone, home with partner, home with home-care/caregiver, rehabilitation center/assisted-living facility and nursing facility), (4) across the different Katz-ADL scores and (5) across seven types of discharge locations (home alone, home with partner, home with home-care/caregiver, rehabilitation center/assisted-living facility, nursing facility/different hospital/hospice, and death). A Mann-Whitney U-test was used to examine (6) the difference in first visit scores between the patients who were visited once by a physiotherapist or visited more than once.

To investigate the inter-rater reliability for each individual item of the AM-PAC “6-clicks” Basic Mobility, a linear weighted kappa statistic was used. To determine the inter-rater reliability of the total AM-PAC “6-clicks” Basic Mobility score, a two-way [2.1] random model of absolute agreement ICC was used. Confidence intervals at the 95% level around the two-way ICC were calculated. Absolute reliability was assessed using the standard error of measurement (SEM), which was calculated as $SEM_{agreement} = \sqrt{(o'_{observer} + o'_{error})}$. The $SEM_{agreement}$ estimates how far apart the measurement results of two raters are [32]. In addition, the minimum metrically detectable change (MMDC) was calculated as $MMDC_{95\%} = SEM \times 1.96 \times \sqrt{2}$ [33].

Results

Construct validity

The validity sample included 64 patients, with a mean age of 73.52 (sd = 13.53) and 55% was male (Table 1). Patients were admitted for a duration of 3 to 75 days and received between 1 and 32 physiotherapy visits during hospitalization.

Table 1. Validity and inter-rater reliability sample baseline characteristics.

Characteristics	Validity sample n = 64	Inter-rater reliability sample n = 50
Age (years), mean (SD, range)	73.52 (13.53, 18-93)	70.94 (14.99, 31-95)
Sex, n (%)		
Female	35 (54.7)	26 (52.0)
Male	29 (45.3)	24 (48.0)
Type of primary diagnosis at admission, n (%)		
Gastroenterology	10 (15.6)	6 (12.0)
Nephrology	2 (3.1)	2 (4.0)
Internal Medicine	15 (23.4)	3 (6.0)
Geriatrics	27 (42.2)	18 (36.0)
Oncology (including hematology)	2 (3.1)	3 (6.0)
Rheumatology	3 (4.7)	8 (16.0)
Dermatology	1 (1.6)	1 (2.0)
Infectious disease	4 (6.3)	4 (8.0)
Urology	0 (0.0)	4 (8.0)
Length of stay (days), median (IQR)	11 (7-20)	
Amount of physiotherapy visits, median (IQR)	3 (2-7)	

n: numbers of patients; SD: standard deviation.

Table 2 shows the living situation prior to the admission, Katz-ADL scores prior to admission, number of patients receiving a single physiotherapy visit and the discharge location. A majority of patients admitted to the hospital lived independently at home either alone (34%) or with a partner (38%). None of the patients died during hospitalization.

The mean of the AM-PAC “6-clicks” Basic Mobility scores at the first physiotherapy visit was 18.88 (sd = 4.90), which converts to the standardized score 43.85 (sd = 9.90). Table 2 shows the raw and standardized AM-PAC “6-clicks” Basic Mobility scores of each subgroup.

The results of the hypotheses-testing show that: (1) lower age is not moderately correlated (r = -0.180, p = 0.528) with higher first visit scores, (2) the patients' length of stay is significantly, inversely correlated with the first visit score (r = -0.408, p = 0.001), (3) there is a linear trend showing that patients living independently at home have significantly higher first visit scores than those living in more restrictive settings ($p = 0.011$), (4) patients have significantly higher first visit scores when they were more independent in their ADL prior to admission ($p = 0.001$), (5) patients who are discharged to home have significantly higher first visit scores than patients returning to more restrictive settings ($p = 0.001$) and (6) patients with a single physiotherapy visit scored significantly higher first AM-PAC “6-clicks” Basic Mobility scores than patients with more than one visit (mean difference = 10.92, $p < 0.001$). Therefore, five of the six hypotheses (83%) were confirmed showing that the AM-PAC “6-clicks” Basic Mobility has a good construct validity.

Inter-rater reliability

The inter-rater reliability sample included 50 patients, with a mean age of 70.94 (sd = 14.99) and an almost equal amount of men and women (Table 1).

Three physiotherapists participated in the data collection. Two physiotherapists assessed both 25 patients separately, in collaboration with the third physiotherapist who observed all 50 patients.

The two-way random model of absolute agreement ICC for the inter-rater reliability of both the first and second pair was 0.920 (95% CI = 0.828-0.964). The $SEM_{agreement}$ was 4.24 and the $MMDC_{95\%}$ was 11.77 on the t-score scale. The weighted Kappa’s for each item are described in Table 3.

Table 2. AM-PAC “6-clicks” Basic Mobility scores of the validity sample

Characteristic	Amount, n (%)	First visit raw basic mobility, median (range)	First visit basic mobility t-scale score, mean (SD)
Living situation prior to admission			
Home alone	22 (34.4)	21.5 (10.0-24.0)	47.41 (8.75)
Home with partner	24 (37.5)	20.0 (11.0-24.0)	44.80 (7.68)
Home with caregiver/ home-care	12 (18.8)	18.0 (9.0-24.0)	42.84 (9.90)
Rehabilitation center/ Assisted living home	3 (4.7)	14.0 (7.0-18.0)	32.00 (11.26)
Nursing home/Hospice	3 (4.7)	9.0 (6.0-14.0)	25.98 (9.48)
Katz-ADL			
0	19 (29.7)	23.0 (16.0-24.0)	49.86 (6.04)
1	5 (7.8)	19.0 (18.0-24.0)	45.85 (6.82)
2	5 (7.8)	21.0 (18.0-22.0)	44.12 (2.90)
3	5 (7.8)	23.0 (20.0-24.0)	51.16 (6.48)
4	8 (12.5)	17.5 (9.0-23.0)	39.26 (10.18)
5	15 (23.4)	17.0 (7.0-24.0)	38.56 (8.92)
6	6 (9.4)	13.0 (6.0-24.0)	33.90 (13.70)
Missing data	1 (1.6)	-	-
Physiotherapy visits			
One	12 (18.8)	23.50 (18.0-24.0)	52.72 (5.83)
Two or more	52 (81.3)	18.00 (6.0-24.0)	41.80 (9.53)
Discharge location			
Home alone	8 (12.5)	23.5 (20.0-24.0)	52.75 (5.77)
Home with partner	15 (23.4)	22.0 (16.0-24.0)	47.11 (6.89)
Home with caregiver/ home-care	16 (25.0)	21.0 (9.0-24.0)	45.04 (9.27)
Rehabilitation center/ Assisted living home	16 (25.0)	17.50 (7.0-24.0)	39.39 (9.51)
Nursing home/Hospice/ Different hospital	9 (14.1)	14.0 (6.0-23.0)	36.34 (11.10)
Death	0 (0)	-	-

n: numbers of patients; SD: standard deviation.

Table 3. Kappa coefficients

AM-PAC “6-clicks” Basic Mobility item	Weighted kappa	95% Confidence Interval	
		Lower bound	Upper bound
Turning in bed left and right	0.831	0.708	0.955
From supine to sitting on the edge of the bed	0.732	0.591	0.873
Transfer from bed to chair and back	0.761	0.625	0.898
From sitting in a chair to standing	0.841	0.730	0.951
Walk in room	0.827	0.728	0.926
Walking three to five steps of a stairs	0.649	0.497	0.801

Discussion

This is the first study investigating the validation and inter-rater reliability of the Dutch AM-PAC “6-clicks” Basic Mobility in a hospital setting. The results provide evidence for the construct validity of the newly translated AM-PAC “6-clicks” Basic Mobility in assessing the mobility of hospitalized patients. Since five of the six hypotheses were confirmed, the construct validity was good. The results found in this study also show that the inter-rater reliability of the Dutch AM-PAC “6-clicks” Basic Mobility is moderate to excellent, with ICC’s exceeding 0.90 and Kappa’s ranging from 0.649 to 0.841.

The forward-backward translation process described in earlier research is a well-described translation protocol [22], which led to a good translation of the AM-PAC “6-clicks” Basic Mobility with little to no questions and uncertainties from physiotherapists.

Contrary to what was found in the study investigating the validity of the original English AM-PAC “6-clicks” Basic Mobility, no relationship was found between age and the AM-PAC “6-clicks” Basic Mobility score [14]. It is possible that the severity and the type of the underlying diseases on the internal medicine departments have a considerably greater effect on the mobility than the patient’s age. The results of hypothesis 3, 4 and 6 were in line with the results of the corresponding hypotheses in the original studies [14,34]. Additionally, we defined two supplementary hypotheses (2 and 4) based on the input of the research team and involved physiotherapists. Earlier research, using other mobility tools, showed that both the patient’s length of stay and the performance of ADL prior to admission have a moderate to strong relationship with the patient’s mobility [35-38]. These relationships were confirmed in this study using the AM-PAC “6-clicks” Basic Mobility to measure the patient’s independent mobility.

Jette et al. [26] also examined the inter-rater reliability of the original English AM-PAC “6-clicks” Basic Mobility. The ICC’s of the English AM-PAC “6-clicks” Basic Mobility were investigated on four separate hospital services with an overall of 0.849, whereas the overall ICC of the Dutch AM-PAC “6-clicks” Basic Mobility are slightly higher (0.920). The Weighted Kappa Coefficients of the Dutch AM-PAC “6-clicks” Basic Mobility (0.649 to 0.841) are also slightly higher when compared with the English AM-PAC “6-clicks” Basic Mobility (0.492 to 0.712) [26]. This difference can be explained by the small number of physiotherapists who participated in this study. Despite the small number of physiotherapists, this study indicated that the inter-rater reliability of the Dutch AM-PAC “6-clicks” Basic Mobility, like the English version, is moderate to excellent.

The AM-PAC “6-clicks” Basic Mobility is designed to be easy to use within regular care. Physiotherapists base the scores on their observations made within regular care in combination with their clinical judgment about the patient’s probable capabilities [14]. Although this method of data collection may affect the psychometric properties of this measuring tool, it does reflect usual care practices of a physiotherapeutic assessment in a hospital. For instance, patients with poor exercise capacity due to the illness cannot perform all six activities during assessment. Still, physiotherapists have to be able to estimate the amount of help needed for all basic mobility activities in order to optimize the care for the patient during and after admission. The AM-PAC “6-clicks” Basic Mobility also offers physiotherapists a way to improve the communication with other medical personal because of the short, standardized format of the measuring instrument. During hospitalization, this instrument easily shows all medical personnel how much assistance the patient needs in each basic mobility activity. Finally, using the AM-PAC “6-clicks” Basic Mobility within regular care helps to improve the accuracy for predicting discharge destinations from a hospital [34]. In a system which aims to decrease the length of stay of hospital admissions nationwide, the added value of an instrument as an early prediction tool of the patient’s ability to go home should definitely not be underestimated [39].

Since the AM-PAC “6-clicks” Basic Mobility is especially designed for use in acute hospital settings it only includes basic mobility items which raises questions about a possible ceiling effect and the generalizability to other settings. Within this study, it was observed that the majority of the patients (59%) scored ≤ 21 points on the AM-PAC “6-clicks” Basic Mobility during the first assessment. This shows that, with a demonstrated minimal detectable change of two to three points [14], there is room for measuring clinically relevant changes during hospital stay. Furthermore, since the AM-PAC “6-clicks” Basic Mobility has been derived from the calibrated AM-PAC item banks, it is possible to convert AM-PAC “6-clicks” Basic Mobility scores to standardized scores [14,21,40]. This makes it possible to compare the AM-PAC “6-clicks” Basic Mobility scores with other AM-PAC mobility questionnaires like the AM-PAC Outpatient Short Form which expands the use of this list [21].

A limitation of this study is that in addition to the hypothesis testing, no convergent validity was explored. The research team chose not to compare the AM-PAC “6-clicks” Basic Mobility with other measuring tools, because these were not administered routinely within the regular care of the physiotherapists due to the aforementioned limitations of tools [15,23,41,42]. However, in future research, it might be interesting to compare the AM-PAC “6-clicks” Basic Mobility with another valid measuring tool to substantiate the convergent validity of the AM-PAC “6-clicks” Basic Mobility and to see how these two measuring tools relate to one another.

Another limitation is that the results have been based solely on data of patients admitted to the internal medicine departments. Jette et al described a difference in inter-rater reliability when the results of the AM-PAC “6-clicks” Basic Mobility were compared between different specialisms within the hospital, such as medical/surgical (ICC = 0.960; 95%CI = 0.857-0.983) and orthopedic (ICC = 0.581; 95%CI = 0.260-0.789) [26]. Although this difference in ICCs might also be because each department had been assessed by different physiotherapists [26], it shows that further research is needed to see how reliable the Dutch AM-PAC “6-clicks” Basic Mobility is when used in other departments.

Also, further psychometric evaluation of the Dutch AM-PAC “6-clicks” Basic Mobility short form is required to support and expand the results herein, including further evaluation of its test-retest reliability, responsiveness to change and predictive values.

To counteract the loss in mobility and ADL patients experience, multiple hospitals in the Netherlands currently explore possibilities to stimulate patients to be more active in a hospital. The lack of activity when hospitalized has also been referred as "pyjama paralysis" [43]. To be able to draw up efficient policies and interventions to stimulate patients to be more active within their mobility capabilities, the independent mobility of every patient should be assessed early on, regularly and in an easy and time efficient way during usual care. However, to be able to measure the mobility of every hospitalized patient within usual care, other healthcare staff should be involved too because physiotherapists only visit a subset of patients. Therefore, an interesting topic for future research is examining the validity and reliability of the AM-PAC "6-clicks" Basic Mobility when administered by other healthcare staff, such as nurses, on a wide variety of departments.

In conclusion, this study provides a good rationale for the use of the Dutch version of AM-PAC "6-clicks" basic mobility in Dutch hospitals as a valid, easy to use, quick tool to assess the basic mobility activities of hospitalized patients.

Supplementary Information

Supplemental Table S1 can be found online: https://doi.org/10.1080/09638288.2018.1471525

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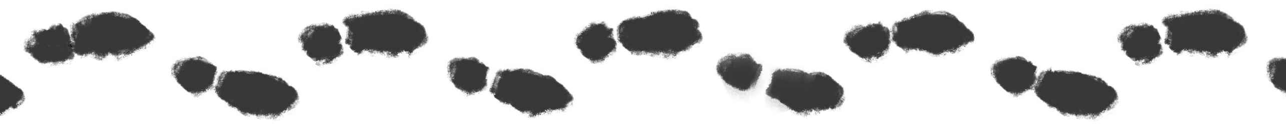

Chapter 4

Extended mobility scale (AMEXO) for assessing mobilization and setting goals after gastrointestinal and oncological surgery: a before-after study

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Abstract

Background

Early structured mobilization has become a key element of Enhanced Recovery After Surgery programs to improve patient outcomes and decrease length of hospital stay. With the intention to assess and improve early mobilization levels, the 8-point ordinal John Hopkins Highest Level of Mobility (JH-HLM) scale was implemented at two gastrointestinal and oncological surgery wards in the Netherlands. After the implementation, however, healthcare professionals perceived a ceiling effect in assessing mobilization after gastrointestinal and oncological surgery. This study aimed to quantify this perceived ceiling effect, and aimed to determine if extending the JH-HLM scale with four additional response categories into the AMsterdam UMC EXtension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale reduced this ceiling effect.

Methods

All patients who underwent gastrointestinal and oncological surgery and had a mobility score on the first postoperative day before (July-December 2018) or after (July-December 2019) extending the JH-HLM into the AMEXO scale were included. The primary outcome was the before-after difference in the percentage of ceiling effects on the first three postoperative days. Furthermore, the before-after changes and distributions in mobility scores were evaluated. Univariable and multivariable logistic regression analysis were used to assess these differences.

Results

Overall, 373 patients were included (JH-HLM n = 135; AMEXO n = 238). On the first postoperative day, 61 (45.2%) patients scored the highest possible mobility score before extending the JH-HLM into the AMEXO as compared to 4 (1.7%) patients after (OR = 0.021, CI = 0.007-0.059, $p < 0.001$). During the first three postoperative days, 118 (87.4%) patients scored the highest possible mobility score before compared to 40 (16.8%) patients after (OR = 0.028, CI = 0.013-0.060, $p < 0.001$). A change in mobility was observed in 88 (65.2%) patients before as compared to 225 (94.5%) patients after (OR = 9.101, CI = 4.046-20.476, $p < 0.001$). Of these 225 patients, the four additional response categories were used in 165 (73.3%) patients.

Conclusions

A substantial ceiling effect was present in assessing early mobilization in patients after gastrointestinal and oncological surgery using the JH-HLM. Extending the JH-

HLM into the AMEXO scale decreased the ceiling effect significantly, making the tool more appropriate to assess early mobilization and set daily mobilization goals after gastrointestinal and oncological surgery.

Keywords
Early ambulation [MESH]; Mobility limitation [MESH]; Postoperative period [MESH]; Patient outcome assessment [MESH]

4

Introduction

Annually, over 300 million patients undergo surgery worldwide [1]. Prolonged bed rest and reduced mobility after surgical procedures have been associated with increased risk of complications [2,3]. Previous research showed that patients after abdominal oncological surgery stay in bed with a median of 19 h a day during the first three postoperative days and walk only six minutes a day [4].

In order to facilitate postoperative recovery, the enhanced recovery after surgery (ERAS) program has been well established worldwide [5-7]. The implementation of ERAS program had decreased hospital stay and reduced postoperative complications [8]. A key element of the ERAS program is early mobilization, which entails the incremental increase in activity ranging from passive range-of-motion exercises to active ambulation, depending on the physical capabilities of the patient, from the first day after surgery to reach predetermined targets using a standardized and structured approach [6,7,9,10]. Previous research showed that multifaceted interventions aimed at creating a culture that made safe and early mobilization possible resulted in significant and sustained improvement of patient mobilization levels [11].

With the intention to create a culture of safe and early mobilization, the John Hopkins University Hospital developed and implemented the Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility Short Form to assess limitations in functional mobility (i.e., what the patient is capable of doing) and the John Hopkins Highest Level of Mobility scale (JH-HLM) to assess mobilization (i.e., what a patient has actually done), set mobilization goals and discuss mobilization success during inter-professional meetings [12-14]. Specifically, the JH-HLM is a validated 1-item ordinal scale ranging from lying passively in bed (score = 1) to walking ≥ 250 ft (score = 8) [12,13]. Previous research showed that the JH-HLM has excellent test-retest reliability and inter-rater reliability for nurses and physical therapists [13]. To sustainably improve the mobilization levels in Dutch hospitalized patients, the JH-HLM scale was implemented in several Dutch hospitals.

After the implementation of the JH-HLM scale at our tertiary university medical center, however, healthcare professionals perceived a ceiling effect in patients after gastrointestinal and oncological surgery as they noticed that at least half of the patients scored the highest possible score on the first day postoperative. Floor and ceiling effects are considered to be present if respectively more than 15% of the patients achieved the lowest or highest possible score, limiting the usability, reliability and responsiveness of the tool [15]. In the case of the JH-HLM, this ceiling effect hampered the multidisciplinary team in adequately assessing mobilization after gastrointestinal and oncological surgery, setting mobilization goals and discussing mobilization success during inter-professional meetings.

Here, in our effort to provide the multidisciplinary team with a tool that can adequately be used after gastrointestinal and oncological surgery, we extended the JH-HLM scale by adding four additional response categories into the AMsterdam UMC EXtension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale. The AMEXO scale was subsequently implemented in routine clinical practice. If the ceiling effects were reduced by extending the JH-HLM into the AMEXO scale, the multidisciplinary team may be better able to assess mobilization, set mobilization goals and discuss mobilization success in patients after gastrointestinal and oncological surgery. Therefore, the aim of this study was two-folded. First, to quantify the perceived ceiling effect of the JH-HLM scale when the multidisciplinary team used it to assess mobility in patients after gastrointestinal and oncological surgery. Second, to determine if extending the JH-HLM scale with four additional response categories into the AMEXO scale reduced this ceiling effect.

Methods

Study design

This is an uncontrolled before-after study performed at two surgical wards. First, the JH-HLM scale was implemented at both surgical wards between March and June 2018, after which the JH-HLM scale was used during routine clinical care from July 2018 until January 2019. Second, the JH-HLM was extended into the AMEXO scale where after the AMEXO scale was implemented in routine care between February 2019 and June 2019 to assess mobilization and set daily mobilization goals during routine care instead of the JH-HLM scale. Data were extracted from the electronic medical records in January 2019 (before extending the JH-HLM into the AMEXO scale) and January 2020 (after extending the JH-HLM into the AMEXO scale) to quantify and compare both tools when used to assess mobilization in gastrointestinal surgical patients.

This study has been conducted according to the principles of the Declaration of Helsinki. The Medical Ethical Review Committee of the Amsterdam UMC, location Academic Medical Center, assessed and approved this study (reference number

W19_034 # 19.053). As the dataset was supplied by the medical center and included only de-identified (anonymous) data; the Medical Ethical Review Committee waived the need for individual informed consents. The study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies [16].

Study population

All adult patients who were admitted to one of the two surgical wards between July and December 2018 (before) or July and December 2019 (after extending the JH-HLM into the AMEXO scale), underwent gastrointestinal and oncological surgery and had a JH-HLM or AMEXO score on the first postoperative day were included. Moreover, every patient was only included once, meaning that all subsequent hospital admissions were excluded from the analysis.

JH-HLM and AMEXO mobility scales

The JH-HLM scale is a 1-item ordinal scale with eight response categories and is used by healthcare professionals to assess mobilization, set mobilization goals and discuss mobilization success during inter-professional meetings [13]. Each category is numbered consecutively from 1 = lying passively in bed to 8 = walking approximately 250 ft or more [13]. Initially, the JH-HLM scale has been developed to assist healthcare professionals caring for hospitalized general medicine patients [12]; however, the JH-HLM scale has also been used more recently in hospitalized adults at acute care units [17], hospitalized geriatric patients [18], hospitalized adults at a neuroscience/brain rescue unit [19,20], surgical unit [21] or intensive care unit [22]. Using a convenience sample of hospitalized adults, Hoyer et al. showed that the test-retest reliability values for physical therapists and nurses (Intraclass Correlation Coefficients 0.94 and 0.95, respectively) and interrater reliability values between physical therapists and nurses (Intraclass Correlation Coefficient 0.99) were excellent [13]. Furthermore, the Standard Error of Measurement was 0.2, the Minimal Detectable Change (MDC_{95}) was 0.6, and evidence was provided that the JH-HLM measured constructs of the ICF domain ‘mobility’ [13,23]. To ensure clarity and ease of use for patients and healthcare professionals in our hospital, 25 and 250 ft was rounded to 7.5 and 75 m, respectively, instead of 7.62 and 76.2.

At first, the JH-HLM was implemented at our hospital and we placed meter markings on the walls to facilitate healthcare professionals in estimating the achieved JH-HLM score and in setting mobilization goals together with hospitalized adult patients. The highest JH-HLM score (i.e., 8 = 250 ft) represents a functional household ambulation distance and is estimated as 4 metabolic equivalents [12]. In three team discussions in January 2019, a multidisciplinary team involving surgeons, physicians, nurses, physical therapists and researchers evaluated the distribution of JH-HLM scores and extended it into the new AMEXO scale using additional response categories. These additional response categories had to present an incremental increase in mobilization, taking highest possible JH-HLM score as the starting point and a walking distance of approximately 1 km as the ceiling. The goal of 1 km after gastrointestinal and oncological surgery was based on our clinical observations and our previous experience of what is achievable after gastrointestinal and oncological surgery [24]. Walking seemed the most appropriate activity to increase mobilization given the context. Other conditions that the new response categories had to meet were that they should be easy to understand for patients and could be easily assessed by healthcare professionals. In between team discussions the additional response categories were pilot tested by a varying composition of nurses, physical therapists and patients to ensure clarity, face validity, and ease of use.

In summary, the AMEXO scale is an extended version of the JH-HLM scale, in which four additional categories (category 9-12) have been added on top of the already existing eight ordinal response categories. Each of the four additional categories presents an incremental increase in mobilization using the highest possible JH-HLM score (i.e., 8 = 250 ft) as a starting point (Additional file 1). This resulted in the following response categories: 9 = 750 ft/225 m (i.e., + 2 times highest possible JH-HLM), 10 = 1500 ft/450 m (i.e., + 3 times highest possible JH-HLM), 11 = 2500 ft/750 m (i.e., + 4 times highest possible JH-HLM) and 12 = 3750 ft/1125 m (i.e., + 5 times highest possible JH-HLM). Using this incremental approach, only four additional response categories were needed to achieve the distance of at least 1 km. Also, each response category could be calculated back to JH-HLM score = 8, providing patients and healthcare professionals with a reference standard to determine the achieved AMEXO score and set mobilization goals together. The AMEXO scale was implemented at the start of February 2019 to replace the JH-HLM in facilitating healthcare professionals in assessing mobilization, setting mobilization goals and discussing mobilization success during inter-professional meetings.

Ceiling effect

Based on previous research, a ceiling effect was considered to be present if more than 15% of patients achieved the highest possible score [25]. The presence of a ceiling effect when using the JH-HLM and AMEXO scales to assess mobilization was therefore determined by evaluating the percentage of patients with the highest possible mobility score on the first postoperative day before (i.e., JH-HLM score = 8) and after extending the JH-HLM into the AMEXO scale (i.e., AMEXO score = 12). Moreover, the presence of a ceiling effect was also determined by evaluating the percentage of patients with the highest possible mobility score on each of the first three postoperative days. Because a ceiling effect might also affect the responsiveness of the measurement tool [25], the percentage of patients who showed a change in mobility score during the first three postoperative days before and after was evaluated. A change was defined as a difference in mobility score of at least one point during one of the first three postoperative days. Whether this may have been related to the four additional response categories 9 to 12 was evaluated by assessing the number of patients that showed both a change in mobility score and scored 9 to 12 using the AMEXO scale during one of the first three postoperative days.

Procedures

Routine care data registration procedures before and after were the same. All mobility scores were based on a patient's mobilization (i.e., what a patient has actually done) over a fixed observation period (e.g. nurse shifts or physical therapist session) [13]. Nurses were instructed to document the mobilization, at the end of each day and evening shift, using the mobility scale implemented at that time. The highest level of mobilization that the nurse observed during her shift was documented in the patient's electronic medical record and used to set mobilization goals and discuss mobilization success inter-professionally and with the patient [17]. All patients who were admitted to one of the surgical wards received a leaflet with information about the JH-HLM scale or AMEXO scale. Additionally, patients were informed by the nurses on the use of mobility scale and were asked to keep track of their mobility scores in addition to the health care professionals. In correspondence with the study performed by Hoyer et al. [12], the JH-HLM and AMEXO scale were used by nurses, physicians, and physical therapists to discuss mobilization success, barriers to mobilizing patients, set mobilization goals and facilitate discharge planning in routine clinical care.

The following patient characteristics were collected: age, sex, surgical area, acute admission and hospital length of stay. Furthermore, the Katz Activities of Daily Living (Katz-ADL) score [26] and the John Hopkins Fall Risk Assessment Tool (JHFRAT) [27] were collected and used to provide insight into the independence in physical functioning.

Data analysis

All analysis were conducted using IBM-SPSS Statistics version 26 (IBM Corp, Armonk, New York) and R (R core team, Vienna, Austria). A two-tailed p-value of 0.05 was considered statistically significant. Normality of data was evaluated by visually inspecting continuous and ordinal data using Q-Q plots. Patient characteristics were described descriptively and differences in patient characteristics before-after extending the JH-HLM into the AMEXO scale were assessed using independent t-tests, Mann-Whitney U tests or Fisher's Exact tests, depending on normality and type of data. Due to low number of patients having Katz-ADL score 1 to 6, we recoded this variable to a binary variable (i.e., number of patients scoring 1 to 6 vs number of patients scoring 0).

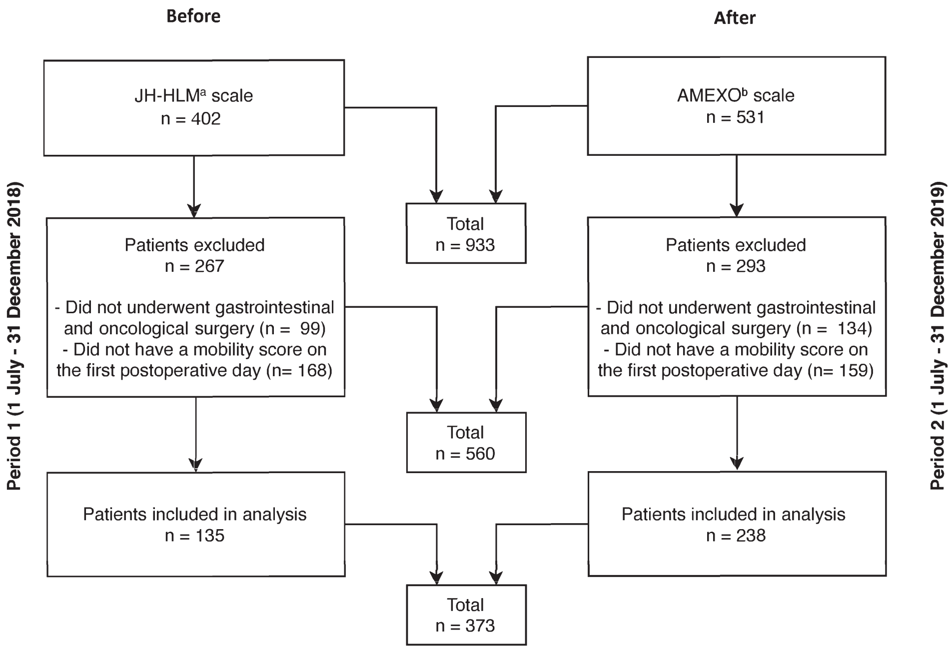
Due to the fact that $>$ 15% of the mobility scores on the second and third postoperative days were missing a multiple-imputation model with 10 imputed sets was applied to both variables and pooled using Rubin's rules [28,29]. Missing data were imputed using all patient characteristics, the mobility score of the first postoperative day, and if available, mobility scores of the second or third postoperative day. Because of the non-normal distribution of missing data predictive mean matching was used [28]. Evaluation of the ceiling effect was performed on both the dataset before imputation as well as after imputation; results were presented separately.

Only the highest mobility score on each postoperative day was used for analysis, as has been in previous studies using the JH-HLM scale to assess mobilization [17]. First, the percentage of patients scoring the highest possible mobility score on the first three postoperative days and the percentage of patients who showed a change in mobility score during the first three postoperative days were analyzed descriptively. Univariable and multivariable logistic regression analyses with backward selection were used to assess the before-after differences with respect to (1) the percentage of patients scoring the highest possible mobility score on the first postoperative day, (2) the percentage of patients scoring the highest possible mobility score during one of the first three postoperative days, and (3) the percentage of patients who showed a change in mobility score during the first three postoperative days. Odds-ratio's (ORs) and their associated 95% confidence intervals (CIs) were calculated to describe the before-after differences. Patient characteristics that differed significantly before-after extending the JH-HLM into the AMEXO scale were considered as covariates.

Results

Study population

Overall, 933 surgical patients were assessed for eligibility (before n = 402; after n = 531), of whom 560 were excluded (60%). Main reasons for exclusion were no gastrointestinal and oncological surgery (before n = 99; after n = 134) or no mobility score on the first postoperative day (before n = 168; after n = 159). Consequently, a total of 373 patients (before n = 135; after n = 238) were included for analysis (Fig. 1).



[a] *John Hopkins Highest Level of Mobility;* [b] *AMsterdam UMC Extension of the John Hopkins Highest Level of mobility*

Figure 1. Flow diagram of patient inclusion.

Of the 135 patients whose mobilization was assessed before extending the JH-HLM into the AMEXO scale, 65 (48.0%) patients had a JH-HLM mobility score on each of the first three postoperative days. In 35 (25.9%) patients the JH-HLM mobility score was missing on the second postoperative day, and in 60 (44.4%) patients the JH-HLM mobility score was missing on the third postoperative day. Of the 238 patients whose mobilization was assessed after extending the JH-HLM into the AMEXO scale, 73 (30.7%) patients had a AMEXO mobility score on each of the first three postoperative days. In 99 (41.6%) patients the AMEXO mobility score was missing on the second postoperative day, and in 134 (56.3%) patients the AMEXO mobility score was missing on the third postoperative day. The distribution of mobility scores on all three postoperative days before and after extending the JH-HLM into the AMEXO scale can be found in Additional file 2 (before imputation) and Table 1 (after imputation).

Table 1. Distribution of the JH-HLM and AMEXO mobility scores during the first three postoperative days (after imputation data)

Measurement instrument		**JH-HLM[a] scale (n = 135)**			**AMEXO[b] scale (n = 238)**		
Postoperative day, mobility score[c] (n,%)		**Day 1**	**Day 2**	**Day 3**	**Day 1**	**Day 2**	**Day 3**
Score 12	Walking approximately 3750 ft / 1125 m or more	N/A	N/A	N/A	4 (1.7)	18 (7.6)	26 (10.9)
Score 11	Walking approximately 2500 ft / 750 m or more	N/A	N/A	N/A	9 (3.8)	7 (2.9)	25 (10.5)
Score 10	Walking approximately 1500 ft / 450 m or more	N/A	N/A	N/A	17 (7.1)	20 (8.4)	28 (11.8)
Score 9	Walking approximately 750 ft / 225 m or more	N/A	N/A	N/A	28 (11.8)	64 (26.9)	53 (22.3)
Score 8	Walking approximately 250 ft / 75 m or more	61 (45.2)	98 (72.6)	94 (69.6)	73 (30.7)	71 (29.8)	57 (24.0)
Score 7	Walking approximately 25 ft / 7.5 m or more	17 (12.6)	12 (8.9)	21 (15.6)	38 (16.0)	32 (13.4)	27 (11.3)
Score 6	Walking 10 or more steps	16 (11.9)	9 (6.7)	9 (6.7)	11 (4.6)	8 (3.4)	4 (1.7)
Score 5	Standing for greater than or equal to 1 min	6 (4.4)	3 (2.2)	7 (5.2)	16 (6.7)	6 (2.5)	7 (2.9)

Score 4	Transferring to chair	20 (14.8)	8 (5.9)	3 (2.2)	16 (6.7)	5 (2.1)	5 (2.1)
Score 3	Sitting at edge of bed	11 (8.2)	4 (3.0)	1 (0.7)	12 (5.0)	3 (1.3)	3 (1.3)
Score 2	Bed activities	3 (2.2)	1 (0.7)	0 (0.0)	6 (2.5)	4 (1.7)	3 (1.3)
Score 1	Only lying	1 (0.7)	0 (0.0)	0 (0.0)	8 (3.4)	0 (0.0)	0 (0.0)

ft. feet, m. meters, N/A not applicable; [a]John Hopkins Highest Level of Mobility; [b]Amsterdam UMC Extension of the John Hopkins Highest Level of mObility; [c]the highest mobility score achieved on each postoperative day (i.e., 24 h), assessed per nursing shift (e.g., day shift with ambulation distance of 300 m and evening shift with ambulation distance of 460 m means AMEXO 10 on that postoperative day)

4

Patient characteristics

Patient characteristics are presented in Table 2. No significant differences before-after extending the JH-HLM into the AMEXO scale were observed for all patient characteristics ($p > 0.05$), except for the number of elective hospital admissions ($p = 0.024$).

Table 2. Patient characteristics

Characteristics	JH-HLM[a] scale	AMEXO[b] scale	
	n = 135	n = 238	p values
Age (years) (median, IQR)	63 (50-71)	64 (51-72)	$p = 0.647$
Sex (male) (n, %)	72 (53.3)	149 (62.6)	$p = 0.100$
Surgical area (n, %)			$p = 0.827$
Upper gastrointestinal surgery	29 (21.5)	56 (23.5)	
Hepato-pancreato-biliary surgery	46 (34.1)	84 (35.3)	
Colorectal surgery	60 (44.4)	98 (41.2)	
Number of elective admissions (n, %)	129 (95.6)	211 (88.7)	$p = 0.024$
Hospital length of stay (days) (median, IQR)	7 (5-11)	7 (5-12)	$p = 0.616$
Missing data (n, %)*	0 (0.0)	1 (0.4)	
Katz Activities of Daily Living score[c]	1 (2.2)	5 (6.2)	$p = 0.416$
(n, % of patients scoring ≥ 1)			
Missing data (n, %)*	89 (65.9)	157 (66.0)	
John Hopkins Fall risk Assessment Tool			$p > 0.999$
Low risk (n, %)	46 (34.1)	81 (34.0)	
Moderate risk (n, %)	0 (0.0)	0 (0.0)	
High risk (n, %)	0 (0.0)	0 (0.0)	
Missing* (n, %)	89 (65.9)	157 (66.0)	

*[a] = John Hopkins Highest Level of Mobility; [b] = Amsterdam UMC Extension of the John Hopkins Highest Level of mobility; *Missing data only reported if present; [c] = number of patients scoring 1 to 6 on the Katz Activities of Daily Living*

Patient characteristics

Sixty-one of the 135 (45.2%) patients scored the highest possible mobility score on the first postoperative day before extending the JH-HLM into the AMEXO scale (i.e., JH-HLM = 8). When divided into subgroups, 20/29 (68.9%) patients after upper gastrointestinal surgery, 17/46 (36.9%) patients after hepato-pancreato-biliary surgery, and 24/60 (40%) patients after colorectal surgery scored the highest possible mobility score on the first operative day before extending the JH-HLM into the AMEXO scale. In contrast, 4/238 (1.7%) patients scored the highest possible mobility score on the first postoperative day after extending the JH-HLM into the AMEXO scale (i.e., AMEXO = 12) (OR = 0.021, CI = 0.007-0.059, $p < 0.001$). Furthermore, 118/135 (87.4%) patients scored the highest possible mobility score on one of the first three postoperative days before, compared to 40/238 (16.8%) patients after extending the JH-HLM into the AMEXO scale (OR = 0.028, CI = 0.013-0.060, $p < 0.001$). A change in mobility score was observed in 88/135 (65.2%) patients before, compared to 225/238 (94.5%) patients after extending the JH-HLM into the AMEXO scale (OR = 9.101, CI = 4.046-20.476, $p < 0.001$). Of these 225 patients, 165 (73.3%) patients showed a change in mobility score and scored AMEXO scale response category 9 to 12 on one of the first three postoperative days. The number of elective hospital admissions did not significantly affect the logistic regression models. A complete case analysis using the before imputation dataset can be found in Additional file 3.

Discussion

This study demonstrated that healthcare professionals frequently experienced a ceiling effect when they use the JH-HLM scale to assess mobilization after gastrointestinal and oncological surgery. In 87.4% of the patients, the highest possible mobility score was used at least once during the first three postoperative days. And in almost half of the patients, the highest possible mobility score was already used on the first postoperative day. Extending the JH-HLM by adding four additional response categories into the AMEXO scale resulted in a significant decrease of this ceiling effect. Moreover, a change in mobility score was more frequently observed and in 69.2% of the patients this change in mobility score was combined with the use of response category 9 to 12.

Previous studies did not report a ceiling effect when healthcare professionals use the JH-HLM scale to assess mobilization in adult patients admitted to general medicine, neuroscience or general surgical ward [11-13,17,20,21,30]. The ceiling effect found in this study might be explained by the fact that ceiling effects are often encountered when an existing scale is applied to a new target population [25]. Initially, the JH-HLM scale was developed for a general medicine patient population [12] and the patients previously assessed using the JH-HLM scale were similar to this patient population as many of these patients were acutely admitted with diseases warranting immediate medical attention (e.g., infection diseases, craniotomy, stroke, chronic obstructive pulmonary disease exacerbation). This is in contrast with our study sample of patients admitted for gastrointestinal and oncological surgery. Almost all admissions were planned, which allowed healthcare professionals to screen patients before surgery and, in case it was necessary, offer them the opportunity to follow some form of prehabilitation [31]. This was substantiated by our data on the patient's fall risk and independence in daily activities — little to none of the patients included in our sample had risk of risk or was limited in activities of daily living before surgery.

In line with previous studies, the majority of patients showed a change in mobility score when healthcare professionals used the JH-HLM to assess mobilization of hospitalized patients [12,17,21,30]. However, our findings also show that when healthcare professionals used the AMEXO scale to assess early postoperative mobilization instead, the number of patients who show a change in mobility score during the first three postoperative days was significantly higher. And in 69.2% of the patients, this change in mobility score was combined with the use of the four newly added response categories 9 to 12. These findings indicate that extending the JH-HLM into the AMEXO scale might not only have reduced the ceiling effect, but might also have improved the scale's ability to detect mobilization changes during postoperative care [25,32].

Many different measurement instruments are currently available to assess aspects of 'mobility' in hospitalized adult patients, including the de Morton Mobility Index (DEMMI), Hierarchical Assessment of Balance and Mobility (HABAM), Short Physical Performance Battery (SPPB), Performance Oriented Mobility Assessment (POMA), Elderly Mobility Scale (EMS) and the AM-PAC "6-clicks" Basic Mobility short form [13,23,33,34]. Almost all of these measurement instruments, however, focus on the 'mobility' aspect of what the patient is capable of doing in a standardized environment. In previous research, this has often been described as the mobility capacity [14] or motor capacity [35] of the patient. In contrast, the JH-HLM and the AMEXO scale are both measurement tools used to assess what patients actually do in ‘current’ (usual) environment, often referred to as mobility performance [14,35]. While this is a very relevant distinction, the term mobility is often used interchangeably in both research and clinical practice. The John Hopkins University Hospital solved this by using the AM-PAC “6-clicks” Basic Mobility short form on one side and the JH-HLM on the other [13]. Other tools that can be used alongside the JH-HLM or AMEXO scale to assess the mobility capacity after gastrointestinal and oncological surgery instead could be the DEMMI or the SPPB; however, advantages and disadvantages in terms of validity, reliability, responsiveness in patients after gastrointestinal and oncological surgery as well as applicability and usability in routine clinical care should be considered.

Strengths and limitations

A strength of this study is the fact that all patients after gastrointestinal and oncological surgery who were admitted to two wards in a university medical center were included. Although the population in non-university hospitals may differ, most hospitals have implemented ERAS program and early mobilization has become universal in surgical practices worldwide [2,3]. Therefore, the results of this study are most likely generalizable to other similar surgical settings.

This study also has to be interpreted in light of some limitations. First, our nonrandomized, uncontrolled before and after study design does not allow us to conclude a direct causation between extending the JH-HLM into the AMEXO scale and the reduction in ceiling effect [36]. Second, although several patient characteristics were considered in our analysis as covariates, we cannot rule out the possibility that other potentially important covariates we were unable to extract from the hospital administrative system (e.g., co-morbidities, type of surgical procedures) may have influenced the observed differences in ceiling effects. Third, because there is no difference in documentation procedures before and after extending the JH-HLM into the AMEXO scale, we hypothesize there are no substantial differences in underlying reasons for missing data when comparing these two groups. Instead, we believe that the before-after differences in missing data may have been caused by an increased documentation of the first postoperative day (i.e., the inclusion criteria) due to the implementation of the AMEXO scale. Still, certain patient groups (e.g., patients with significant mobility and/or cognitive impairments, patients who mobilize faster than expected) may be underrepresented throughout the entire study, therewith limiting the generalizability of our findings. Fourth, within this study a ceiling effect was defined as scoring the highest possible mobility score. As described by Braun et al., patients who score within the minimal detectable change (MDC) of the highest possible score can also be regarded as being at the ceiling effect, as a real change could cross the ceiling [33]. Although Hoyer et al. [13] reported a MDC_{95} of 0.6 for the JH-HLM, the MDC_{95} might have increased over the 1.0 after extending the JH-HLM into the AMEXO scale. Fifth, the scientific limitations that come with single-item measures – such as the JH-HLM and AMEXO – require healthcare professionals, researchers, and policymakers to carefully consider what they intend to use these scales for [37]. While these scales are easy-to-use tools for patients and healthcare professionals to improve mobilization levels during routine clinical care, other more valid and reliable measures for mobility performance should be used to evaluate new interventions.

Recommendations for future research

Although local healthcare professionals found the AMEXO scale to be a suitable tool to assess mobilization after gastrointestinal and oncological surgery in current clinical care, further psychometric evaluation is warranted. Regarding the validity of the AMEXO scale we would suggest using another tool measuring mobility performance (e.g., accelerometers, concurrent video recordings) to determine whether the response categories of the AMEXO scale are validly assessed after gastrointestinal and oncological surgery (i.e., construct or criterion validity). Furthermore, the inter-rater reliability, test-retest reliability and the responsiveness of the AMEXO scale in patients after gastrointestinal and oncological surgery should be assessed using established methods as described by COSMIN (COnsensus-based Standards for the selection of health Measurement Instruments) [25,38].

Furthermore, involving patients in improving and sustaining postoperative mobilization has the potential to impact adherence to the ERAS program which is central to effectiveness [39,40]. The JH-HLM and AMEXO scale have both been developed set individual patient mobilization goals; however, how healthcare professionals can efficiently involve patients in determining these goals and become motivated to achieve them is still unknown. Behavior change techniques such as goal-setting, self-monitoring, instant feedback and reward, have shown to be promising in involving and motivating patients [4]. More insight is needed on how these scales relate to these behavioral change techniques and what else healthcare professionals may need to sustainably improve early mobilization levels in gastrointestinal and oncological surgery patients (e.g., changes to the hospital environment to provide more meaning to ambulation [41]). Although we believe mobility scales are not the only solution to improve early mobilization levels [42], we dare say it is a good first step towards achieving higher mobilization levels in patients after gastrointestinal and oncological surgery.

Lastly, early mobilization entails the incremental increase in activity ranging from passive range-of-motion exercises to active ambulation, depending on the physical capabilities of the patient, from the first day after surgery to reach predetermined targets using a standardized and structured approach [6,7,9]. To provide health-care professionals and policymakers with guidance on how and with what speed mobilization should be increased, future research should explore different early mobilization protocols in relation to surgical outcome, length of stay and mortality. Given the low administrative burden of the AMEXO scale, the AMEXO scale can be used to assess and document the mobilization levels in such studies.

Conclusions

Healthcare professionals who use the JH-HLM scale to assess early mobilization in patients after gastrointestinal and oncological surgery were frequently hampered by a ceiling effect. Extending the JH-HLM into the AMEXO scale decreased this ceiling effect significantly, making the AMEXO scale more appropriate to assess early mobilization and set daily mobilization goals after gastrointestinal and oncological surgery. Furthermore, the use of the AMEXO scale in patients after gastrointestinal and oncological surgery may provide healthcare professionals with an opportunity to involve patients in creating a culture of safe and improved postoperative mobilization.

Supplementary Information

Additional file 1 to 3 can be found online: https://doi.org/10.1186/s12893-021-01445-3

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Part II

Understanding why hospitalized patients are physically inactive

Chapter 5

Barriers and enablers to physical activity in patients during hospital stay: a scoping review

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Abstract

Background
Low levels of physical activity are common during the hospital stay and have been associated with negative health outcomes. Understanding barriers and enablers to physical activity during a hospital stay can improve the development and implementation of tailored interventions aimed at improving physical activity. Previous studies have identified many barriers and enablers, but a comprehensive overview is lacking. This study aimed to identify and categorize all published patient- and healthcare professional-reported barriers and enablers to physical activity during a hospital stay for acute care, using the Theoretical Domains Framework (TDF).

Methods
We conducted a scoping review of Dutch and English articles using MEDLINE, CINAHL Plus, EMBASE, PsycINFO, and Cochrane Library (inception to September 2020), which included quantitative, qualitative, and mixed-methods studies reporting barriers and enablers to physical activity during a hospital stay for acute care, as perceived by patients or healthcare professionals. Two reviewers systematically extracted, coded, and categorized all barriers and enablers into TDF domains.

Results
Fifty-six articles were included in this review (32 qualitative, 7 quantitative, and 17 mixed-methods). In total, 264 barriers and 228 enablers were reported by patients, and 415 barriers and 409 enablers by healthcare professionals. Patient-reported barriers were most frequently assigned to the TDF domains *Environmental Context & Resources* (*ECR*, n = 148), *Social Influences* (n = 32), and *Beliefs about Consequences* (n = 25), while most enablers were assigned to ECR (n = 67), Social Influences (n = 54), and *Goals* (n = 32). Barriers reported by healthcare professionals were most frequently assigned to *ECR* (n = 210), *Memory, Attention and Decision Process* (n = 45), and *Social/Professional Role & Identity* (n = 31), while most healthcare professional-reported enablers were assigned to the TDF domains *ECR* (n = 143), *Social Influences* (n = 76), and *Behavioural Regulation* (n = 54).

Conclusions
Our scoping review presents a comprehensive overview of all barriers and enablers to physical activity during a hospital stay and highlights the prominent role of the TDF domains *ECR* and *Social Influences* in hospitalized patients' physical activity behavior. This TDF-based overview provides a theoretical foundation to guide

clinicians and researchers in future intervention development and implementation.

Scoping review registration
No protocol was registered for this review

Keywords
Physical activity; Mobility; Hospital; Barrier; Enabler; Theoretical Domains Framework

Contributions to the literature

- Physical inactivity during the hospital stay is a frequent problem, but an overview of patient- and healthcare professional-reported barriers and enablers to physical activity was lacking.
- The majority of barriers and enablers were categorized under the TDF-domains *Environmental Context and Resources* and *Social Influences*, highlighting the need for interventions that target the physical environment, hospital care processes, organizational characteristics, resources, patient-related factors, and social influences.
- Our comprehensive theory-informed overview of all published barriers and enablers to physical activity during a hospital stay can assist clinicians and researchers in developing and implementing tailored interventions in local clinical practice.

Introduction

Hospitalized patients spend between 87 and 100% of their time lying in bed or sitting, irrespective of the reason for admission [1]. Low levels of physical activity have been associated with negative health outcomes like functional decline [2,3], increased length of stay [4], increased risk of institutionalization [5,6], and mortality [2,3,7,8]. Previous research has shown that these negative health outcomes of inactivity can be counteracted by increasing physical activity levels [9-13]. Thus, interventions aimed at increasing the physical activity levels of hospitalized patients are of great importance [14].

Many different barriers and enablers influence patients' physical activity behavior [14-20]. While barriers reduce or negatively affect a patient's physical activity behavior [15,18,21], enablers enhance or positively affect this behavior [14,16,19,20]. Brown et al. have investigated barriers to physical activity in older adults admitted to a medical ward [15]. They identified having symptoms (e.g., weakness, pain, fatigue), being concerned about falls, and a lack of staff to assist with out-of-bed physical activity as frequently reported barriers. So et al. also described not being provided with adequate walking aids and being attached to an intravenous line as barriers [14]. Moreover, they identified many enablers, such as being encouraged to exercise, preventing the negative effects of prolonged bed rest, and promoting functional recovery.

Over the past two decades, the number of studies identifying barriers or enablers to physical activity during a hospital stay for acute care has grown significantly [14-21]. In these studies, barriers and enablers were identified in a wide variety of patient populations and clinical settings [14-21]. Furthermore, they were explored from the perspective of patients [14,20], healthcare professionals (HCPs) [16-18,21], or both [15,19]. To our knowledge, no comprehensive overview of barriers and enablers to physical activity during a hospital stay for acute care has been published. Such a comprehensive overview would provide clinicians and researchers with a better understanding of these barriers and enablers. This might improve the development of future interventions or implementation of existing interventions in different health care settings.

To be able to use such an overview in future intervention development or translation, it is essential to adopt a theoretical framework that links barriers and enablers to intervention strategies. A theoretical framework can help to guide interventions targeting modifiable factors for physical activity during the hospital stay for acute care [22,23]. Moreover, using a theoretical framework to identify barriers and enablers to behavioral change has been demonstrated to be more successful in changing behavior than using a non-theory-driven approach [24,25].

One such integrative theoretical framework is the Theoretical Domains Framework (TDF) [25]. The TDF facilitates a systematic and theoretically based approach to behavior change. The validated TDF contains 14 domains, comprising 84 theoretical constructs from 33 theories of behavior and behavior change. Barriers and enablers can be categorized in the following domains: *Knowledge, Skills, Social/ Professional Role and Identity (SPRI), Beliefs About Capabilities, Optimism, Beliefs about Consequences, Reinforcement; Intentions, Goals, Memory, Attention and Decision Processes (MADP), Environmental Context and Resources (ECR), Social Influences, Emotion,* and *Behavioural Regulation*. The TDF has been extensively used as a guide to identify and categorize modifiable factors that influence behavior [25]. The objective of this review was to identify and categorize patient- and HCP-reported barriers and enablers to physical activity during a hospital stay for acute care, using the TDF.

Methods

Study design

A scoping review was performed to explore the nature and quantity of published literature on barriers and enablers to physical activity during a hospital stay for acute care, as perceived by hospitalized patients and their HCPs. We used the scoping review methodology suggested by Arksey and O'Malley [26] and developed further by Levac, Colquhoun, and O'Brien [27,28]. The Joanna Briggs Institute (JBI) guidance document for the conduct of scoping reviews and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Review (PRISMA-ScR) were used to inform the methodology (Additional file 1) [29,30]. The TDF was used to categorize the barriers and enablers extracted from the included studies [25], as described in further detail in "Collating, summarizing, and reporting the results". No protocol was registered for this review.

Search strategy and study selection

A comprehensive search strategy was developed in collaboration with an experienced research librarian (FvE) of the University of Amsterdam (Additional file 2). An electronic database search of MEDLINE (through Pubmed), CINAHL Plus, Cochrane, EMBASE, PsycINFO, and the Cochrane library was performed, from the inception of the electronic databases to September 23, 2020.

All electronic database searches were combined and de-duplicated in Endnote version X9.1 (Clarivate Analytics, Philadelphia, Pennsylvania, USA) [31]. Two reviewers (SJGG and HCvDH) independently screened all titles and abstracts to determine eligibility, based on the following inclusion and exclusion criteria. Studies were considered eligible if they reported barriers or enablers to physical activity during a hospital stay as perceived by patients or HCPs. Patients had to be hospitalized in an acute care setting and HCPs had to be involved in clinical care (e.g., physicians, nurses, nursing assistants, occupational therapists, and physiotherapists). Barriers were defined as any factor reducing or negatively affecting a patient's engagement in physical activity. Enablers were defined as any factor enhancing or positively affecting a patient's engagement in physical activity. Barriers and enablers had to be self-reported. Studies reporting factors associated or correlated to physical activity during were not included in this study [32]. Published full-text articles using quantitative, qualitative, or mixed-method study designs were considered, as was gray literature (i.e., academic papers, theses, and dissertations). Only studies written in English or Dutch were included. Studies reporting solely on children (< 18 years), short-stay admissions (< 24 h), the Intensive Care Unit, or psychiatric ward were excluded because of the differences in care and context (e.g., in terms of organization of care, length of hospital stay, patient characteristics, and care provided). Protocols and reviews were excluded as they lack empirical data. Case studies were also excluded as they often describe extreme cases that do not represent the general population of hospitalized patients. Lastly, conference abstracts were excluded.

To ensure that at least 80% agreement was reached between the reviewers in determining eligibility based on study titles and abstracts, a pilot was performed using 5% of the references. The pilot resulted in minor revisions of the inclusion and exclusion criteria, to enhance the clarity of the criterion descriptors. Full-text articles were obtained when studies fulfilled the criteria or when additional information was needed to determine eligibility. Subsequently, full-text articles were independently screened by both reviewers to determine eligibility. To ensure that at least 80% agreement was reached between reviewers in determining eligibility based on full texts, a pilot was first performed using 10% of the references.

To reduce the risk of missing relevant studies, reference lists of included studies and the reviewers' own literature databases were screened for additional studies. Any disagreements during the study selection process were resolved by discussion, mediated by a senior researcher (AFL). The web application of Rayyan QCRI (Qatar Computing Research Institute, Hamad Bin Khalifa University) was used to facilitate the study selection process [33]. A PRISMA-ScR flowchart was created to track the screening and inclusion process of this review [30,33].

Data extraction

Both reviewers (SJGG and HCvDH) independently extracted data using a custom-built data extraction form. Characteristics of included studies (author(s), year of publication, type of study, study aim, method, population, setting, and study sample) were extracted according to the JBI Guidance document for the conduct of scoping reviews [29]. Barriers and enablers identified in the results sections of the included studies were extracted using an iterative data extraction process. Barriers and enablers reported by patients and HCPs were extracted separately. Different extraction methods were used for qualitative and quantitative studies [34]. From qualitative studies, all barriers and enablers reported by patients or HCPs were extracted. For quantitative studies, the approach described by Weatherson [35] was used, meaning that barriers and enablers were extracted if ≥ 50% of participants agreed that the factor influenced patients' physical activity behavior. For example, in a survey with dichotomous answering options (agree/disagree), the factor "discussing physical activity during physician rounds increases patients' physical activity levels" was not extracted as an enabler if 42% of the HCPs agreed. Some questionnaire measures contained an intermediate category, such as 5-point Likert-scale questions with answering options: 1 = strongly agree, 2 = somewhat agree, 3 = neither agree nor disagree, 4 = somewhat disagree, and 5 = strongly disagree. Barriers or enablers were only extracted if at least 50% of participants somewhat agreed or strongly agreed that they perceived it as a barrier or enabler [35]. For example, if 60% of the HCPs agreed (18% somewhat agreed and 42% strongly agreed) that "discussing physical activity during physician rounds increases patients' physical activity levels" was an enabler, this factor was extracted as enabler [35]. If a quantitative study included open-ended questions, the responses were extracted as in qualitative studies.

To ensure the reliability of the data extraction process, the reviewers first extracted data from five randomly selected articles [14-16,19,36] and discussed their findings to resolve disagreements and improve the preliminary data extraction table. This process was then repeated with five other articles [17,21,37-39], after which both researchers agreed on the data extraction and no further changes to the data extraction table were required. Finally, each reviewer independently extracted half of the remaining articles and then critically reviewed the extraction of the other half performed by the other reviewer. Disagreements were resolved by discussion and rereading source material, and two senior researchers were consulted in case of discrepancies (AFL and MvdS).

Collating, summarizing, and reporting the results

Both reviewers (SJGG and HCvDH) independently coded the extracted barriers and enablers and categorized them into the 14 TDF domains [25,40,41]. The theoretical definitions and component constructs of the domains as presented in Additional file 3 were used to guide the coding process. Barriers and enablers were coded separately for patients and HCPs and were coded to more than one domain if the content suited multiple domains. To increase inter-coder reliability, the two reviewers (SJGG and HCvDH) met to discuss coding discrepancies and to iteratively modify the coding structure after every ten articles. Discrepancies were solved by discussion and rereading the articles. If necessary, a senior researcher (MvdS) was consulted to discuss and resolve discrepancies. This process was repeated until a final TDF categorization had been obtained. Two senior researchers (AFL and MvdS) supervised the categorization process. The entire authorship team reviewed the final categorization. MAXQDA Analytics Plus 2020 (VERBI Software, 2018, Berlin, Germany) was used to facilitate data coding and the categorization process. The numbers of different barriers and enablers assigned per TDF domain as well as the number of articles reporting on barriers and enablers per TDF domain were presented separately for patients and HCPs. Finally, a descriptive summary of the reported barriers and enablers was composed for patients and HCPs.

Results

The search retrieved 6716 studies, of which 2382 were excluded as duplicates. An additional three studies [42-44] were retrieved by hand-searching the researchers' own literature database (i.e., two studies which did not explicitly mention "barrier," "enabler," or "hospital" in the title and abstract, and one which was a Masters thesis). A total of 4334 studies were screened based on titles and abstracts. Of the 143 articles that were assessed as full texts, 45 were identified for inclusion [11,14-16,18-21,36-39,42-74]. An additional 11 studies were included after hand-searching the reference lists of included studies [17,75-84], resulting in a total of 56 included studies [11,14-21,36-39,42-84]. The PRISMA-ScR flowchart (Fig. 1) shows the screening and inclusion process.

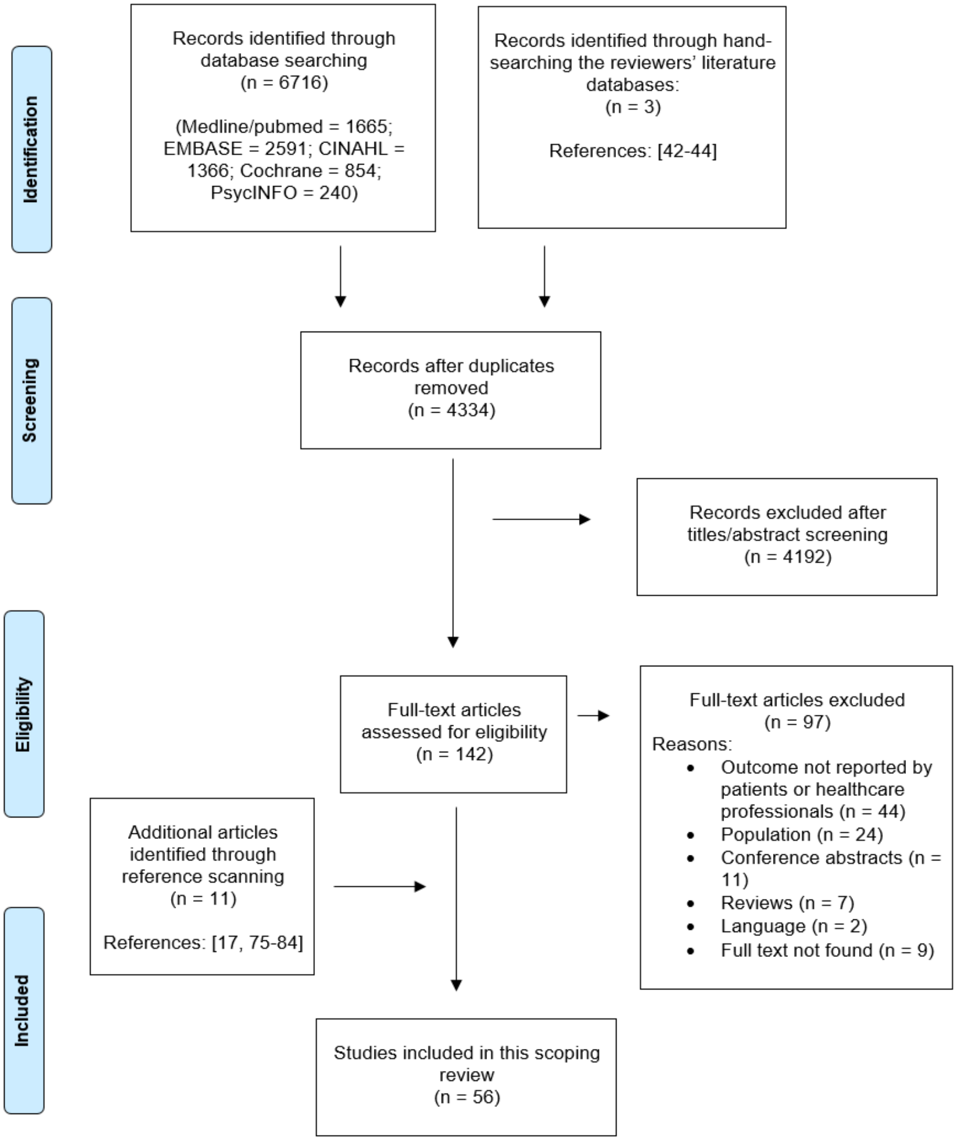

Figure 1. PRISMA-ScR flowchart

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Description of included studies

Additional file 4 presents an overview of the included studies. Of the 56 studies, 32 used a qualitative study design [14-20,38,42,44-46,49-54,57,61,67,68,70,72-76,78-80,83], seven a quantitative study design [21, 37, 39, 63, 66, 69, 82], and 17 a mixed-methods study design [11,36,43,47,48,55,56,58-60,62,64,65,71,77,81,84]. Nineteen studies reported barriers and enablers as perceived by patients [14,20,36,37,39,48,51,61,63-65,67,70,73,78,79,81,83], 23 reported those perceived by HCPs [16-18,21,38,42,43,47,50,52-55,57,59,60,68,69,74-76,80,82], and 14 reported those perceived by patients and HCPs [11,15,19,44-46,49,56,58,62,66,71,72,77,84]. Sample sizes varied between n = 6 and n = 345 patients and between n = 5 and n = 261 HCPs. Two studies did not specify the sample size [11,77], and one study only specified the number of included sites [47]. Further descriptions of the populations and settings included are provided in Additional file 4. The included studies were published between 2003 and 2020, and only seven studies were published before 2010 [15,52,56,75,77,78,82].

Identification of patient- and HCP-reported barriers and enablers to physical activity during a hospital stay for acute care

The results of the data extraction process are presented in Additional file 5. After coding and discussing all extracted fragments containing barriers and enablers, SJGG and HCvDH reached a consensus on 1316 barriers and enablers. Two hundred sixty-four (20.2%) patient-reported barriers and 415 (31.7%) HCP-reported barriers were coded. Two hundred twenty-eight (17.3%) patient-reported enablers and 409 (31.2%) HCP-reported enablers were coded.

Categorizing patient- and HCP-reported barriers using the TDF

Patient- and HCP-reported barriers were assigned to 13 of the 14 TDF domains. An overview of the TDF coding of all barriers is provided in Additional file 6 and summarized in Fig. 2. Patient-reported barriers were assigned most frequently to the TDF domains *ECR* (n = 148, 56.1%), *Social Influences* (n = 32, 12.1%), and *Beliefs about Consequences* (n = 25, 9.5%). Of the other 11 domains, the largest numbers of barriers were assigned to the domains *Emotion* (n = 16, 6.1%) and *SPRI* (n = 10, 3.8%). HCP-reported barriers were assigned most frequently to the TDF domains *ECR* (n = 210, 50.6%), *MADP* (n = 45, 10.8%), and *SPRI* (n = 31, 7.5%). Of the other 11 domains, the largest numbers of barriers were assigned to the domains *Beliefs about Consequences* (n = 27, 6.5%) and *Emotion* (n = 22, 5.3%). No patient- and HCP-reported barriers were assigned to the domain *Optimism*.

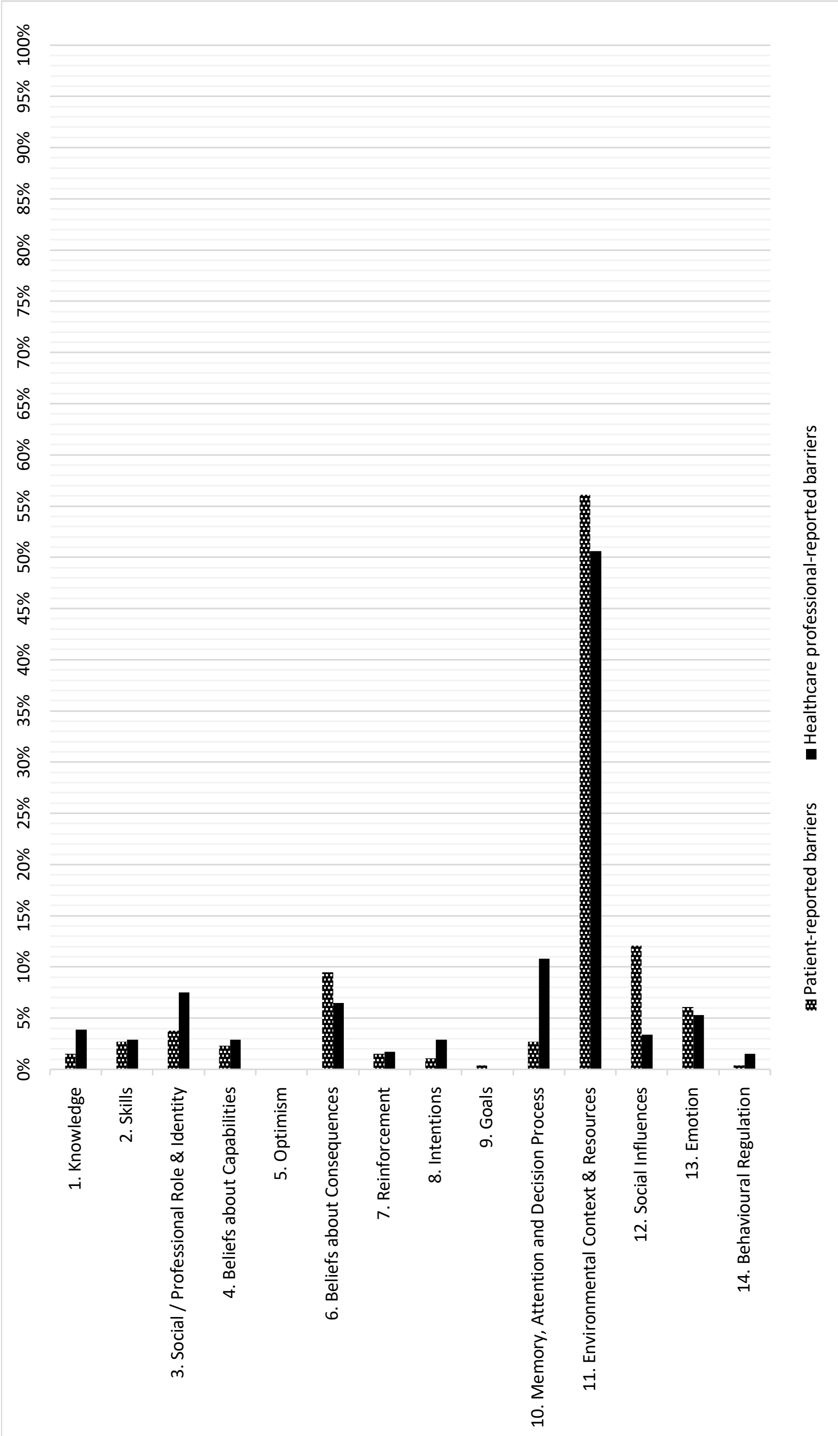

Figure 2. Barriers assigned to each domain of the Theoretical Domains Framework (% of total number of reported barriers)

The TDF domains to which barriers were most frequently assigned are highlighted below. The domain *ECR* had the majority of both patient- and HCP-reported barriers assigned to it and covered four main topics: (1) patient-related factors (e.g., medical factors, age, language barriers), (2) care processes and organizational characteristics (e.g., prescribed immobility, communication, hospital culture, bed-centered care), (3) physical environment of the hospital (e.g., room, unit, hospital), and (4) resources (e.g., limited time, staffing, equipment) (Additional file 6). Patient-reported barriers assigned to the domain *Social Influences* included interpersonal processes between patients, visitors, and HCPs that negatively influence physical activity, such as lack of encouragement and assistance and providing more care than necessary. Patient-reported barriers assigned to the domain *Beliefs about Consequences* included the belief that physical activity results in negative consequences (e.g., injuries, falling, or missing meals and care), the belief that rest is needed for recovery, and the belief that patients may be inconveniencing busy HCPs. Most of the HCP-reported barriers assigned to the domain *MADP* related to prioritization. A high workload and safety considerations resulted in physical activity receiving a lower priority than medical treatment or rest. HCP-reported barriers assigned to the domain *SPRI* included the passive and dependent attitude patients adopt during hospitalization (e.g., the idea that patients should remain in bed, personality, and character traits). In addition, HCPs mentioned the role they fulfill regarding physical activity (e.g., lack of role clarity in improving physical activity, attributing responsibility to others, and nurses lacking autonomy in deciding how and when to mobilize patients).

Categorizing patient- and HCP-reported enablers using the TDF

Patient- and HCP-reported enablers were assigned to 11 and 13 of the 14 TDF domains, respectively. An overview of the TDF-coding of all enablers is provided in Additional file 7 and summarized in Fig. 3. Patient-reported enablers were most frequently assigned to the TDF domains *ECR* (n = 67, 30.2%), *Social Influences* (n = 54, 24.3%), and *Goals* (n = 32, 14.4%). Of the remaining 11 domains, the largest numbers of enablers were assigned to the domains *Knowledge* (n = 24, 10.5%) and *Beliefs about Consequences* (n = 17, 7.7%). No patient-reported enablers were assigned to the domains *Reinforcement*, *MADP*, and *Emotion*. HCP-reported enablers were most frequently assigned to the TDF domains *ECR* (n = 143, 35.0%), *Social Influences* (n = 76, 18.6%), and *Behavioral Regulation* (n = 54, 13.2%). Of the remaining 11 domains, the largest numbers of enablers were assigned to the domains *SPRI* (n = 45, 11%) and *Knowledge* (n = 19, 4.7%). No HCP-reported enablers were assigned to the domain *Optimism*.

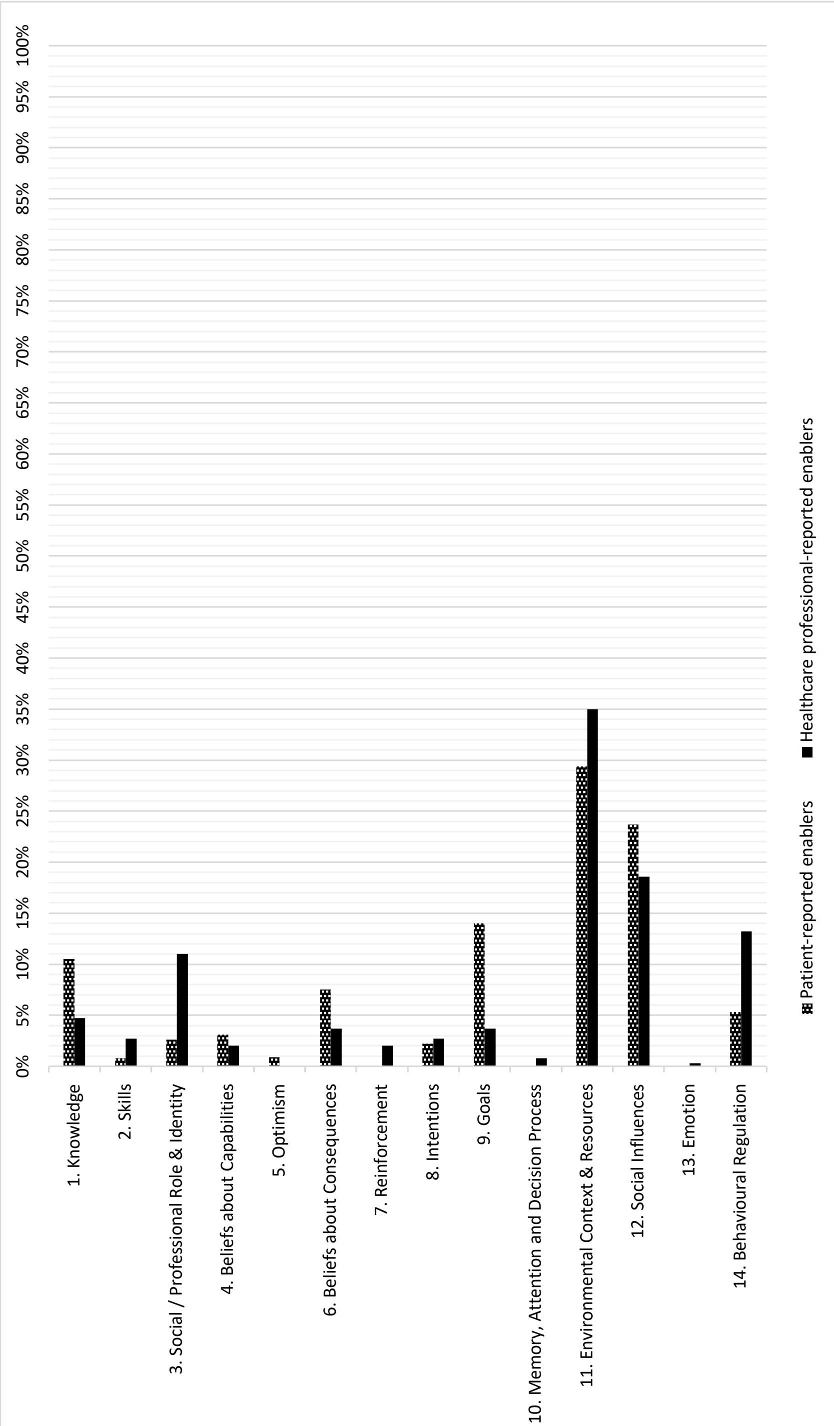

Figure 3. Enablers assigned to each domain of the Theoretical Domains Framework (% of total number of reported enablers)

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In line with the categorization of the barriers, most patient- and HCP-reported enablers were assigned to the domain *ECR* and covered the same four main topics: (1) patient-related factors, (2) care processes and organizational characteristics, (3) physical environment of the hospital, and (4) resources (Additional file 7). Patient- and HCP-reported enablers assigned to the domain *Social Influences* included interpersonal processes between patients and visitors or HCPs that positively influence physical activity, such as being encouraged and assisted. Patients also described that other patients motivated them to perform more physical activity, while HCPs described how leadership and multidisciplinary collaboration enabled them to improve patients' physical activity. Patient-reported enablers assigned to the domain *Goals* included the importance of having a goal (e.g., experiencing the positive effects of physical activity or preventing the negative effects of physical inactivity). This domain also included the importance of having autonomy and being involved in physical activity-related decision-making. HCP-reported enablers assigned to the domain *Behavioural Regulation* included strategies aimed at regulating behavior, such as providing education, appointing mobility champions, making performance and expectations visible, creating a habit, and using mobility documentation tools, reminders, daily schedules, exercise programs, and mobility audits.

Discussion

The aim of this study was to identify and categorize patient- and HCP-reported barriers and enablers to physical activity during a hospital stay for acute care, using the TDF. Our systematic search identified 679 barriers and 637 enablers, reported in 56 studies. The majority of barriers and enablers were assigned to the key domain *Environmental Context and Resources* (i.e., "patient-related factors," "care processes and organizational characteristics," "physical environment of the hospital," and "resources"). Other key TDF domains to which the largest numbers of barriers were assigned were *Social Influences, Beliefs about Consequences, Memory, Attention and Decision Process*, and *Social/Professional Role & Identity*. Additionally, other key domains to which the largest numbers of enablers were assigned were *Social Influences, Goals*, and *Behavioural Regulation*. This is the first scoping review of patient- and HCP-reported barriers and enablers relating to physical activity during the hospital stay for acute care using a TDF analysis. This review presents a comprehensive overview of these barriers and enablers from a theoretical perspective, which can help clinicians and researchers identify and target modifiable factors within future intervention development.

Our findings highlight the prominent role of the domain *Environmental Context and Resources* with respect to physical activity during the hospital stay for acute care. Upon hospital admission, patients are taken out of their own environment and enter a different, unfamiliar context, filled with many uncertainties. In addition to patients' illness and associated medical factors, the hospital environment exerts an inactivating influence on patients, resulting in a loss of autonomy and freedom [15,44]. Our findings indicate that "care processes and organizational characteristics," the "physical environment," "patient-related factors," and "resources" are the main topics of the domain *Environmental Context and Resources* that influence the physical activity behavior of hospitalized patients. Several studies have aimed to improve physical activity in hospitalized patients by targeting these main environmental factors [11,12,71,85]. "Care processes and organizational characteristics" was targeted by incorporating physical activity in usual care [12,85,86], creating policy to promote mobility [71], incorporating specific timeslots for physical activity in HCPs' schedules [71], improving communication [12], and providing patients with graded exercise programs [11]. "Physical environment" was targeted by providing interesting walking destinations [11], marked walking trails [71], distance markers in the hallway [71], ward maps and signs [11], and by making mobilization goals visible [12,86]. "Patient-related factors" were targeted by optimizing pain control [12], and "resources" by purchasing more walking aids [71], supporting physical activity with technology [86,87], and supplying activity diaries and exercise booklets [11,85].

Our results also highlight the role of the domain *Social Influences*, identified as the second most prominent TDF domain. The absence of encouragement and assistance by others (i.e., nurses, physical therapists, physicians, visitors, volunteers, or other patients) was identified as an important barrier by patients, whereas their presence as an important enabler. This was substantiated by HCPs, who also added multidisciplinary teamwork, leadership support, the presence of physical therapists, and involving visitors as important enablers of physical activity. Several studies have aimed to improve physical activity by targeting the domain *Social Influences*, by providing systematic encouragement and assistance from HCPs [11,71,85,86], involving volunteers or family members in basic mobility activities [11,86], and encouraging independence in activities of daily living [11].

Moreover, the domains *Beliefs about Consequences, Memory, Attention and Decision Process*, and *Social/Professional Role & Identity* also contained many barriers. Several studies have targeted these domains to improve patients' physical activity levels, such as providing education to counter the belief that physical activity will result in injuries [86,88], using shift huddles to address prioritizing physical activity [89], or mapping the therapy consultation process within a multidisciplinary team to create role clarity and avoid unnecessary treatments [90]. Likewise, the domains *Goals* and *Behavioural Regulation* contained many enablers. Examples of interventions that specifically focus on goal setting and behavioral regulation are the Johns Hopkins Highest Level of Mobility tool [12], the WALK-FOR 900 steps per day behavioral target [91], and Hospital Fit monitor [87]. All these interventions enable monitoring physical activity levels and setting physical activity goals in daily clinical care.

Our findings indicated that there were several TDF domains (e.g., *Skills*, *Optimism*, *Reinforcement*) to which few or no barriers and enablers were assigned. The many factors assigned to the TDF domains *Environmental Context and Resources* and *Social Influences*, and the few factors assigned to the domains *Skills*, *Optimism*, and *Reinforcement* are in agreement with the results of similar research performed in other populations, such as physical activity at school [35], work [92], or in primary care [93]. Although this highlights the prominent role of the domains *Environmental Context and Resources* and *Social Influences* on physical activity behavior, it does not indicate whether the domains *Skills*, *Optimism*, and *Reinforcement* do not contain relevant barriers and enablers to physical activity, or whether they were under-identified.

Lastly, although many patient-reported barriers and enablers were also reported by HCPs, our results demonstrated that HCPs perceived a greater number of barriers and enablers than patients. This could be explained by the different perspectives of patients and HCPs on physical activity during the hospital stay. Patients are hospitalized for a relatively short period, with their main focus being their illness and getting better. They experience how it feels to be a patient and how this influences their physical activity behavior. On the other hand, HCPs perceive barriers and enablers from a much broader perspective. Firstly, they report barriers and enablers from their own as well as their patients' perspectives. Secondly, they provide care to many patients with different pathologies, ages, and backgrounds. Thirdly, they perceive barriers and enablers related to providing care, different care processes, and organizational characteristics. These differences in perspectives between patients and HCPs emphasize that both must be taken into account to gain a comprehensive understanding of the barriers and enablers to physical activity during a hospital stay.

Strengths and limitations

This is the first scoping review on patient- and HCP-reported barriers and enablers relating to physical activity during the hospital stay for acute care using a TDF analysis. A strength of this study is that it was designed and conducted according to the systematic scoping review methodology and that it followed the PRISMA-ScR statement recommendations [26-30]. Secondly, almost all aspects of data collection, data extraction, and data analysis were carried out independently by two researchers, with a third party available in case of disagreements. Thirdly, given the extensive, thorough search strategy in multiple databases, along with the inclusion of quantitative, qualitative as well as mixed-methods study designs, we were able to present a complete overview of all barriers and enablers reported in the current literature. Fourthly, an additional strength of this study is the use of the TDF as a theoretical framework to categorize barriers and enablers. The use of the TDF ensured that the reviewers assessed barriers and enablers from a broad perspective, thereby also exploring underexposed domains.

We also recognize some limitations. While the use of the TDF facilitates reviewers in exploring barriers and enablers from a broad perspective, it does not provide an explanation as to how barriers and enablers are connected and influence one another. Another limitation of this study is that barriers and enablers are presented based on the number of articles in which they have been reported. As the frequency of reporting is primarily a function of the methods used to present the data, this alone should not be used as a proxy of importance. In other words, a barrier that has only been reported once may be just as relevant as one that has been reported many times. Furthermore, a secondary analysis of differences in perceived barriers and enablers among patient subgroups or among professions could not be performed due to the lack of detailed reporting in the included studies. Lastly, as this was a scoping review, no quality appraisal of included articles was performed [30].

Clinical implications and recommendations for future research

Our findings provide a comprehensive overview of barriers and enablers to physical activity during a hospital stay for acute care. The large number of barriers and enablers we found, distributed across many TDF domains, highlight the complexity of physical activity behavior during the hospital stay and the need for tailored interventions. A context-based assessment should be performed to determine which barriers and enablers can be targeted in a specific clinical setting. Our comprehensive overview will enable clinicians and researchers to perform this context-based assessment from a broad perspective and support them in establishing a behavioral diagnosis of what needs to change in a specific context in order to improve physical activity behavior during the hospital stay.

Subsequently, clinicians and researchers will be able to link relevant barriers and enablers to specific intervention strategies and behavior change techniques (BCTs) [25,41,94]. An example of a framework that could be used to assist clinicians and researchers in selecting appropriate BCTs is the Behaviour Change Wheel (BCW) [22]. Our TDF-based overview provides the initial step in developing and implementing theory-informed behavior change interventions aimed at improving physical activity during the hospital stay [41].

Given the large number of factors influencing the physical activity behavior of hospitalized patients, we recommend that clinicians and researchers develop and implement interventions targeted at multiple barriers and enablers. Previous research suggests that developing and implementing such tailored multimodal interventions may be more effective than unimodal interventions [95]. Moreover, given a large number of barriers and enablers assigned to the *Environmental Context and Resources* and *Social Influences* context in our review, we suggest that clinicians and researchers should always consider incorporating intervention strategies targeting these TDF domains in their multimodal interventions.

Future research should focus on exploring relationships between barriers and enablers both within and between TDF domains. Revealing these relationships may facilitate the assessment of barriers and enablers in specific clinical settings and may increase the effectivity of future tailored multimodal interventions. Future research is also needed to explore the differences in perspectives perceived by different patient subgroups (e.g., age, sex, pathologies). Similarly, more research is needed to investigate differences in perceived barriers and enablers among professions and how these differences relate to their role in improving physical activity during the hospital stay. Additionally, further research is needed to develop and validate a TDF-based questionnaire that could facilitate the context-based assessment of barriers and enablers across all TDF domains. Further research is needed to retrospectively identify which barriers and enablers to physical activity during the a hospital stay have been targeted in previously described intervention studies [94], so clinicians may be better able to implement these interventions in other contexts. Finally, there is a need for research assessing the effectiveness of tailored multimodal interventions that target context-based barriers and enablers to physical activity in hospitalized patients.

Conclusions

This article presents a comprehensive overview of 1316 patient- and HCP-reported barriers and enablers to physical activity during a hospital stay for acute care. A large number of barriers and enablers found highlight the complexity of physical activity behavior during the hospital stay. Our overview can assist clinicians and researchers in performing a context-based assessment to determine which barriers and enablers to target in future interventions. Given the large number of factors influencing the physical activity behavior of hospitalized patients, we recommend developing and implementing multimodal interventions. This scoping review also highlights the large role of environmental and social factors on physical activity behavior during the hospital stay and suggests that intervention strategies targeting these domains should be incorporated. Future research should focus on exploring the relationships between barriers and enablers both within and between different TDF domains. Revealing these relationships may facilitate the assessment of barriers and enablers in specific clinical settings and may increase the effectivity of future tailored multimodal interventions. Furthermore, future research is also needed to explore the differences in perspectives perceived among different patient subgroups or different professions. Lastly, a validated TDF-based questionnaire is needed to facilitate future context-based assessments of barriers and enablers, and further research should investigate the effectiveness of tailored multimodal interventions.

Supplementary Information

Additional file 1 to 6 can be found online: https://doi.org/10.1186/s13643-021-01843-x

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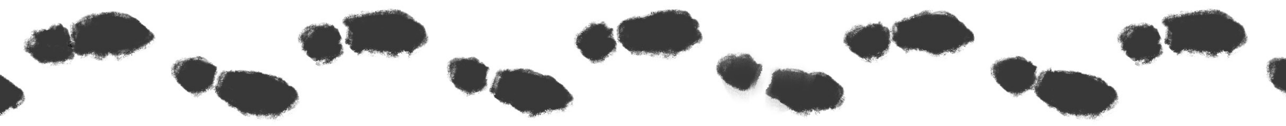

Chapter 6

Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals

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Abstract

Purpose
To identify healthcare professionals' perspectives on key barriers to improving physical activity in hospitalized adult patients, and to identify solutions to overcome these barriers.

Methods
We used an explanatory sequential mixed-methods study design in a Dutch university hospital. A survey exploring 39 potential barriers was completed by 15 physicians/physician assistants, 106 nurses, four nursing assistants, and four physical therapists working on surgery, internal medicine, and cardiology wards. Next, three in-depth semi-structured focus groups – comprising 30 healthcare professionals – discussed the survey findings to identify key barriers and solutions. Focus group discussions were analyzed using thematic analysis.

Results
Five themes were identified that described both the key barriers and the solutions to overcome these barriers. Healthcare professionals proposed several solutions, including clarifying the definition of physical activity, empowering patients to take responsibility for physical activity, giving physical therapists or physicians a prominent role in encouraging physical activity, and changing the hospital ward to entice patients to become physically active.

Conclusions
Healthcare professionals need clear guidelines, roles, and responsibilities when it comes to physical activity. They also need personalized interventions that empower patients in physical activity. Finally, hospital wards should be designed and furnished so that patients are encouraged to be active.

Keywords
Mobility; physical activity; hospital; barrier; solution; adults

Implications for rehabilitation

- Many healthcare professionals want to sustainably improve physical activity in hospitalized adults.
- For this they need clear guidelines that not only define physical activity, but also describe the roles and responsibilities of all members of the medical team.
- Healthcare professionals need interventions that help to empower patients to take an active role in physical activity during hospital stay.
- Hospital wards should be designed and furnished so that patients are encouraged to be physically active.

Introduction

Over one-third of hospitalized patients experience hospitalization-associated disability, defined as the loss of the ability to perform one or more activities of daily living independently due to hospital admission [1-4]. Hospitalization-associated disabilities (HADs) have been associated with a prolonged length of stay, increased risk of long-term institutionalization, and increased mortality [5-7]. Given the increasing number of patients being admitted to a hospital in the Netherlands [8], addressing HADs is becoming increasingly crucial.

HADs are known to be associated with low physical activity levels during hospital stay [9,10]. And interventions aiming to increase physical activity during hospital stay have proven to be effective in preventing HADs [11-13]. Nevertheless, physical activity levels during hospital stay remain low and patients continue to spend most of the time lying in bed or sitting [14,15].

To sustainably improve physical activity in hospitalized patients, a thorough understanding of the behavior of the healthcare professionals involved in medical and nursing care is needed [16,17]. Healthcare professionals report that while they are willing to improve physical activity in hospitalized patients, they also encounter multiple barriers, including insufficient knowledge, tools, physician's orders, and time [18-22]. The authors of a recent study in a Dutch university hospital proposed that the entire team involved in routine medical and nursing care should be responsible for prioritizing and improving physical activity in hospitalized patients [20].

When it comes to identifying key barriers to physical activity in clinical practice, such involvement of the team is limited by current methods of data collection. The limitations of surveys and individual interviews are that they may fail to include the priorities, group norms and cultural values of the team [23]. If healthcare professionals' perspectives are instead discussed in focus groups, we may be better able to identify the key barriers encountered in clinical practice by all members of the team rather just a select few. And we may also be able to identify collectively the solutions to overcome these key barriers.

To our knowledge, no studies have investigated these key barriers and solutions by discussing the perspectives of healthcare professionals in focus group discussions. Therefore, we conducted a mixed methods research study in which we first inventory the healthcare professionals' perspectives on improving physical activity in hospitalized patients. Thereafter, we discussed these perspectives in focus groups to identify key barriers and solutions. The research questions of this study were: What do the healthcare professionals working at a university hospital consider to be the key barriers to improving physical activity in adults during hospital stay? And what solutions will help them to overcome these barriers?

Materials and methods

Study design

This study used an explanatory sequential mixed methods study design. In this type of study, quantitative data is collected and analyzed first, followed by the collection and analysis of qualitative data. The qualitative phase builds directly on the results of the quantitative phase, allowing a more robust analysis and help to gain a better understanding of the problem [24]. In phase 1, we used a quantitative survey to identify factors that healthcare professionals perceived as important barriers to improving physical activity in hospitalized patients. In phase 2, we used in-depth qualitative focus group discussions to further explore these barriers and to collectively identify solutions that might help to overcome the key barriers. A certified Medical Research Ethics Committee approved the study protocol [W19_216 # 19.261]. All surveys were anonymized, and all focus group participants gave written informed consent to participate in the study. This study was reported according to the Good Reporting on a Mixed Methods Study (GRAMMS) criteria as proposed by O'Cathain, Murphy, and Nicholl [25] (Supplementary Material S1).

Context and study population

This study was conducted between March 2018 to June 2019 at a 1002-bed university hospital (Amsterdam University Medical Center (UMC), location Academic Medical Center) in Amsterdam, the Netherlands within five wards: two 29-bed gastrointestinal and oncology surgery wards, one 29-bed internal medicine hematology ward, one 29-bed internal medicine infectious diseases ward, and one 29-bed cardiology ward. The staff on each hospital ward was comprised of approximately 35 nurses who performed their duties in shifts (day, evening, night), 2-5 physicians or physician assistants dedicated to daily care, and one physical therapist. The healthcare professionals participating in this study met the following criteria: (1) they were employed as a physician, physician assistant, nurse, nursing assistant, or physical therapist (for at least 70% of full-time equivalent); and (2) were working on one of the following wards: gastrointestinal- and oncology surgery, internal medicine hematology, internal medicine infectious diseases, or cardiology.

Phase 1 – using surveys to identify important barriers

Data collection

To our knowledge, no surveys were available in the literature to assess all of the factors that might be perceived by healthcare professionals as a barrier to improving physical activity in hospitalized patients. We therefore developed a survey using the 38-item pilot checklist described by Huijg et al. [26], which is based on the Theoretical Domains Framework and aims to identify the most important barriers and enablers to the implementation of physical activity interventions [26-28]. The final version of the survey consisted of 39 items (Supplementary Material S2), and a detailed description of this survey's development can be found in Supplementary Material S3. A 5-point Likert response scale was used for all survey items with the following options: 1, strongly agree; 2, agree; 3, neutral; 4, disagree; 5, strongly disagree. Items were randomly alternated between positive and negative wordings to avoid response bias. Items with higher average scores indicate the barriers considered by healthcare professionals to be the most important when it comes to improving physical activity, while items with lower average scores indicate the barriers they consider the least important.

Recruitment

This survey was distributed digitally via an online survey system (Limesurvey GmbH., Hamburg, Germany) among all eligible healthcare professionals at each hospital ward. All eligible healthcare professionals were asked to complete the survey independently. Paper versions were also distributed to increase the response rate. Reminders were sent three times by e-mail, and healthcare professionals were reminded three times during staff meetings.

Data analysis

Quantitative data was analyzed using IBM-SPSS Statistics version 25 (IBM Corp, Armon, New York). Descriptive statistics of the study sample were expressed as means and standard deviations. Before analyzing the 39-item survey, the scoring order of negatively formulated items (questions 8, 9, 11, 13, 25, 28, 29, 30, 31, and 35) was reversed. After analyzing the survey, all items were listed in descending order (from most to least considered to be a barrier) with the scores expressed as mean and standard deviation (SD).

Integration – using the survey findings to build focus group topic guides
Methodological integration occurred by using the findings of phase 1 to build the topic guide for the focus group discussions of phase 2 [29]. The ten items with the highest average scores (i.e., indicating the most important barriers) were incorporated as main topics in the semi-structured focus group topic guides. Also, to facilitate the focus group discussion and validate the survey findings, at least three items with the lowest average scores (i.e., indicating the least important barriers) were incorporated in the semi-structured focus group topic guides.

Phase 2 – using focus groups to discuss these important topics

Recruitment
Because most healthcare professionals work in shifts, a combination of a "convenience" and a "purposive" sampling approach was used to assemble a heterogeneous group of participants with respect to age, working experience, and profession, as recommended by Holloway and Wheeler [23]. To facilitate effective discussions [23], each focus group consisted of 7-12 participants including at least one physician/physician assistant and at least six nurses/nursing assistants.

Data collection
One focus group was held for both surgery wards, one for both internal medicine wards and one for the cardiology hospital ward. To facilitate in-depth discussions, each focus group was moderated by a quality advisor (BMG) and a medical psychologist (SdM). In all focus group discussions, privacy was ensured, and the moderators experienced no limitations in terms of creating a cordial discussion atmosphere. The maximal amount of time used was 60 min, and each focus group was fully audiotaped.

Data analysis
Qualitative data was analyzed using MAXQDA Analytics Plus 2020 (VERBI Software, 2018, Berlin, Germany). The first author (SJGG) fully transcribed and checked all group discussions and notes. This was followed by a thematic analysis according to the methods of Braun and Clarke [30]. In detail, two authors (SJGG, BMG) assigned initial codes using all of the data from the first two focus groups. Next, both authors collectively developed a preliminary codebook and used the codebook to code the third focus group. The preliminary themes and the codebook were further discussed by both authors and finalized within three consensus meetings attended by a varying composition of the following participants: two nurses, a physician as-

sistant, a physical therapist (SJGG), a quality advisor (BMG), three senior researchers (RHHE, FvN, MvdS), and a medical psychologist (SdM). These analyses resulted in five themes based upon the data of all three focus groups together. The Dutch quotes and codes were translated into English and checked by a native speaker in line with recommendations of Van Nes et al. [31].

Trustworthiness

We enhanced the credibility of our findings in several ways. Firstly, we wanted to make sure that the focus group participants were given the opportunity to have in-depth discussions. Each focus group was therefore moderated by a quality advisor who was also a physical therapist (BMG), and by a medical psychologist (SdM), neither of whom had a professional or social relationship with any of the participants. Secondly, two authors (SJGG, BMG) coded the data independently, and multiple consensus meetings were held to discuss the codes and preliminary themes. Thirdly, we used member checking of synthesized analyzed data to explore whether results have resonance with the participants' perspectives [32]. Finally, we kept track of all methodological and analytical decisions during the study by maintaining an audit trail and writing methodological memos.

Results

Participant characteristics

Survey participants

In total, 15 physicians/physician assistants, 106 nurses, four nursing assistants, and four physical therapists completed the survey. Their median working experience was 5 years (interquartile range [IQR] 2-14.5) (Table 1).

Table 1. Descriptive data of survey participants

		Surgery ward #1 n = 24		Surgery ward#2 n = 33		Hematology n = 23		Infectious diseases ward n = 26		Cardiology ward n = 26	
Profession (n, %)	Physician	1	(4.2)	4	(12.1)	1	(4.2)	4	(15.4)	2	(7.7)
	Physician assistant	1	(4.2)	1	(3)	1	(4.2)	0	(0)	0	(0)
	Nurse	19	(79.2)	25	(75.8)	22	(91.7)	19	(73.1)	21	(80.8)
	Nursing assistant	1	(4.2)	1	(3)	0	(0)	2	(7.7)	0	(0)
	Physical therapist	1	(4.2)	1	(3)	0	(0)	0	(0)	2	(7.7)
Age (n, %)	18-25 years	9	(37.5)	7	(21.2)	6	(25)	9	(34.6)	9	(34.6)
	26-35 years	10	(41.7)	17	(51.5)	5	(20.8)	8	(30.8)	11	(42.3)
	36-45 years	1	(4.2)	2	(6.1)	4	(16.7)	3	(11.5)	2	(7.7)
	46-55 years	3	(12.5)	3	(9.1)	4	(16.7)	3	(11.5)	2	(7.7)
	55+ years	1	(4.2)	4	(12.1)	4	(16.7)	3	(11.5)	2	(7.7)
	missing	0	(0)	0	(0)	1	(4.2)	0	(0)	0	(0)
Working experience (median, IQR)		4.5	(2-9)	5	(2-15)	15	(2-24)	4.5	(1-8.5)	2.5	(1-6.5)

n: numbers; IQR: interquartile range.

Focus group participants

The three focus groups were made up of thirty healthcare professionals (surgery wards n = 7, internal medicine wards n = 13, cardiology ward n = 10) (Table 2). Each focus group consisted of 1 physician or physician assistant, and 6-11 nurses. A nursing assistant also participated in the internal medicine focus group. No physical therapists participated in the focus groups. Overall, 87% was female and the median working experience was 5 years (IQR 2-12). The duration of the focus group discussions ranged between 47 and 60 min.

Table 2. Descriptive data of focus group participants.

Participant No.	Focus group No.	Hospital ward	Profession	Age (years)	Gender	Experience as a healthcare professional (years)
1	1	Surgery ward #1	Physician assistant	26-35	Female	2
2	1	Surgery ward #2	Nurse	46-55	Female	29
3	1	Surgery ward #2	Nurse	26-35	Female	5
4	1	Surgery ward #2	Nurse	55+	Female	26
5	1	Surgery ward #1	Nurse	18-25	Female	1
6	1	Surgery ward #1	Nurse	26-35	Female	10
7	1	Surgery ward #1	Nurse	26-35	Female	1
8	2	Infectious diseases ward	Nursing assistant	55+	Male	10
9	2	Hematology ward	Nurse	46-55	Male	16
10	2	Infectious diseases ward	Nurse	18-25	Female	1.5
11	2	Hematology ward	Nurse	55+	Female	39
12	2	Infectious diseases ward	Nurse	26-35	Female	7
13	2	Hematology ward	Nurse	18-25	Female	0.5
14	2	Hematology ward	Physician	26-35	Male	9
15	2	Hematology ward	Nurse	26-35	Female	6
16	2	Infectious diseases ward	Nurse	36-46	Female	12
17	2	Infectious diseases ward	Nurse	26-35	Female	12
18	2	Hematology ward	Nurse	46-55	Female	26.5
19	2	Infectious diseases ward	Nurse	26-35	Female	5
20	2	Hematology ward	Nurse	18-25	Female	0.5
21	3	Cardiology ward	Nurse	26-35	Female	1
22	3	Cardiology ward	Nurse	26-35	Female	10
23	3	Cardiology ward	Nurse	55+	Female	23
24	3	Cardiology ward	Nurse	26-35	Female	4
25	3	Cardiology ward	Nurse	18-25	Female	4
26	3	Cardiology ward	Nurse	26-35	Female	4
27	3	Cardiology ward	Nurse	18-25	Female	2
28	3	Cardiology ward	Nurse	18-25	Female	2
29	3	Cardiology ward	Nurse	18-25	Male	1
30	3	Cardiology ward	Physician	26-35	Female	1

Phase 1 – the most and least important barriers from an individual perspective
The ten items considered the most important barriers for each hospital ward, and the three items considered the least important barriers are shown in Table 3. Of the ten items most considered as being a barrier, four items emerged on all five hospital wards: item 11 “If I improve the physical activity levels of hospitalized patients, this will lead to a lack of time for other tasks/things I have to do”, item 13 “Other work tasks/things I need to do interfere with my intention to improve the physical activity levels of hospitalized patients”, item 20 “I have sufficient time to improve the physical activity levels in hospitalized patients” and item 31 “I would like to have more assistance to improve physical activity levels in hospitalized patients”. Two items were considered the least important barriers on all five hospital wards: item 16 “Improving the physical activity level in hospitalized patients gives me a lot of benefits” and item 7 “If I improve the physical activity level of hospitalized patients, this will lead to improved physical performance in these hospitalized patients”. All other items appeared to vary between hospital wards.

Table 3. The ten items considered the most and the three items considered the least as barriers, categorized per hospital ward

	Surgery ward #1		Surgery ward #2		Hematology ward		Infectious diseases ward		Cardiology ward	
	n = 24		n = 33		n = 23		n = 26		n = 26	
Order*	**Question**	**Mean (SD)**	**Question**	**Mean (SD)**	**Question**	**Mean (SD)**	**Question**	**Mean (SD)**	**Question**	**Mean (SD)**
1st	**13**	**3.26 (0.62)**	**20**	**3.50 (0.95)**	**13**	**3.61 (0.89)**	**13**	**3.83 (0.76)**	**13**	**3.72 (0.79)**
2nd	**20**	**3.26 (0.96)**	**13**	**3.45 (1.09)**	28	3.50 (1.10)	**20**	**3.76 (0.60**	**11**	**3.64 (0.91)**
3rd	27	3.13 (0.80)	**31**	**3.40 (0.98)**	**20**	**3.48 (0.73)**	**31**	**3.68 (0.80)**	**31**	**3.58 (0.76)**
4th	**31**	**3.13 (0.99)**	28	3.30 (1.21)	**11**	**3.48 (0.85)**	30	3.50 (0.81)	36	3.54 (0.93)
5th	25	2.96 (0.91)	**11**	**3.30 (1.02)**	38	3.22 (1.17)	28	3.40 (0.91)	38	3.54 (0.93)
6th	**11**	**2.96 (1.02)**	25	3.24 (0.94)	**31**	**3.12 (0.87)**	23	3.40 (0.76)	23	3.46 (0.90)
7th	24	2.92 (0.97)	27	3.21 (0.89)	36	3.09 (1.16)	38	3.35 (0.78)	30	3.46 (0.95)
8th	15	2.83 (0.92)	24	3.06 (0.90)	30	3.04 (1.02)	**11**	**3.35 (0.89)**	**20**	**3.42 (0.76)**
9th	8	2.74 (0.96)	36	2.97 (1.05)	23	3.00 (0.98)	15	3.29 (0.69)	24	3.42 (0.86)
10th	26	2.63 (0.82)	15	2.94 (0.98)	37	2.96 (0.96)	24	3.24 (0.97)	28	3.42 (0.95)
…	…	…	…	…	…	…	…	…	…	…
37th	7	1.42 (0.58)	12	2.59 (0.52)	19	1.46 (0.59)	7	1.83 (0.72)	7	1.58 (0.70)
38th	12	1.38 (0.58)	7	2.55 (0.55)	7	1.46 (0.51)	14	1.79 (0.51)	19	1.54 (0.51)
39th	16	1.13 (0.34)	16	1.12 (0.33)	16	1.08 (0.28)	16	1.35 (0.49)	16	1.23 (0.43)

** = items ordered from most considered as barrier to least considered as barrier; n = number;* ***bold*** *= relevant determinant on all five hospital wards; 7 = "If I improve the physical activity levels of hospitalized patients, this will lead to improved physical performance in these hospitalized patients"; 8 = "If I improve the physical activity levels of hospitalized patients, I will risk physical injury"; 11 = "If I improve the physical activity levels of hospitalized patients, this will lead to a lack of time for other tasks/things I have to do"; 12 = "I am motivated to improve the physical activity levels of hospitalized patients"; 13 = "Other work tasks/things I need to do interfere with improving the physical activity levels in hospitalized patients"; 15 = "All information and materials that are necessary to improve the physical activity levels in hospitalized patients are available"; 16 = "Improving the physical activity levels in hospitalized patients gives me a lot of benefits"; 19 = "The effects of improving the physical activity levels in hospitalized patients are clearly visible to me (e.g. participants' motivation, behavior, health)"; 20 = "I have sufficient time to improve the physical activity levels in hospitalized patients"; 23 = "On my hospital ward, formal arrangements are made with regard to improving the physical activity levels in hospitalized patients (i.e. policy, work plans)"; 24 = "On my hospital ward, there are sufficient facilities to improve the physical activity levels in hospitalized patients (e.g. equipment, material, space)"; 25 = "On my hospital ward, other changes interfere with improving the physical activity levels in hospitalized patients (e.g. reorganizations, cutbacks, the introduction of other innovations)"; 27 = "In general, hospitalized patients are motivated to improve their physical activity levels during hospital admission"; 28 = "In general, increased medical complexity of my patient influences my motivation to improve the physical activity level during hospital admission"; 30 = "I would like to have training to improve physical activity levels in hospitalized patients"; 31 = "I would like to have more assistance to improve physical activity levels in hospitalized patients"; 36 = "I have clear plans of how I will improve the physical activity levels in hospitalized patients"; 37 = "I check regularly whether I am doing everything necessary to improve the physical activity levels in hospitalized patients"; 38 = "I have clear plans of how I will improve the physical activity levels in hospitalized patients when I encounter barriers (e.g. lack of time, participants are not motivated)".*

6

Integration – using the survey findings to develop focus group topic guides
Using the quantitative survey findings, three topic guides were developed (Table 4). Each topic guide was derived from phase 1 and incorporated 10 items considered to be the most important barriers and at least three items considered to be the least important barriers. These topic guides allowed for clarification of the barriers most likely to be key to improving physical activity in hospitalized patients and thus informed the focus group moderators (BMG and SdM) in directing the sequence and coverage of the topics under study.

Table 4. Topic guides

General introduction including informed consent procedures
Definition of physical activity during focus groups: For the purpose of this study, physical activity is defined as any bodily movement of the patient that requires energy expenditure. This refers to all activities in which the patient does not sit still, lie still or sleep.
General prompts used during focus groups:
• Do you recognize […]? • What does the organization already offer as a solution for […]? • What else can the organization offer? • How do you get that impression? • From your perspective, what could help? • Do you recognize yourself in […]? • What is your view on […]? • How do you explain […]? • What support would you like to experience? • Which effects are visible to you? • Does […] influence your behavior? • What need is there for […]? • What information and resources are missing? • How do you get that impression? • What would help you?

Topic guide surgery wards	Topic guide internal medicine wards	Topic guide cardiology ward
The following items were used to elicit an in-depth focus group discussion:	The following items were used to elicit an in-depth focus group discussion:	The following items were used to elicit an in-depth focus group discussion:
[Most perceived to be an important barrier]	[Most perceived to be an important barrier]	[Most perceived to be an important barrier]
Domain: Motivation & Goals	Domain: Motivation & Goals	Domain: Motivation & Goals
Item 13: "Other work tasks/things I need to do interfere with improving the physical activity levels in hospitalized patients."	Item 13: "Other work tasks/things I need to do interfere with improving the physical activity levels in hospitalized patients."	Item 13: "Other work tasks/things I need to do interfere with improving the physical activity levels in hospitalized patients."
Domain: Beliefs about consequences:	Domain: Beliefs about consequences:	Domain: Beliefs about consequences:
Item 8: "If I improve the physical activity levels of hospitalized patients, I will risk physical injury."	Item 11: "If I improve the physical activity levels of hospitalized patients, this will lead to a lack of time for other tasks/things I have to do."	Item 11: "If I improve the physical activity levels of hospitalized patients, this will lead to a lack of time for other tasks/things I have to do."
Item 11: "If I improve the physical activity levels of hospitalized patients, this will lead to a lack of time for other tasks/things I have to do."		
Domain: Environmental context and resources	Domain: Environmental context and resources	Domain: Environmental context and resources
Item 20: "I have sufficient time to improve the physical activity levels in hospitalized patients."	Item 20: "I have sufficient time to improve the physical activity levels in hospitalized patients."	Item 31: "I would like to have more assistance to improve physical activity levels in hospitalized patients."
Item 27: "In general, hospitalized patients are motivated to improve their physical activity levels during hospital admission."	Item 23: "On my hospital ward, formal arrangements are made with regard to improving the physical activity levels in hospitalized patients (i.e. policy, work plans)."	Item 38: "I have clear plans of how I will improve the physical activity levels in hospitalized patients when I encounter barriers (e.g. lack of time, participants are not motivated)."
Item 31: "I would like to have more assistance to improve physical activity levels in hospitalized patients."	Item 25: "On my hospital ward, other changes interfere with improving the physical activity levels in hospitalized patients (e.g. reorganizations, cutbacks, the introduction of other innovations)."	Item 23: "On my hospital ward, formal arrangements are made with regard to improving the physical activity levels in hospitalized patients (i.e. policy, work plans)."
Item 24: "On my hospital ward, there are sufficient facilities to improve the physical activity levels in hospitalized patients (e.g. equipment, material, space)."	Item 28: "In general, increased medical complexity of my patient influences my motivation to improve the physical activity levels during hospital admission."	Item 30: "I would like to have training to improve physical activity levels in hospitalized patients."
Item 25: "On my hospital ward, other changes interfere with improving the physical activity levels in hospitalized patients (e.g. reorganizations, cutbacks, the introduction of other innovations)."	Item 31: "I would like to have more assistance to improve physical activity levels in hospitalized patients."	Item 20: "I have sufficient time to improve the physical activity levels in hospitalized patients."

Item 15: "All information and materials that are necessary to improve the physical activity levels in hospitalized patients are available."	Item 30: "I would like to have training to improve physical activity levels in hospitalized patients."	Item 24: "On my hospital ward, there are sufficient facilities to improve the physical activity levels in hospitalized patients (e.g. equipment, material, space)."
Item 28: "In general, increased medical complexity of my patient influences my motivation to improve the physical activity levels during hospital admission."		Item 28: "In general, increased medical complexity of my patient influences my motivation to improve the physical activity levels during hospital admission."
	Domain: Behavioral regulation	Domain: Behavioral regulation
	Item 37: "I have clear plans of how I will improve the physical activity levels in hospitalized patients when I encounter barriers (e.g. lack of time, participants are not motivated)."	Item 36: "I have clear plans of how I will improve the physical activity levels in hospitalized patients"
[Least perceived to be an important barrier]	[Least perceived to be an important barrier]	[Least perceived to be an important barrier]
Item 16: "Improving the physical activity levels in hospitalized patients gives me a lot of benefits."	Item 16: "Improving the physical activity levels in hospitalized patients gives me a lot of benefits."	Item 16: "Improving the physical activity levels in hospitalized patients gives me a lot of benefits."
Item 12: "I am motivated to improve the physical activity levels of hospitalized patients"	Item 7: "If I improve the physical activity levels of hospitalized patients, this will lead to improved physical performance in these hospitalized patients."	Item 19: "The effects of improving the physical activity levels in hospitalized patients are clearly visible to me (e.g., participants' motivation, behavior, health)."
Item 7: "If I improve the physical activity levels of hospitalized patients, this will lead to improved physical performance in these hospitalized patients."	Item 14: "I can easily remember what I need to do to improve physical activity levels in hospitalized patients."	Item 7: "If I improve the physical activity levels of hospitalized patients, this will lead to improved physical performance in these hospitalized patients."
	Item 19: "The effects of improving the physical activity levels in hospitalized patients are clearly visible to me (e.g. participants' motivation, behavior, health)."	

Phase 2 – key barriers and solutions to overcome these key barriers

Five themes were identified that describe both the key barriers to improving physical activity in hospitalized patients and the solutions healthcare professionals perceive as possibly helping them overcome these barriers: (1) differences in how healthcare professionals define physical activity; (2) the extent to which patients have freedom of choice; (3) role expectations within the multidisciplinary team; (4) the importance of patients' characteristics and expectations; and (5) the hospital bed as a centerpiece. All five themes were raised in each focus group, regardless of the type of hospital ward.

Theme 1: differences in how healthcare professionals define physical activity
Even though healthcare professionals perceived physical activity as being important, each healthcare professional defined “physical activity/inactivity” differently. The healthcare professionals described how this variation in defining physical activity makes it difficult for them to estimate the extent to which they should improve physical activity in hospitalized patients. They also indicated that they perceived this variation not only across different hospital wards but also between different healthcare professionals working with the same patient population within a single hospital ward. They also noted that defining physical activity is even more difficult in patients who are not motivated or who are “sick” in their opinion. This is exemplified by the following two comments:

> *Sitting in the chair is a start, but it’s not enough; I wouldn’t consider sitting passively in a chair as physical activity. (Participant 2)*

> *… We’ve transferred someone with the electric hoist out of bed. That’s already mobilizing to us. (Participant 17)*

During the focus group discussions, the healthcare professionals indicated that they often used the pre-admission living situation to estimate the extent to which they should improve a patient’s physical activity. But they also indicated that this was insufficient and that it would be more helpful if they received help in three key areas: knowledge about the relationship between physical activity and positive health outcomes; the formulation of specific goals; and education from physical therapists to help clarify the definition of physical activity. The following quote exemplifies the formulation of specific goals:

> *What I think can help is; if you have a clear goal; for example: “This patient is supposed to be able to walk to the toilet himself because then he can go home.” But the specification of a goal like this is often lacking … (Participant 16)*

Theme 2: the extent to which patients have freedom of choice
Healthcare professionals reported varying perspectives on the extent to which patients may decide to be physically inactive. On the one hand, healthcare professionals indicated that they believe patients should adhere to the healthcare professionals’ physical activity recommendations. After all, physical activity is part of the treatment if they want to recover as quickly as possible and prevent complications. On the other hand, healthcare professionals indicated that they believe physical activity is part of self-responsibility and self-management. Patients themselves should

therefore decide whether they are physically active or inactive. Healthcare professionals described how this difference in perspective is perceived as a key barrier because it leads to uncertainty among healthcare professionals and to contradictory messages towards patients. In the following comment a healthcare professional exemplifies how healthcare professionals might deliver their physical activity recommendations:

> *Like this morning, "it's a part of the package coming to the hospital, it's now time to sit in the chair. or at least stand briefly next to the bed." (Participant 29)*

All healthcare professionals agreed that the immediate solution would be for patients to take more responsibility for themselves in terms of physical activity and – if that is not possible – for them to be at least more intrinsically motivated to be physically active. Various interventions that would help patients understand their responsibility regarding physical activity during hospital stay were specifically proposed. Providing the patient with more insight is an example given by a healthcare professional:

> *… that's is what I always try to do; to really tell people what they can do themselves to speed up the whole process and help it go more smoothly; "The solution is to get out of bed and to move around. You can do that yourself." (Participant 4)*

Theme 3: role expectations within the multidisciplinary team

The perceived barriers and solutions also seemed to depend on the extent to which each healthcare professional perceived improving physical activity to be their responsibility, and which responsibilities they attributed to other healthcare professionals. For example, nurses indicated that they are the most suitable professionals when it comes to improving the patient's physical activity. Every nurse feels responsible for the patient's general well-being, including promoting basic mobility and independent activities of daily living. However, nurses also indicated that if the patient's physical activity levels need improving, they cannot be the only one responsible because they are also responsible for other important tasks. The solutions they proposed included allowing more time for the nurses to invest in this particular task or giving the responsibility for this task to other health professionals. The perceived lack of time to improve the patient's physical activity level is exemplified in the following comment:

As a nurse you've got more and more things to do, not just nursing tasks. And then on top of all that you also get the responsibility of improving someone's physical activity levels! (Participant 9)

Due to their knowledge, skills, time, and expertise, physical therapists were considered by nurses and physicians/physician assistants to be the best healthcare professional responsible for improving physical activity in hospitalized patients. Therefore, the focus groups agreed that it is essential for physical therapists to play a more prominent role on hospital wards. Furthermore, while physicians emphasized that the primary responsibility lies with nurses and physical therapists, they indicated that physicians themselves could contribute by using their regular conversations with patients to also motivate them to be physically active. The following comment exemplifies a physician's efforts to improve the patient's physical activity level:

I immediately tell the patient during my first conversation after admission: "we expect you get out of bed immediately after the operation." One time I'll tell the patient "at least three times a day"; another time I'll tell the patient something else. It depends on how the patient responds. (Participant 1)

Theme 4: the importance of patients' characteristics and expectations

Healthcare professionals reported that some of the barriers they perceive also depend to a great extent on the patient's background (i.e., lifestyle, pre-existing physical activity levels, age, and culture). Healthcare professionals also signaled that these barriers depend on whether the patient expects to be physically active during hospital stay. Healthcare professionals thereby specifically stated that it is undesirable that patients typically associate hospital stay with "wearing pajamas" and "lying in bed". In the following comment a healthcare professional describes how particular patients might be more active than others due to their background:

Those patients who are affected by cancer; they were always so sporty and after an operation, they will be again . they understand what to do. But you also have a large group of patients that have never been physically active at all. (Participant 4)

Healthcare professionals indicated that it is essential that the patient's background and expectations are taken into account when determining which solutions to use. Multiple solutions were suggested, such as repeatedly giving them advice about being physically active, making physical activity as easy as possible, mentioning the possible complications due to physical inactivity, helping the patient have positive experiences concerning physical activity, involving family members and visitors, and, for patients undergoing surgery, by providing sufficient information beforehand. The role family members could take is exemplified in the following comment:

> *What I sometimes do, when I can't seem to motivate someone, I ask the family of the patient for help. We've noticed on this hospital ward that the family has a big influence on the patient; for example, during my evening shifts; I encourage the family to take my patient with them off the hospital ward. (Participant 10)*

Theme 5: the hospital bed as a centerpiece

Healthcare professionals reported that another important reason for physical inactivity is that the hospital bed is a centerpiece during hospital stay (e.g., food and drinks are placed at the bedside, medication is brought to the patient, and the television is within reach). Healthcare professionals indicated that the lack of an activating hospital environment which encourages physical activity adds to the patient's expectation that getting out of bed may not be necessary at all. This is exemplified in the following comment:

> *No, when the room is organized around the bed, and everything is within reach and the television is also free; which means it's available for everyone; then it's incredibly tempting for people to stay in their beds. (Participant 2)*

Moreover, healthcare professionals indicated that the lack of sufficient, adequate equipment needed to support physical activity limits both the patient's physical activity and the healthcare professional's efforts to improve the patient's physical activity. How healthcare professionals perceive malfunctioning equipment is exemplified in the following comment:

> *Recently we noticed that we needed to "steal" walkers from other rooms or we only had walkers with broken brakes; (Laughter) Yeah; We laugh about that, but it's really pretty dire. (Participant 25)*

Healthcare professionals mentioned numerous possibilities for attracting and inviting patients to get out of bed, or to make it easier for patients to be out of bed, such as clean, spacious hospital rooms, attractive shared rooms (e.g., comfortable patient lounge), rooms specifically dedicated to physical activity and regularly organized activities. They also mentioned that sufficient and adequate equipment (e.g., IV poles with handles, walkers, electric hoists) on each hospital ward would be a possible solution for them to encourage patients to get out of bed, and would enable patients to be physically active independently. A healthcare professional's own perspective of the hospital ward's surrounding is exemplified in the following two comments:

> *And maybe if we made our patient lounge more appealing; that it's also lovely to sit there with other patients and; now it's just depressing; yeah sorry.*
> *(Participant 2)*

> *But also a kind of exercise room or something; for people who can walk themselves. (Participant 22)*

Discussion

This mixed-methods study at a Dutch university hospital explored healthcare professionals' perspectives on the key barriers to improving physical activity in adult patients during hospital stay, and on the solutions to help overcome these barriers. Five themes were identified: (1) the differences in how healthcare professionals define physical activity; (2) the extent to which patients have freedom of choice; (3) the role expectations within the multidisciplinary team; (4) the importance of patients' characteristics and expectations; and (5) the hospital bed as a centerpiece. These five themes were identified regardless of the type of hospital ward. Examples of the solutions healthcare professionals suggested included the following: clarifying what is defined as physical activity, empowering patients to take responsibility for physical activity, giving both physical therapists and physicians a more prominent role, and changing the hospital ward such that it encourages patients to be physically active.

Our findings suggest that healthcare professionals define physical activity in different ways and that this is a key barrier to improving physical activity in adult patients during hospital stay. Variations in the definition of physical activity are also found in scientific research, where frequently used terms for physical activity during hospital stay are "mobility" [21,22,33,34], "physical function" [35], "exercise" [36], "ambulating" [19,37] and the words "physical activity" itself [20,38]. The ways in which healthcare professionals define physical activity also seem to differ from the ways that patients describe physical activity [38]. Previous research highlights that the barriers perceived by healthcare professionals and patients probably depend on the internal standards, values, and conceptualization used for physical activity [39]. The results of the current study suggest that two solutions to help overcome this barrier are clarifying what is defined as physical activity on a hospital ward, and formulating specific goals in terms of the amount of physical activity expected of a patient.

In our study, healthcare professionals indicated that solutions can also lie in patients themselves taking the responsibility for achieving sufficient physical activity during their hospital stay. The healthcare professionals emphasized this by indicating that interventions are needed that help patients understand their responsibility regarding in-hospital physical activity. Such interventions that empower patients to take a more active role in physical activity during hospital stay have been described in the Early Recovery After Surgery (ERAS) program [40]. In addition, a collaborative investigation into contentious areas of healthcare from Luxembourg found that patient empowerment requires the to (1) understand their role, (2) have sufficient knowledge, (3) have sufficient skills, and (4) be in a facilitating environment [41]. Taken together, this suggests that interventions that help patients understand their responsibility regarding physical activity – as mentioned in our findings – are not the only interventions needed to effectively empower patients to take responsibility for physical activity in clinical practice.

Our findings also suggest that a key barrier to improving physical activity in hospitalized patients is nurses' workload: a high workload means they cannot take on tasks to improve physical activity, and therefore attribute these tasks to other healthcare professionals. This finding is in line with previous research, that has found that nurses often perceive the particular task of improving physical activity as time-consuming, while they are also responsible for many other tasks [20,35,37]. Consequently, perceiving a task as time-consuming may often cause healthcare professionals to neglect it [42]. Previous studies have shown that increased awareness and understanding of physical activity among nurses often results in improved levels of physical activity [20]. In addition to that, our results emphasize that to improve physical activity sustainably, it is not only nurses who should be aware of the importance of physical activity: all healthcare professionals need to feel responsible and be involved in future interventions. For instance, the studies of Hoyer [16], Mudge [17], and Zisberg [34] demonstrate that all members of the multidisciplinary team can and should be involved in the development and implementation of new interventions aimed at improving physical activity. Therefore, we recommend teams involved in routine care to discuss each healthcare professional's role in improving physical activity and involve all healthcare professionals in the development of future interventions.

Finally, our findings indicate that a key barrier to improving physical activity is related to context, including the patient's characteristics, the patient's expectations, and the hospital environment. This is in line with the results of several previous studies on this topic [20,37,38]. Even though the main priority during a hospital stay will always be medical treatment, our study emphasizes that context-related barriers must be addressed in order to improve physical activity during hospital stay in a sustainable manner.

Strengths and limitations

This study's first strength is the inclusion of healthcare professionals from surgery, hematology, infectious diseases, and cardiology hospital wards. Including such a variety of healthcare professionals allowed for the inclusion of different perspectives on physical activity in a hospital setting. A second strength is the use of a survey before conducting the focus groups, as this ensured consideration of the perspectives of healthcare professionals working on these different hospital wards. Third, basing this survey on the Theoretical Domains Framework ensured that the focus group discussions considered all potential barriers to improving physical activity. Finally, the multidisciplinary involvement of researchers, physical therapists, nurses, senior researchers, physicians, a quality advisor, and a medical psychologist in both the development of the survey and the analysis of the focus group data ensured that the data was analyzed from all possible angles of a team.

Some study limitations also need to be addressed. Even though we did not aim for full saturation, we believe sufficient saturation was reached, consistent with the chosen thematic analysis approach [43]. Secondly, only one physicians/physician assistants and no physical therapists participated in the focus group discussions. Because physical inactivity during hospital stay occurs in all age and patient groups [15], we focused on discussing the key barriers and solutions with healthcare professionals involved in routine care of all hospitalized patients. However, it may have been beneficial to include more perspectives of physicians, physician assistants and physical therapists on this topic. Thirdly, all participants had the Dutch nationality and worked at the Amsterdam UMC location Academic Medical Center, which might affect the generalizability of our results. However, we assume that our results will also apply to non-university hospitals. In a previous study, Hoyer et al.

investigated barriers to early mobility of hospitalized general medicine patients and found the same overall barriers in different hospitals [22]. Fourth, the perspectives of patients and their visitors were not included. These groups may have provided additional valuable information regarding the key barriers and solutions. For the interpretation of the results of this study, it should be realized that key barriers and solutions as perceived by healthcare professionals are investigated. To optimally translate our proposed solutions into interventions, involvement of patients and their visitors is of additional value.

Conclusions

Based on our findings, healthcare professionals need clear guidelines, roles, and responsibilities when it comes to improving physical activity in hospitalized patients. Healthcare professionals also need tools that help to empower patients to take an active role in physical activity. Furthermore, hospital wards should be designed and furnished so that patients are encouraged to be active. A possible next step towards adopting physical activity as a priority in clinical practice would be to translate the solutions suggested in this study into feasible interventions in collaboration with patients, healthcare professionals, team leaders, and hospital managers. Future research is needed on effectiveness of these interventions and the dose-response relationship between physical activity and the prevention of HADS. More research is also needed to understand how healthcare professionals can empower patients to take an active role in physical activity during hospital stay. Finally, our findings imply that more insight is needed to identify the changes in the hospital environment that can help to increase the patient's level of physical activity.

Supplementary Information

Supplementary Material S1, S2 and S3 can be found online: https://doi.org/10.1080/09638288.2021.1879946

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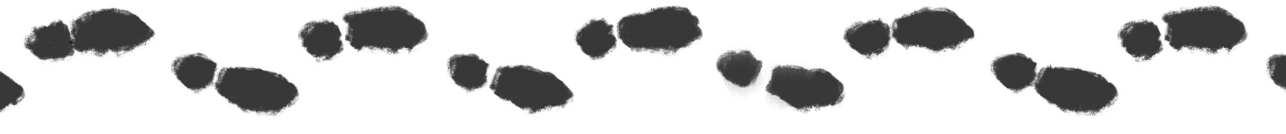

Part III

Improving physical activity in hospitalized patients through implementation of a multifaceted intervention

Chapter 7

Improving physical activity in adults admitted to a hospital with interventions developed and implemented through cocreation: protocol for a pre-post embedded mixed-methods study

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Abstract

Background

Admission to a hospital is often related with hospital-associated disabilities. Improving physical activity during hospitalization is considered effective to counteract hospital-associated disabilities, whereas many studies report on very low physical activity levels. Gradually developing and implementing interventions in cocreation with patients and health care professionals rather than implementing predefined interventions may be more effective in creating sustainable changes in everyday clinical practice. However, no studies have reported on the use of cocreation in the development and implementation of interventions aimed at improving physical activity.

Objective

This protocol presents a study that aims to investigate if interventions, which will be developed and implemented in cocreation, improve physical activity among patients in surgery, internal medicine, and cardiology hospital wards. The secondary aims are to investigate effectiveness in terms of the reduction in the time patients spend in bed, the length of hospital stay, and the proportion of patients going home after discharge.

Methods

The Better By Moving study takes place for 12 months at the following five different wards of a university hospital: two gastrointestinal and oncology surgery wards, one internal medicine hematology ward, one internal medicine infectious diseases ward, and one cardiology ward. The step-by-step implementation model of Grol and Wensing is used, and all interventions are developed and implemented in cocreation with health care professionals and patients. Outcome evaluation is performed across the different hospital wards and for each hospital ward individually. The primary outcome is the amount of physical activity in minutes assessed with the Physical Activity Monitor AM400 accelerometer in two individual groups of patients (preimplementation [n=110], and 13 months after the start of the implementation [n=110]). The secondary outcomes are time spent in bed measured using behavioral mapping protocols, and length of stay and discharge destination assessed using organizational data. A process evaluation using semi-structured interviews and surveys is adopted to evaluate the implementation, mechanisms of impact, context, and perceived barriers and enablers.

Results

This study is ongoing. The first participant was enrolled in January 2018. The last outcome evaluation and process evaluation are planned for May and June 2020, respectively. Results are expected in April 2021.

Conclusions

This study will provide information about the effectiveness of developing and implementing interventions in cocreation with regard to improving physical activity in different subgroups of hospitalized patients in a university hospital. By following step-by-step implementation and by performing process evaluation, we will identify the barriers and enablers for implementation and describe the effect of new interventions on improving physical activity among hospitalized patients.

Keywords

implementation science; quality improvement; physical; mobility; outcome and process assessment; health care

Introduction

Admission to a hospital is often related with the occurrence of hospital-associated disabilities, such as a reduced muscle mass, reduced muscle strength, malnutrition, and new limitations in activities of daily living (ADLs) [1-3]. In turn, hospital-associated disabilities are related with a prolonged length of stay, increased risk of institutionalization, permanent loss of ADLs, and mortality [4-6]. As hospital-associated disabilities are frequently registered in hospitalized older patients [7] and the age of the general population increases by the year, it is important to develop intervention strategies to reduce hospital-associated disabilities.

Improving physical activity during hospitalization is considered to be effective for counteracting hospital-associated disabilities [1,8-10]. Several studies showed that early mobilization and increasing physical activity in surgical and nonsurgical patients reduces hospital length of stay and improves independence in daily activities and discharge destination [11-13]. Yet, despite the knowledge that increasing physical activity contributes to the prevention of in-hospital functional decline, many studies continue to report on very low physical activity levels among hospitalized patients [14,15].

Previous research showed that physical activity in specific subgroups (ie, gastrointestinal surgery, internal medicine, and stroke) of hospitalized patients can be improved with a single intervention involving a one size fits all approach [10,16,17]. Gradually developing and implementing interventions in cocreation rather than implementing predefined interventions is believed to be more effective in creating sustainable changes in everyday clinical practice [18-20]. However, no studies have recently reported on the use of cocreation in the development and implementation of interventions aimed at the improvement of in-hospital physical activity. Therefore, the Better By Moving study in our university hospital is the first study that has been developed to investigate whether interventions, which will be developed and implemented in cocreation with patients and health care professionals, improve physical activity in patients admitted to surgery, internal medicine, or cardiology hospital wards. Moreover, by improving physical activity, we aim to reduce the time patients spend in bed, reduce hospital length of stay, and improve the number of patients going home after discharge. A systematic process evaluation provides important information on barriers and facilitators for future quality improvement projects aiming to improve physical activity in hospitalized patients.

Methods

Study Design

An uncontrolled pre-post embedded mixed-methods study is designed to evaluate whether we can improve physical activity in hospitalized patients by using interventions that we develop and implement in cocreation. The development and implementation describe the iterative (cyclical) process of planning, conducting, reflecting, and refining, which is being used in close collaboration with local stakeholders, such as patients, health care professionals, and managers [19]. The study has been approved by the Medical Research Ethics Committee of the Amsterdam University Medical Centers (Amsterdam UMC), Academic Medical Center (W17_479 #18.003 and W19_213 #19.258). Written informed consent will be obtained from all participants in both the outcome and process evaluations.

Setting

This study will be conducted at five different hospital wards (two gastrointestinal and oncology surgery wards, one internal medicine hematology ward, one internal medicine infectious diseases ward, and one cardiology ward) in a 1000-bed tertiary university teaching hospital Amsterdam UMC, Academic Medical Center, the Netherlands. Each hospital ward has 29 beds and a nursing-to-patient ratio of either 1:3 or 1:4, depending on the patient acuity. Allied health staffing involves 0.5 to 1 physical therapists for each hospital ward.

Development and Implementation of Interventions

The Better By Moving study consists of a 6-month preparation phase and a 12-month hospital ward-specific implementation phase, starting in January 2018. The entire project timeline has been described in Figure 1. At each hospital ward, the step-by-step implementation model of Grol and Wensing will be used [21]. A summary of the different steps according to Grol and Wensing has been described below. Stakeholders participate in cocreation at the following different levels as described by Cornwall: "co-option," "compliance," "consultation," "co-operation," "colearning," and "collective action" [22,23].

Step 1: Defining the Proposal for Change

The purpose of step one is to finalize the Better By Moving project plan. Therefore, hospital-wide attention is attracted on the benefits of physical activity with presentations and workshops during the 6 months prior to the start in the first hospital ward. Patient representatives, local stakeholders (ie, nurses, physicians, rehabilitation professionals, managers, and team leaders), and experts working on this topic in different hospitals will be asked to participate in discussions to develop the project plan.

Step 2: Analysis of Actual Performance

The purpose of step two is to quantify the outcome measures at baseline. Therefore, a cross-sectional audit will be performed at each hospital ward prior to assess the total amount of physical activity using accelerometers (Physical Activity Monitor [PAM] AM400, PAM BV) [24,25]. In addition, behavioral mapping protocols [26-28] will be used during the same cross-sectional audits to assess the time patients spend in bed, as well as on other physical activities. While the PAM AM400 accelerometer assesses the activity duration and intensity by measuring accelerations, the behavioral mapping protocols indicate how much time patients spend on each type of activity (ie, lying in bed, sitting, standing, or walking) by observing the patient every 10 minutes. Both outcomes complement each other in the understanding of in-hospital physical activity behavior. Further details on both assessments and the included patient population can be found in "Outcome and Process Evaluation."

Step 3: Analysis of Barriers and Enablers Among Patients and Health Care Professionals

The purpose of step three is to gain insights into the barriers and enablers to improve physical activity during hospital stay. Barriers and enablers for physical activity as perceived by patients and health care professionals will be assessed by a mixed-methods design using surveys, interviews, observations, and focus group discussions.

The patient surveys identify the perceived barriers and enablers to physical activity using two open-ended questions, the level of encouragement patients perceive from health care professionals and context using six questions with a 5-point scale based on the questions of van Delft et al [29], and their perceived self-efficacy in performing basic mobility activities independently using seven standardized questions with a 5-point scale based on the Short Falls Efficacy Scale-International [30]. Patients participating in the baseline cross-sectional audit will be asked to complete the survey. In addition, to further assess the perceived barriers and enablers to physical activity, patients will be asked to participate in an additional short face-to-face interview using the following purposeful sampling criteria: survey responses and age.

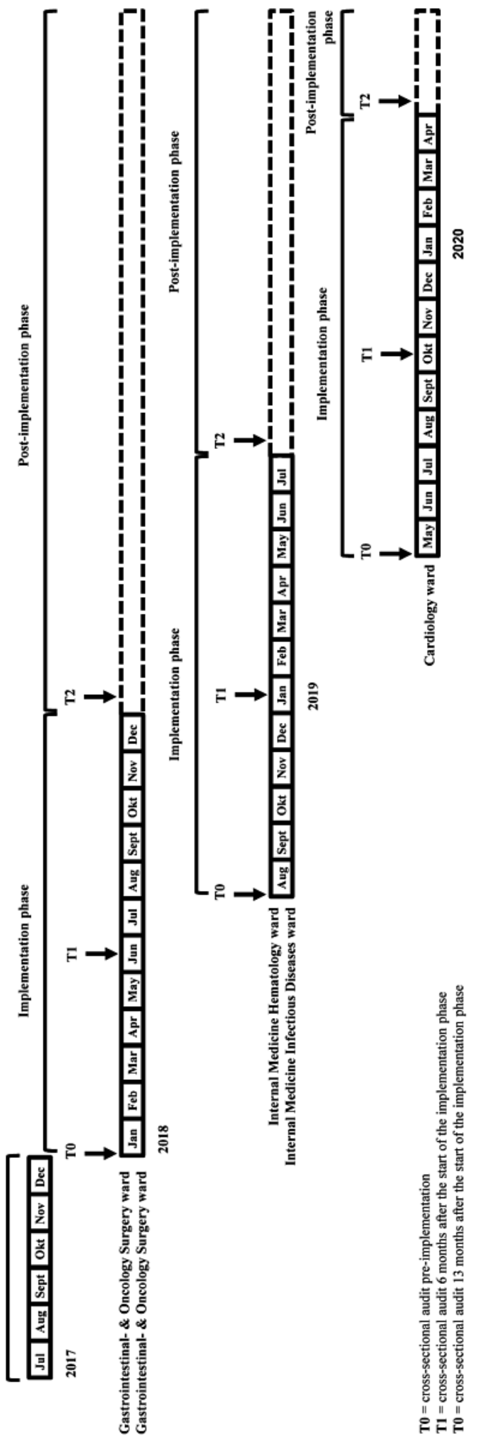

Figure 1. Project timeline.

To identify the barriers and enablers as perceived by health care professionals, we developed a survey based on the theoretical domains framework (TDF) [31]. The TDF encompasses 12 domains, providing a theoretical lens to view all cognitive, affective, social, and environmental influences on behavior and behavior change. Using the 12-domain TDF as a basis, a multidisciplinary team of physical therapists, senior researchers, nurses, and a medical psychologist developed a survey consisting of 39 items and a 5-point Likert scale (totally disagree, disagree, neutral, agree, and totally agree), with two items assessing the health care professional's "knowledge" with regard to improving physical activity in hospitalized patients, one item assessing the health care professional's "skills," one item assessing "social/professional role and identity," two items assessing "beliefs about capabilities," five items assessing "beliefs about consequences," two items assessing "motivation and goals," one item assessing "memory, attention, and decision processes," 17 items assessing "environmental context and resources," two items assessing "social influences," two items assessing "emotion," three items assessing "behavioral regulation," and one item assessing "nature of behaviors." The TDF ensures that all cognitive, affective, social, and environmental influences on behavior will be considered. Further elaboration on the 12 domains of the TDF can be found in the study of Atkins et al [31]. The survey will be distributed among all health care professionals working in each of the hospital wards. Subsequently, at each hospital ward, focus groups will be held to further substantiate the most relevant items. Participants will be asked to participate in the focus groups based on the following purposeful sampling criteria: survey responses, age, working experience, and profession. Finally, health care professionals will be observed at random intervals during the 12-month implementation phase to better understand the daily hospital care, culture, environment, and context (ie, social and environmental influences) in each of the hospital wards.

Step 4: Development and Selection of Interventions and Strategies

The purpose of step four is to develop interventions and strategies in cocreation while taking into account the barriers and enablers raised by hospitalized patients and health care professionals. Therefore, a working group will be formed at each hospital ward with the project manager (SJGG), nurses, physicians, and a physical therapist. In periodic working group meetings, interventions most suitable to the local context will be developed based on information from the previous steps. Through the use of an iterative (cyclical) process of planning, conducting, reflecting, and refining, the working group will develop various interventions [19]. The behavioral change wheel (BCW) framework will be used to guide the development of interventions [32]. In the BCW, behavior is explained as part of an interacting system between capability, opportunity, motivation, and behavior, also known as the COM-B model. These BCW components will help the working groups to better understand the patients' and health care professionals' behaviors. Moreover, the use the BCW framework will help the working groups to identify optimal behavioral change techniques, which they can incorporate in the detailed intervention proposals [32]. Working group progress will be closely coordinated and supported by the project manager, and the project manager will keep track of the cocreation process using an audit trail. When needed for the iterative (cyclical) development process, the working groups will consult caregivers, family members, patient representatives, local stakeholders, hospital managers, or experts regarding in-hospital physical activity in different hospitals for additional input. At random intervals, a group of patients from the hospital ward will be asked for feedback on the interventions.

Step 5: Development, Testing, and Execution of an Action Plan With Multiple Interventions

The purpose of step five is to gradually implement the intervention proposals in the local context. For each intervention proposal, a testing and implementation plan will be developed in collaboration with the local hospital ward team leader and carried out by the hospital ward specific working group. Hospital managers will be involved and will provide input on a regularly basis. Experience with potentially effective interventions will be translated to the subsequent participating hospital wards.

Step 6: Including Integration of Changes in Routine Care

The purpose of step 6 is to ensure implemented interventions are integrated in routine hospital care. All implemented interventions considered potentially effective will therefore be further refined by the working group and project manager during the 12-month implementation phase. In consultation with hospital managers, local team leaders, and the working group, integration in daily hospital practice will be ensured. In addition, tools will be developed for each hospital ward to systematically evaluate the implementation of the interventions.

Outcome and Process Evaluation

Target Population

A cross-sectional audit will be conducted at baseline, 6 months, and 13 months after the start of the implementation phase. During each cross-sectional audit, a random sample of hospitalized patients will be approached to participate during one day from 8 AM to 8 PM. Eligible patients are 18 years or older, have sufficient Dutch or English speaking ability and reading skills, and are admitted for at least 24 hours. The following exclusion criteria will be used: inability to perform independent transfers prior to hospital admission, delirium, obligatory bed rest as indicated by the attending physician, expectation to be discharged before 12 AM on the day of observation, and receiving end-of-life care. Random selection of potential participants will be performed using a computer-generated list based on the room numbers of the hospital ward, and potential participants will be approached one or two days prior to the day of observation. In the case of refusal or when the patient does not meet the study criteria, the investigator will approach the patient in the next hospital room on the computer-generated list. Each participant can only be enrolled once. No a priori sample size calculations are performed. Resources allow us to spend 1 year at the iterative (cyclical) process at each hospital ward; therefore, we determined a pragmatic sample size. Considering the duration of the different steps, including three cross-sectional audits, the inclusion of 65 participants is deemed feasible at each hospital ward. Given this sample size ($n = 110$ at baseline and $n = 110$ at 13 months) and assuming normality of the outcome parameter, we will be able to detect an effect size of 0.38 or higher for the primary outcome (two groups t test of equal means; $\alpha = .05$; $1 - \beta = .80$; nQuery 8, Statistical Solutions Ltd).

Primary Outcome

The primary outcome is the total amount of physical activity in minutes (> 1.4 metabolic equivalent tasks [METs] [33]), which will be measured during each cross-sectional audit from 8 AM to 8 PM using the PAM AM400 wireless accelerometer. The PAM AM400 is a 2-cm-wide coin and is waterproof, and it will be attached to the ankle. The PAM AM400 measures accelerations 10 times per second in three dimensions and converts these accelerations to the total amount of time of physical activity in minutes > 1.4 METs. METs is a concept that is used to assign an intensity value to specific activities. In healthy participants, light-intensity physical activity involves < 3.0 METs, moderate physical activity involves 3.0-6.0 METs, and vigorous physical activity involves > 6.0 METs [33]. Sedentary behavior is defined as ≤ 1.5 METs [34]. In addition to the total amount of physical activity in minutes > 1.4 METs, the PAM AM400 compares each second of physical activity with the following three predefined intensity zones: light physical activity (1.4-3.0 METs), moderate physical activity (3.0-7.0 METs), and vigorous physical activity (> 7.0 METs), and measures the derivative of METs for 24-h physical activity (PAM score = [METs − 1] × 100 averaged over the day). The validity and reliability of the PAM in healthy adults is moderate to good for assessing the estimate of energy expenditure [24,25].

Secondary Outcomes

Secondary outcomes include the time patients spend in bed, length of stay, and discharge destination. Data on the time patients spend in bed will be measured during each of the cross-sectional audits using the behavioral mapping method [26-28]. In detail, structured observations will be undertaken by trained physical therapy graduate students for a 1-minute period every 10 minutes between 8 AM and 8 PM, using a predetermined set of mutually exclusive types of activities (lying in bed, sitting on the edge of a bed or sitting in a chair, making a transfer from bed to chair, or standing, walking, and using the ergometer). For each minute of observation, the activity with the highest intensity is recorded. Patients are not followed off the ward and not intruded on if behind closed curtains. In addition, the following patient characteristics will be collected during each of the cross-sectional audits: sex, age, comorbidities, number of functional restraints (eg, intravenous lines and drains), functional ability with the Katz-ADL 2 weeks before admission [35], and independence in mobility using the Activity Measure for Post-Acute Care "six clicks" Basic Mobility Short Form [36]. Data will be directly recorded in the online Castor Electronic Data Capture database (Ciwit BV).

Data on length of stay and discharge destination will be obtained from the hospital administrative data for all patients admitted to the surgery, internal medicine, and cardiology hospital wards. Discharge destination will be categorized as follows: going home or going to a temporary institution (ie, nursing home, geriatric rehabilitation center, or medical rehabilitation center). Data on patients who are discharged to a permanent nursing home or other hospitals, those who receive end-of-life care (at home or at a facility), or those who die during hospitalization will be omitted because other influences (such as illness, prognosis, and cognitive function) determine the outcome.

Process Evaluation

Process evaluations are advised to monitor the implementation processes of complex interventions. In this study, the framework of the Medical Research Council guideline is followed to guide the process evaluation [31,37]. The three key functions of this framework include "implementation," "mechanisms of impact," and "context." "Implementation" contains the goals and interventions that have been delivered, and how the implementation is achieved. The "mechanisms of impact" include the response to the interventions, the mediators, and all (unexpected) results 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 costs) and enablers [31]. In this study, we will assess these three key functions by using semi-structured interviews by purposefully selecting health care professionals, team leaders, and managers 13 months after the start of the implementation. A topic guide in Dutch will be developed specifically for each hospital ward, which will consist of items covering all three key functions. In addition, 13 months after the start of the implementation, we will re-evaluate the perceived barriers and enablers to physical activity, the level of encouragement patients perceive from health care professionals and context, and their perceived self-efficacy in performing basic mobility activities independently using the survey described in step 3. We will assess the experience with our implemented interventions and various aspects of implementation fidelity (ie, adherence, exposure, and participant responsiveness) by adding both questions with a 5-point scale and open-ended questions to the patient survey (eg, "Did you receive …?" and "If so, did you find … of added value?"). We will also assess health care professionals' perception and experience with the project and our implemented interventions by using an additional survey with open-ended questions (eg, "The following intervention does/does not add to more in-hospital physical activity …" and "Were you made aware of …?") and by adding specific questions to our process evaluation topic guide.

Data Analysis

All analyses will be conducted using IBM SPSS Statistics version 25 (IBM Corp). Patients' characteristics in each cross-sectional audit will be described using descriptive statistics. Primary outcome evaluation will be performed between month 0 and month 13 across all hospital wards, and only the data of patients wearing the PAM during the entire observation period (8 AM-8 PM) will be used. The total amount of physical activity in minutes will be tested on normality with the Kolmogorov-Smirnov test and will be visually inspected using Q-Q plots. A logarithmic transformation will be considered in case of non-normality. Analysis of covariance will be used to assess the difference in the total number of minutes of physical activity ($>$ 1.4 METs), whereby the covariates include independence in mobility and the presence of a urinary catheter. Both covariates are based on unpublished results of multivariable regression models considering various patient factors in relation to physical activity. In case non-normality persists after logarithmic transformation, a Poisson regression model will be considered using the same covariates.

Additionally, data of behavioral mapping observations will be categorized into different activity types, from which time spent lying in bed between 8 AM and 8 PM in percentage will be derived. The difference in time patients spend lying in bed will be assessed among months 0, 6, and 13. An interrupted time series (ITS) will be used to evaluate the changes in length of stay and discharge destination among the following three predefined periods: 12 months prior to the implementation phase, 12 months implementation phase, and 6 months after finishing the implementation phase [38].

For the process evaluation, MAXQDA Analytics Plus 2018 (VERBI Software) will be used to facilitate the data analysis. All semi-structured interviews will be thematically analyzed following the methods of Braun and Clarke [39]. The analytic process will be performed by two independent researchers (BMG and SJGG) and supervised by MvdS. Consensus meetings will be used to discuss and refine each theme. Member checking will be used to ensure the credibility of the data analysis. Triangulation of data will be performed by using the open-ended survey data during the qualitative data collection and analysis. Patient and health care professional survey results will be compared using chi-square tests and analysis of variance tests, depending on the type of data.

Results

This study is ongoing. The first participant was enrolled in January 2018 at the gastrointestinal and oncology surgery ward. The last outcome evaluation and process evaluation are planned for May and June 2020, respectively. Results are expected in April 2021. A summary of all participation types within this study can be found in Multimedia Appendix 1.

Discussion

While the amount of evidence on the negative consequences of physical inactivity during hospitalization continues to grow, few studies have evaluated the effectiveness of interventions that have been specifically tailored (ie, developed and implemented) in collaboration with the target population. So far, several studies revealed that increasing physical activity in general or encouraging early mobilization (after admission or operation) has a positive influence on physical functioning in daily activities, the duration of admission, and discharge home [11,13]. However, these studies often focus on unilateral interventions and have been performed in a specific context, while physical inactivity seems to affect patients in all hospital wards and patients of all ages [27]. The integration of multiple interventions in daily hospital care entails various challenges, as also described in the quality improvement projects of Mudge et al and Hoyer et al [9,16]. The Eat Walk Engage program of Mudge et al describes an approach using multiple interventions, which demonstrated a reduced length of stay after implementation in older hospitalized patients [9]. In addition, the currently ongoing Hospital in Motion study of van Delft et al describes the usage of multiple interventions tailored to tackle the numerous described barriers perceived by health care professionals and hospitalized patients [29]. The Better By Moving study will contribute to this research by providing more insight into the effectiveness of interventions that are developed bottom-up and in cocreation with the target population and by thoroughly analyzing the process of cocreation.

The strength of the Better By Moving study is the thorough problem analysis of actual performance, and barriers and enablers, which will be carried out prior to the development of the first intervention. More specifically, the barriers and enablers perceived by patients or health care professionals will be assessed through different mixed methods, such as surveys, physical measurements, observations, interviews, and focus groups. In addition, we hypothesize that the extensive analysis will create support among health care professionals, manifest ownership among local stakeholders, and facilitate the development of a local testing and implementation plan. Second, colearning in the development and implementation of new interventions together with local stakeholders from five different hospital wards can offer both an in-depth and a broad perspective on what works and what does not work when trying to improve physical activity in hospitalized patients. Third, the use of evidence-based behavioral change theories, such as the TDF [31] and BCW [32], makes it more likely that the underlying reasons for physical inactivity in hospitalized patients will be identified and countered [31,32]. Finally, the ITS analysis, which will be used, is considered one of the strongest quasi-experimental designs to evaluate outcomes such as length of stay and discharge destination. So far, none of the previously published studies investigating physical activity-improving interventions incorporated ITS analysis.

Diverse factors could challenge the success of the Better By Moving study. First, several "system" factors may affect the implementation process, such as a change in the environmental context (ie, staff turnover, competing trials, and workload) and the hospital ward culture (ie, attitude to change, commitment, and motivation) [40]. For instance, the planned renovation of the participating hospital wards and the recent merger with the Vrije Universiteit Medical Center may create a lack of focus and provide additional workload. Second, because it is not known in advance which interventions will be developed and implemented, the achieved effect may differ in each hospital ward owing to differences in the interventions used. To counter this as much as possible, we will provide for both an overall and a ward-specific analysis. Third, changing the health care professionals' and patients' behaviors toward in-hospital physical activity through the development and implementation of multiple interventions in cocreation takes time. While we have 12 months for each hospital ward to cocreate interventions, important changes in hospital culture, environmental context, and outcomes may arise after the last cross-sectional audit. Lastly, a pre-post mixed-methods design is used to investigate if interventions developed and implemented in cocreation improve physical activity among patients. To evaluate the effect of an intervention, a randomized controlled trial is considered the gold standard. With respect to cocreational bottom-up intervention development and implementation, in which the process, to a large extent, determines the outcome, it is considered not feasible to use a control group. Instead, we aim to evaluate the impact of our interventions on physical activity as representative as possible by approaching a random sample of at least 110 hospital patients using a computer-generated list based on hospital room numbers before and after the implementation of interventions.

By using cocreation to develop and implement interventions and by performing a process evaluation, useful insights will be provided on the effect and underlying processes of bottom-up intervention development and implementation in close collaboration with the target population and local stakeholders. Using this information, health care professionals, managers, and researchers will be able to better assess the elements that do and do not work with regard to improving physical activity in daily hospital care.

Supplementary Information

Multimedia Appendix 1 can be found online: https://doi.org/10.2196/19000

Acknowledgments

BMG and SJGG declare equal contribution, as both provided equal contribution in drafting the protocol. BMG, SJGG, and MvdS designed the framework and methodology, and drafted the protocol. SJGG and MvdS developed the research protocol, database, and data collection tools. FN and RHHE participated in designing the protocol and participated in writing the manuscript. MvdS critically revised the manuscript and approved the final version.

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Chapter 8

The Better By Moving study: a multifaceted intervention to improve physical activity in adults during hospital stay

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Abstract

Objective:
To evaluate whether and how 'Better By Moving' (BBM) – a multifaceted intervention developed to improve physical activity in hospitalized adults – resulted in increased physical activity, reduced time spent lying in bed, reduced length of stay and increased discharges home, using an outcome and process evaluation.

Design:
Mixed-methods evaluation study informed by the MRC process evaluation framework.

Setting:
Tertiary university hospital in Amsterdam, Netherlands.

Participants:
Adult patients admitted to surgery, haematology, infectious diseases and cardiology wards, and healthcare professionals.

Measures:
Differences in physical activity (Physical Activity Monitor AM400) and time spent lying in bed (Behavioural Mapping) were assessed before-after implementation. Changes in length of stay and discharges home were assessed using Interrupted Time Series analyses. Process data were collected using surveys, interviews and an audit trail.

Results:
There was no significant difference observed in physical activity (median [IQR] 23 [12-51] vs 27 [17-55] minutes, $p = 0.107$) and time spent lying in bed (72.6% vs 67.4%, $p = 0.115$) before-after implementation. No significant changes were observed for length of stay and discharges home. The intervention components' reach was moderate and adoption was low among patients and healthcare professionals. Additionally, patients indicated they perceived more encouragement from the environment and performed exercises more frequently, and healthcare professionals signalled increased awareness and confidence among colleagues. Support (priority, resources and involvement) was perceived a key contextual factor influencing the implementation and outcomes.

Conclusion:
Implementing BBM did not result in significant improvements in patient outcomes. However, the process evaluation yielded important insights that may improve the effectiveness of implementation.

Keywords
hospitalization; physical activity; adults; mobility; intervention

Introduction

Hospitalized adult patients spend up to 87-100% of their time sitting or lying in bed [1]. These low levels of physical activity during hospital stay have been observed in geriatric, surgical, medical, and post-stroke patients [1,2]. There is growing evidence that low levels of physical activity during hospital stay lead to adverse outcomes such as functional decline, prolonged length of hospital stay, institutionalization after discharge, and mortality [3-8].

Recent evidence revealed that interventions improving physical activity during hospital stay can help prevent functional decline [7,9-15]. However, patients are still put in bed when admitted [16], the hospital bed remains to be centrepiece [17-19], and very low physical activity levels continue to be observed in hospitalized patients all over the world [1,2,20-22]. A discrepancy exists between what is known to prevent functional decline and what happens in current hospital care.

To bridge this gap, multifaceted interventions are needed that tackle multiple barriers and effect behavioural and cultural change with respect to physical activity during hospital stay [23,24]. To date, several multifaceted interventions have been described and these show they can effectuate positive changes regarding the time patients spent lying in bed and sitting [14,25], mobility levels [26], functional decline [12], length of hospital stay [14,26], and discharge home [14,25]. Although these results are promising, most of them lack a process evaluation illuminating how these results occurred and how improvements can be made.

Process evaluations have been conducted concurrently or following a complex intervention to assess whether implementation was successful and to explore if, how and why the intervention had an impact [27]. The UK Medical Research Council (MRC) offers a framework consisting of three key functions: *implementation, mechanisms of impact* and *context* to guide a process evaluation [27]. This framework has frequently been used to evaluate physical activity interventions [28].

‘Better By Moving’ (BBM) is a theory-driven, multifaceted intervention that was developed and implemented to improve physical activity in hospitalized adult patients. The aim of this study was to evaluate the effectiveness of BBM on physical activity, time spent lying in bed, length of hospital stay and discharge destination as well as the implementation process.

Methods

Setting

BBM was developed in collaboration with patients and healthcare professionals and included multiple tailored intervention components – such as physical activity goal setting tools, information brochures and clinical lessons – to achieve behavioural and cultural changes with respect to physical activity during hospital stay. BBM was implemented at five hospital wards of the tertiary university hospital Amsterdam UMC, location Academic Medical Center, the Netherlands: two gastrointestinal and oncology surgery wards, one haematology ward, one infectious diseases ward, and one cardiology ward. Development and implementation at each hospital ward took 12 months' time [29].

The multifaceted intervention BBM

The primary goal of BBM was to improve physical activity in adult patients during hospital stay. We used a structured, step-by-step implementation plan according to the evidence-based Implementation of Change process model by Grol and Wensing [29-31].

The first stage to develop the content of BBM was to assess the amount of time patients spent physically active and lying in bed on each ward and to identify the barriers and enablers to improve physical activity from the perspective of patients and healthcare professionals [29]. The 'Theoretical Domains Framework' (TDF) to identify determinants of behaviour was used to support the exploration of barriers and enablers [32]. The results have recently been published [21,33].

Having established the barriers and enablers, the 'Behaviour Change Wheel' (BCW) [34] was used to select intervention components and implementation strategies. This was conducted by ward-specific working groups consisting of physician(s), physician assistant(s), nurses, nursing assistant(s), physical therapists, a program manager (SG), and a senior nurse or team leader [32,34]. Convenience samples of patients, caregivers, team leaders and local policymakers provided occasional input. This process is outlined in Appendix 1 and resulted in eight intervention components targeting patients (Table 1) and 15 intervention components targeting healthcare professionals (Table 2). Most intervention components (n=12) targeted the *Physical Opportunity* and *Social Opportunity* of patients and healthcare professionals. Seven intervention components targeted the *Physical Capability* and *Psychological Capability* and four intervention components targeted the patients' and healthcare professionals' *Reflective Motivation* (Table 1 and 2) [34].

Implementing BBM

Each working group developed and executed an implementation plan for the intervention components they deemed feasible and effective at their hospital ward. The taxonomy of 93 Behaviour Change Techniques (BCTs) was used to specify implementation strategies [35]. Throughout the implementation, working groups strived for optimal integration within routine hospital care. The implementation strategies linked to the intervention components are shown in Table 1 and 2.

Table 1. Overview of intervention components targeting hospitalized patients

COM-B domain	Intervention components *[including TDF domain that was addressed]*	Implementation strategies	Implemented at the following hospital wards: A	B	C	D
Capability (physical)	None intervention components selected.					
Capability (psychological)	Increasing knowledge on the adverse health consequences as a result of physical inactivity during hospital stay. *[TDF domain Knowledge]*	➢ Provide newly admitted patients with information brochures informing them on the adverse outcomes related to physical inactivity	X	X	X	X
		➢ Place these information brochures on a visible place at the hospital ward	X	X	X	X
		➢ Create a website incorporating information on the adverse outcomes related to physical inactivity	X	X	X	X
		➢ Integrate the website in the hospital mailing for elective surgery patients	X	X		
	Increasing knowledge regarding what to do besides simply walking on the hallway. *[TDF domain Knowledge]*	➢ Provide newly admitted patients with information brochures informing them on what they could do in the hospital to remain physically active			X	X
		➢ Place these information brochures on a visible place at the hospital ward			X	X
Opportunity (physical)	Ensuring there is sufficient, adequate equipment. *[TDF domain Environmental Context and Resources]*	➢ Add a cycle ergometer with virtual reality screen to ensure alternatives are available to be physically active	X	X	X	
		➢ Add mobilizers (IV-pole which are more suitable to walk with) to ensure patients can ambulate independently	X	X		
	Organizing other activities to be physically active on the hospital ward. *[TDF domain Environmental Context and Resources]*	➢ Organize alternatives to be physically active: painting in the patient lounge				X
		➢ Organize alternatives to be physically active: shared lunch	X	X		
		➢ Organize alternatives to be physically active: exercise group			X	

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	Making the harmful effects of physical inactivity visible. *[TDF domain Environmental Context and Resources]*	➢ Add prompts and cues to highlight the harmful effects of bedrest, such as posters, flyers, info-graphics	X	X	X	X
		➢ Reduce prompts and cues that promote inactivity	X	X	X	X
	Creating a stimulating hospital environment. *[TDF domain Environmental Context and Resources]*	➢ Add prompts and cues to reinforce physical activity behaviour, such as posters, infographics, whiteboards incorporating physical activity goals and mobility icons on the walls	X	X	X	X
Opportunity (social)	Creating a culture of increased physical activity. *[TDF domain Social Influences]*	➢ Provide patients with regular instructions on why the hospital advices patients not to wear pyja-ma's	X	X		
		➢ Incorporate the advice not to wear pyjama's during hospital stay in information brochures.	X	X		
		➢ Ensure activities are available for patients to participate in, such as: painting in the patient lounge, a breakfast buffet, and a coffee break in the patient lounge.	X	X		X
Motivation (auto-matic)	None intervention components selected.					
Motivation (re-flective)	Determining physical activity goals in collabora-tion with healthcare professionals. *[TDF domain goals]*	➢ Involve patients in determining physical activity goals on a daily basis	X	X	X	X
		➢ Prompt patients to participate in the determina-tion of their physical activity goals	X	X	X	X
		➢ Provide feedback on the patients physical activity goals on a regular basis	X	X	X	X
		➢ Prompt patients to participate in the monitoring of their physical activity goals	X	X	X	X
		➢ Reflect with patients on their participation in the determination and monitoring of physical activity goals	X	X	X	X

COM-B = the Capability, Opportunity, Motivation – Behaviour system which forms the hub of the Behaviour Change Wheel (BCW); TDF = the Theoretical Domains Framework determinant framework; A = surgery ward #1; B = surgery ward #2; C = haematology ward; D = infectious diseases ward; E = cardiology ward

Table 2. Overview of intervention components targeting healthcare professionals

COM-B condition	Intervention components *[including TDF domain that was addressed]*	Implementation Strategies	Implemented at the following hospital wards: A	B	C	D
Capability (physical)	Learning how to use motivational interviewing. *[TDF domain Skills]*	➢ Organize clinical lessons to teach nurses and nursing assistants on motivational interviewing	X	X		X
		➢ Prompt nurses to practice motivational interviewing in patients who are unmotivated	X	X		X
		➢ Repeat the prompt for nurses to practice motivational interviewing in patients who are unmotivated	X	X		X
	Learning how to assist patients in physical activity. *[TDF domain Skills]*	➢ Organize clinical lessons to teach nurses and nursing assistants the skills to physically assist patients	X	X		X
		➢ Prompt nurses and nursing assistants during clinical care to practice the skills to physically assist patients	X	X		X
		➢ Repeat the prompt for nurses and nursing assistants during clinical care to practice the skills to physically assist patients	X	X		X
Capability (psychological)	Increasing knowledge on the adverse health consequences as a result of physical inactivity during hospital stay. *[TDF domain Knowledge]*	➢ Organize clinical lessons to inform healthcare professionals on the adverse outcomes related to physical inactivity	X	X	X	X
		➢ Organize clinical lessons to inform healthcare professionals on how improving physical activity relates to patient safety (i.e., fall avoidance)	X	X		X
		➢ Place infographics in the locker rooms informing all who pass on the adverse outcomes related to physical inactivity	X	X	X	
		➢ Add information on physical activity in the weekly hospital ward mailing lists				
	Providing the multidisciplinary team with a clear definition for 'physical activity'. *[TDF domain Knowledge]*	➢ Organize hospital ward team meetings to discuss and agree on the definition of physical activity in their patient population	X	X		X

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	Recognizing physical activity as a priority in routine clinical care. *[TDF domain Memory, Attention and Decision Processes]*	➢ Organize hospital ward team meetings to discuss, agree and reflect on physical activity as a priority in clinical care	X	X	X	X
		➢ Reflect with individual healthcare professionals on physical activity as a priority in clinical care	X	X	X	X
		➢ Add prompts and cues to remind healthcare professionals about encouraging patients in physical activity	X	X	X	X
Opportunity (physical)	Increasing transparency of the physical therapy recommendations. *[TDF domain Environmental Context and Resources]*	➢ Assess the factors why nurses and physicians might miss the physical therapy recommendations				X
		➢ Change the physical therapy reports according to these factors				X
		➢ Add prompts and cues to find the physical therapy reports				X
		➢ Demonstrate where physical therapy reports can be found				X
	Countering the lack of physical therapy consultations. *[TDF domain Environmental Context and Resources]*	➢ Integrate physical therapy consultations in protocols	X	X	X	
		➢ Integrate physical therapy consultations in routinely placed Electronic Medical Record orders	X	X	X	
	Making the harmful effects of physical inactivity visible. *[TDF domain Environmental Context and Resources]*	➢ Add prompts and cues to highlight the harmful effects of bedrest, such as posters, flyers, infographics	X	X	X	X
		➢ Reduce prompts and cues that promote inactivity	X	X	X	X
	Creating a stimulating hospital environment. *[TDF domain Environmental Context and Resources]*	➢ Add prompts and cues to reinforce physical activity behaviour, such as posters, infographics, whiteboards incorporating physical activity goals and mobility icons on the walls	X	X	X	X
	Ensuring there is sufficient, adequate equipment. *[TDF domain Environmental Context and Resources]*	➢ Add turners (bed-chair assistive support device) to improve bed-chair mobility	X	X		
		➢ Add mobilizers (IV-pole which are more suitable to walk with) to ensure patients can ambulate independently	X	X		

	Countering the perceived lack of time to encourage physical activity. *[TDF domain Environmental Context and Resources]*	➢ Analyse the factors influencing the lack of time	X	X	X	X
		➢ Assess how much time nurses lose on improving physical activity	X	X		
		➢ Find solutions to counter the factors influencing the lack of time	X	X	X	X
		➢ Provide feedback on the nurses' behaviour, depending on the factors	X	X	X	X
		➢ Ensure the profit for improving physical activity is visible	X	X		
Opportunity (social)	Creating a culture of increased physical activity. *[TDF domain Social Influences]*	➢ Provide feedback on actual behaviour	X	X		X
		➢ Demonstrate the ideal behaviour in a situation of their choosing	X	X		
		➢ Discuss with the team of healthcare professionals common pitfalls with regard to encouraging physical activity	X	X		
		➢ Provide verbal rewards when the team of healthcare professionals collectively encourage physical activity as a team	X	X		
Motivation (automatic)	None intervention components selected.					
Motivation (reflective)	Responsibility for physical activity during hospital stay *[TDF domain Social/Professional Role and Identity]*	➢ Assess and review with physicians how they view their responsibility to improving physical activity	X	X	X	
		➢ Assess and review with physical therapists how they view their responsibility to improving physical activity	X	X	X	X
		➢ Assess and review with teams of healthcare professionals how they can share responsibility to improving physical activity	X	X	X	
		➢ Assess and review with teams of healthcare professionals how they view the role of the patient	X	X	X	X
	Creating confidence among healthcare professionals. *[TDF domain Beliefs about Capabilities]*	➢ Support nurses in encouraging physical activity	X	X	X	X

	➢ Demonstrate and practice how healthcare professionals can encourage patients	X	X	X	X
	➢ Invite physical therapists to encourage healthcare professionals	X	X	X	X
	➢ Provide occasional feedback on behaviour	X	X	X	X
	➢ Encourage healthcare professionals in their self-efficacy	X	X	X	X
Determining physical activity goals in collaboration with patients. *[TDF domain Goals]*	➢ Assess the factors why nurses and physicians do not determine physical activity goals on daily basis	X	X	X	X
	➢ Prompt nurses and physicians to determine physical activity goals on a daily basis	X	X	X	X
	➢ Demonstrate how to use goal setting to improve physical activity	X	X	X	X
	➢ Provide tools to determine physical activity goals	X	X	X	X
	➢ Monitor the use of these tools	X	X	X	X
	➢ Provide feedback on the nurses' and physicians use of these tools	X	X	X	X
	➢ Provide feedback on the nurses' and physicians behaviour to use goal setting	X	X	X	X
	➢ Provide information on the consequences of inconsistently using goal setting (e.g., invalid measurements, failure to motivate patients)	X	X	X	X
	➢ Provide nurses and physicians with feedback on how to determine physical activity goals	X	X	X	X
	➢ Introduce environmental and social reminders to determine goals and use the tools	X	X	X	X
	➢ Incorporate goal setting in the electronic medical record	X	X	X	X

COM-B = the Capability, Opportunity, Motivation – Behaviour system which forms the hub of the Behaviour Change Wheel (BCW); TDF = the Theoretical Domains Framework determinant framework; A = surgery ward #1; B = surgery ward #2; C = haematology ward; D = infectious diseases ward; E = cardiology ward

Study design

This study used a mixed-methods evaluation study design [36], and the MRC evaluation framework [27] was used to guide the evaluation. To evaluate the effectiveness of BBM on patient outcomes, we collected quantitative data using before-after implementation cross-sectional measurements and longitudinal data from the hospital administrative system. To evaluate the process, we concurrently collected quantitative and qualitative data using an audit trail (i.e., a strategy to trace the process), surveys and interviews. Study reporting followed the Standards for QUality Improvement Reporting Excellence (SQUIRE version 2.0) [37]. The study protocol including details on design, implementation process, and outcome measures has been published elsewhere [29]. Ethical approval was granted by the Medical Ethics Committee of the Amsterdam UMC (W17_479 #18.003 and W19_213 #19.258), Amsterdam, The Netherlands. All patients and healthcare professionals provided written informed consent.

Outcome evaluation

Primary outcome

Primary outcome was the difference in amount of physical activity of patients before-after implementation. Physical activity was assessed on one random day during hospital stay between 8 am and 8 pm using the Physical Activity Monitor (PAM) AM400 [38,39]. The PAM AM400 is a 2-cm-wide coin attached to the ankle, and validly measures 3-dimensional accelerations as a derivative for Metabolic Equivalent Tasks (METS) to determine the time patients spent physically active in minutes (> 1.4 METS) [38-40]. METS expresses the energy cost of physical activities. Exclusion criteria were: insufficient Dutch or English speaking and reading skills, inability to perform independent bed-to-chair transfer before hospital admission, delirium, obligatory bed rest, receiving end-of-life care, and discharge before 12 AM on the day of observations. Eligible patients were asked in random order.

Secondary outcomes

Secondary outcomes were time spend lying in bed, length of hospital stay and proportion of patients discharged home instead of a temporarily institution.

Time spend lying in bed was assessed over the same time period as the primary outcome using a behavioural mapping protocol [41]. Length of stay and proportion of patients discharged home were assessed in all patients admitted for three days or longer to one of the hospital wards using an interrupted time series approach over 30 months (i.e., 12 months before BBM, 12 months during BBM, six months after BBM) [42]. This approach allowed us to assess the effect over time by comparing the slopes (i.e., trends) before-during-after implementation and to assess the immediate effect by comparing the level changes at implementation start (month 0) and stop (month 13) [42]. Discharge destination was categorized as 1: home with or without homecare and 2: discharged to a temporary institution (i.e., temporary nursing home, geriatric rehabilitation centre, or medical rehabilitation centre). Discharges to permanent nursing homes, other hospitals, end-of-life care facilities, or patients who passed away were omitted. The data were obtained as de-identified data from the hospital administrative system.

Process evaluation

Process outcomes were defined as *implementation*, *mechanisms of impact*, and *context* [27,29] (Figure 1):

- *Implementation*: (1) an audit trail detailing which and how intervention components were implemented and (2) a questionnaire for patients and healthcare professionals containing closed- and open-ended items before and after implementation assessing reach (i.e., the extent to which patients and healthcare professionals come into contact with the intervention components and adoption (i.e., uptake of the intervention components).
- *Mechanism of impact*: (1) the questionnaire for patients contained 5-point Likert scale items to assess the perceived encouragement from healthcare professionals and hospital environment, the perceived need for information, the frequency patients indicate they perform exercises, and the perceived self-efficacy to perform mobility activities before and after implementation, and (2) the questionnaire for healthcare professionals contained closed- and open-ended items exploring their perspective on the mechanisms after implementation.
- *Context*: (1) an audit trail keeping track of all contextual factors that may have influenced the implementation process, and (2) open-ended survey questions exploring their perspective on the contextual influences after implementation.

For the process evaluation, all hospitalized patients were asked to complete the questionnaire one day after the day of observation. Furthermore, healthcare professionals employed for at least 70% of full-time equivalent at one of the five wards were asked to complete the questionnaire after implementation. After the questionnaire, we conducted semi-structured interviews with healthcare professionals to provide a more in-depth understanding of the survey responses concerning all three process outcomes. We aimed to include a heterogeneous group with respect to working group participation, working experience, and profession.

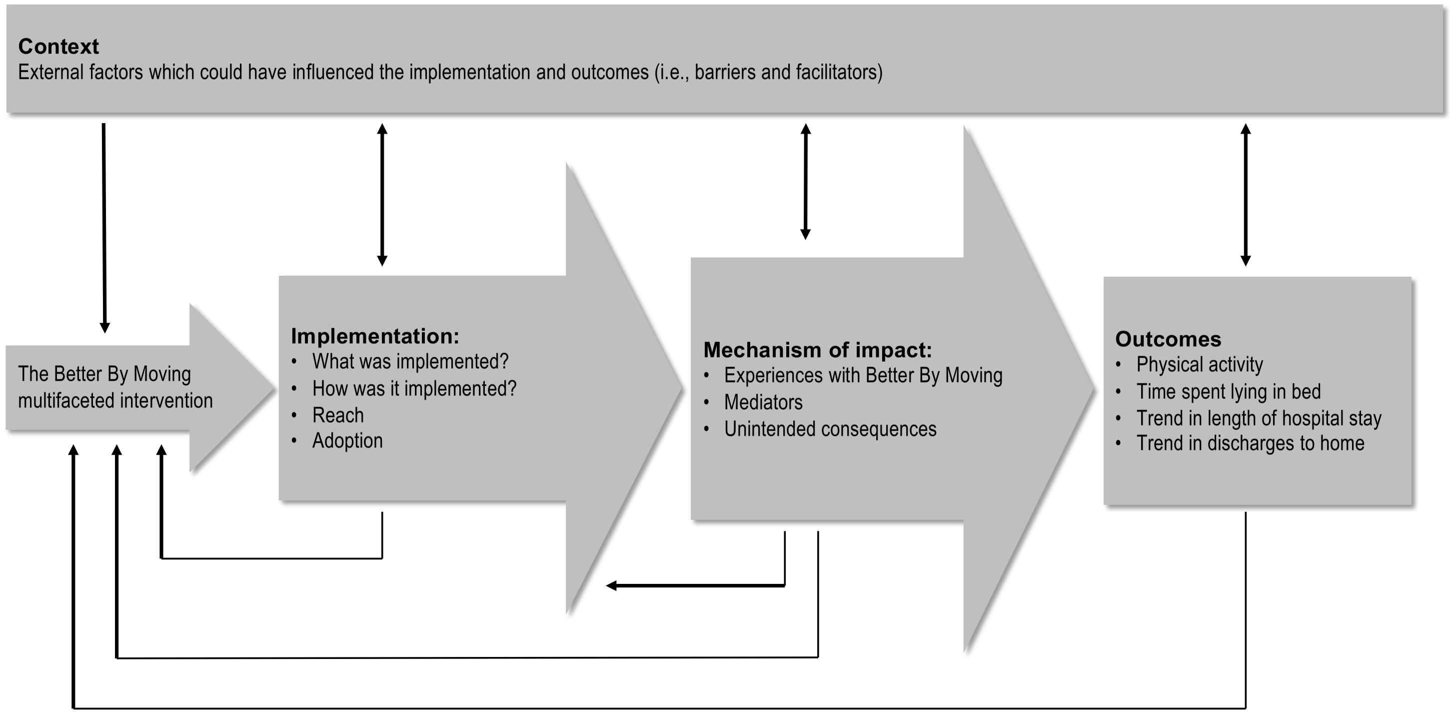

Figure 1. Key functions of the Better By Moving process evaluation and relations among them (after UK Medical Research Council [MRC] Guidance [27]).

Data analysis

No a priori sample size calculations were performed. Financial and logistic resources allowed us to include a pragmatic sample with an estimated size of n = 110 before implementation and n = 110 after implementation. Given this sample size, we were able to detect an effect size of 0.38 or higher for the primary outcome variable (two groups t test of equal means; $\alpha = 0.05$; $1\text{-}\beta = 0.80$; nQuery 8, Statistical Solutions Ltd) [29].

Descriptive statistics were derived to describe the patient characteristics. Normality was evaluated with the Kolmogorov-Smirnov test and Q-Q plots. A negative binomial regression model was used to assess the difference in physical activity before-after implementation, with presence of urinary catheter used as covariate [21,29]. An Analysis of Covariance (ANCOVA) was performed to assess the difference in time spent lying in bed, and included the same covariate. In the published protocol [29], independence in mobility was also mentioned as covariate; however, due to a significant difference ($p = 0.026$) in independence of mobility between the two groups we could not assume independence of the covariate and effect [43]. An Interrupted Time Series (ITS) analysis was used to evaluate the changes in length of hospital stay and discharge destination using a monthly interval. All quantitative analyses were conducted using IBM SPSS Statistics version 26 (IBM Corp). Parameter estimates were expressed using a 95% confidence interval (95%CI) and results were considered significant if $p < 0.05$.

Qualitative data were analysed using the thematic analysis approach as described by Braun and Clark [29,44]. The research team participated in refining the preliminary themes and member checking was used with the participants to ensure the credibility of the data analysis. MAXQDA Analytics Plus 2018 (VERBI Software) supported the analysis.

Results

Outcome evaluation

Participant characteristics

Due to the COVID-19 crisis the implementation of BBM on the Cardiology ward was put on hold in March 2020 and, as a result, the cardiology ward could not be evaluated.

In total, 88 and 85 patients respectively were included before-after implementation. Patient characteristics of both groups are presented in Table 3. No significant differences in patient characteristics before-after implementation were observed ($p > 0.05$), except for independency in basic mobility activities (n = 54 [61.4%] before vs n = 66 [77.6%] after, $p = 0.026$).

Table 3. Patient characteristics

Characteristic	Before n = 88	After n = 85	*p* value
Female, n (%)	42 (47.7%)	41 (48.2%)	0.115
Age (years), median (IQR)	60 (46-69)	63 (50-72)	0.154
Charlson Comorbidity Index, median (IQR)	3 (1-6)	3 (1-4)	0.118
Number of days between day of admission and day of observation, median (IQR)	8 (3-11)	6 (3-12)	0.775
Length of stay (days), median (IQR)	13 (7-25)	12 (8-22)	0.890
Independent in basic mobility[a], n (%)	54 (61.4%)	66 (77.6%)	0.026
Urine catheter[b], n (%)	26 (29.5%)	24 (28.2%)	0.850

IQR: interquartile range; [a] score of 20 when using question 1 to 5 Activity Measure for Post-Acute Care (AM-PAC) Basic Mobility; [b] urine catheter presence

For the evaluation of length of stay and discharge destination, the de-identified dataset comprised of 2584 patients before, 2454 patients during, and 1229 patients after implementation. No time-varying confounders were identified (e.g., significant changes in admission and discharge procedures) [42].

Primary outcome

After implementation, there was no significant difference observed in physical activity between 8 AM and 8 PM compared to before implementation (median [IQR] 23 [12-51] minutes before vs 27 [17-55] minutes after, $p = 0.107$) (Table 4).

Table 4. Before-after implementation differences in physical activity and time spent lying in bed between 8 am and 8 pm

Outcome	Before n = 88	After n = 85	*p* value
Physical activity in minutes, median (IQR)	23 (12-51)	27 (17-55)	0.107
Percentage of time spent lying in bed, mean (SD)	72.6% (19.3)	67.4% (23.4)	0.115

IQR: interquartile range; SD: standard deviation

Secondary outcomes

No significant difference was observed in the time spent lying in bed between 8 AM and 8 PM (72.6% before vs 67.4% after, $p = 0.115$) (Table 4). The trend for length of stay did not change after starting and completing the implementation. Additionally, there were no significant level changes at the start and after completing the implementation (Table 5). The trend for the proportion of patients discharged home did not change after starting and completing the implementation (p-values$>$0.05). Additionally, there was also no significant level change at the start and after completing the implementation (Table 5).

Table 5. Trend and level changes over time in length of hospital stay and proportion of patients discharged home

Outcome	β	Standard error	*p* value
Length of hospital stay			
Change in trend after starting BBM	<0.001	0.006	0.998
Change in level at the start of BBM	-0.020	0.042	0.63
Change in trend after completing BBM	0.005	0.013	0.73
Change in level after completing BBM	0.056	0.056	0.72
Discharges home			
Change in trend after starting BBM	0.013	0.035	0.72
Change in level at the start of BBM	-0.008	0.244	0.97
Change in trend after completing BBM	0.029	0.075	0.70
Change in level after completing BBM	-0.089	0.319	0.78

Process evaluation

Participant characteristics

In total, n = 87 of the n = 88 patients completed the survey before and n = 81 of the n = 85 after implementation. Sixty-seven of 144 eligible (47%) healthcare professionals working at the moment of survey distribution completed the survey (n = 16 at surgery #1, n = 13 at surgery #2, n = 21 at haematology, n = 17 at infectious diseases). They were working as a physician (n = 4), nurse or nurse assistant (n = 61), or physical therapist (n = 2). The median (IQR) working experience was 3 years (2-12). Three team leaders, three senior nurses, two physicians, one nursing assistant and three nurses participated in semi-structured interviews.

Implementation

Which intervention components were implemented and how were they implemented?

Table 1 and 2 show which intervention components were implemented and how they were implemented per hospital ward. In summary, clinical lessons to increase knowledge (attendance 61%) and to improve skills (hands-on training; attendance 23%) were provided. Furthermore, a cycle ergometer with virtual reality, a turntable, and ambulation-friendly IV poles were purchased. Posters, flyers, and infographics were placed and, where possible, care pathways incorporated an increased mobilization regime, structured physical therapy consultations, and daily physical activity goals. A person-centred communication board focusing on mobility was implemented and a mobility scale was implemented into the electronic medical record to monitor these goals. Bedside teaching and individual coaching were conducted by physical therapists to improve skills and increase confidence.

Reach

Reach among patients varied from 26% to 78%, with the lowest reach for the component encouraging patients to set physical activity goals with healthcare professionals and the highest for the component aiming to create a stimulating hospital environment (e.g., posters, infographics and mobility icons on the walls). According to healthcare professionals reach was sufficient, except for the low-reach components: ‘learning how to use motivational interviewing techniques’, ‘learning how to assist patients in physical activity’, ‘recognizing physical activity as a priority in clinical care’, and ‘counteracting the perceived lack of time to encourage physical activity’.

Adoption

Adoption among patients varied from 19 to 57%, with the lowest reach for the component encouraging patients to set physical activity goals with healthcare professionals and the highest for the component aiming to organize activities on the hospital ward for patients. According to healthcare professionals adoption was low to moderate, depending on the type of component. Adoption was highest for components targeting physical therapists, equipment, and ward environment. By contrast, components requiring daily attention or aiming to change every day routines were scarcely adopted.

Mechanisms of impact

In total, 43.8% of the patients were aware of the project BBM and 74.1% was satisfied with how physical activity was encouraged after implementation. Furthermore, patients perceived significantly more encouragement from the hospital environment (mean 2.93 [SD = 1.054] before vs 3.36 [0.971] after on a 5-point Likert scale, $p = 0.007$) and indicated they exercised more frequently (mean 3.17 [SD = 1.287] before vs 3.59 [1.249] after on a 5-point Likert scale, $p = 0.032$) after implementation. No significant before-after differences were observed regarding all other survey items.

The majority (59.7%) of the healthcare professionals believed that the intervention components of BBM combined resulted in improved levels of physical activity in patients at their ward. These healthcare professionals indicated that BBM increased the healthcare professionals' awareness regarding the benefits of physical activity, leading to more frequent encouragement of patients to be physically active. Additionally, confidence in encouraging physical activity was improved. A minority (40.3%) of healthcare professionals believed that BBM needed more time to influence patient's physical activity behaviour as currently, they still encounter difficulties in motivating patients to be physically active.

Context

We identified five barriers influencing the implementation and outcomes from the perspective of healthcare professionals. Firstly, the inability of nurses to consistently participate in the working groups. Secondly, the lack of active involvement of physicians in the working group. Thirdly, the lack of resources to facilitate working group participants to spend more time on implementing intervention components or to finance more substantive changes to the wards' environment. Fourthly, an imminent renovation or relocation of the wards, preventing more permanent environmental changes from being allowed. Lastly, the working group participants at some wards perceived a lack of support from leadership and the multidisciplinary team, caused by the multiplicity of different projects.

A facilitator was the availability of a project manager to manage, facilitate and keep an overview of the quality improvement process during all phases at the different wards. The multidisciplinary approach was also commonly noted as a facilitator to develop intervention components that were not only related to one profession. Furthermore, the extensive exploration of barriers and enablers and the bottom-up approach to select and implement intervention components meeting the needs of the wards were noted as facilitators. Both contributed to making the healthcare professionals feel heard and to creating ownership among working group participants. They also indicated the project did not increase the nursing workload. Support of the leadership and involvement of patients and caregivers in selecting intervention components were specifically reported as facilitators by workgroup participants. Lastly, having small multidisciplinary projects focusing on improving physical activity prior to BBM and aligning intervention components with routine clinical care or other running projects (e.g., the involvement of patients' caregivers in postoperative care) were perceived as facilitators.

Discussion

The aim of this study was to comprehensively evaluate BBM, a newly developed theory-informed multifaceted intervention to improve physical activity in hospitalized adult patients. Our outcome evaluation showed that implementing BBM was not associated with significant improvement in physical activity, reduction of time spent lying in bed or length of hospital stay, or increase in discharges home. These results are in contrast with previous studies that reported improved patient outcomes after implementing a multifaceted intervention during hospital stay [12-14,25,45]. Based on our process evaluation, we hypothesize that moderate reach and low adoption contributed to the lack of effectiveness of BBM. By using a bottom-up co-creational approach to select, tailor and implement the intervention components [29], we intended to establish ownership among healthcare professionals and leadership [46,47]. Apparently, this was not achieved, likely due to the lack of support in terms of priority, resources and involvement, both at staff- and ward level. Other reasons for different outcomes compared to previous studies may be the amount and variety in intervention components [12-14,25,45], difference in outcome evaluation (e.g., procedures, analyses) [12-14,25,45], difference in patient population [12,13,45] or difference in context (e.g., local hospital admissions and discharge policies) [12,13,45].

To date, two previous multifaceted interventions to improve in-hospital physical activity included a process evaluation [45,48] and only one of these evaluated reach and adoption of their intervention components [48]. With reach and adoption varying from 54 to 86% [48], they observed a significant decrease in time spent lying in bed and number of discharges to a rehabilitation setting after implementation [25]. This contrasts with our findings indicating that significant improvements in patient outcomes are likely depending on the level of reach and adoption of each intervention component [27,49]. Therefore, we recommend that reach and adoption should be monitored during implementation. A recent study performed by Khadjesari et al. [50] provides guidance on how to measure reach and adoption validly and reliably during implementation.

Further, statistically significant differences in several mechanisms of impact were observed: more patient encouragement from the hospital environment, patients indicating they exercised more frequently, and increased awareness and confidence among healthcare professionals. A new implementation cycle would be needed to determine how to sustain these changes and assess why these mechanisms did not result in more physical activity and better patient outcomes [31]. Two previous studies in which similar multifaceted interventions were implemented also illustrated that going through an implementation cycle once does not necessary result in positive outcomes on every hospital ward [14,25]. This suggests that multifaceted interventions can benefit from a more flexible and iterative approach in general wherein healthcare professionals are encouraged to continually evaluate and, where necessary, adapt the intervention and implementation in short cycles.

Even though it is commonly assumed that multifaceted interventions lead to more effective changes when compared to single-component interventions, compelling evidence is still lacking [24]. Given the moderate reach and low adoption, we agree with the suggestion made by previous researchers that fewer components with a clear hierarchical structure may help to increase effectiveness [24,48] because a narrow focus ensures that more attention and effort can go to implementing the intervention components (i.e., improving reach and adoption). An example of such intervention is the multifaceted intervention study conducted by Zisberg et al. [12,51] focusing on implementing the 900-steps mobility goal to prevent hospitalization-associated functional decline among older adults. Video clips, in-personal communication, brochures, posters and staff-training were all used to support achieving this walking-dose benchmark in as many patients as possible [12].

Finally, implementing a multifaceted intervention may have different effects in different contexts even if its implementation does not vary [27]. Through the implementation of BBM in the Amsterdam UMC, we identified five contextual barriers and eleven contextual facilitators, with the level of support in terms of priority, resources and involvement – both at staff- and ward level – appearing to be the common denominator. Context includes anything external to the intervention [27], but this does not necessarily mean that contextual factors cannot be influenced. This has recently been highlighted by Geerligs et al. [46], who recommends to consider factors relating to the staff and system (e.g., ward) as active components that can be influenced during intervention development and implementation.

Strengths and limitations of the study

A major strength of this study is the integration of effectiveness and process evaluation [27]. Another strength of this study was the combination of different theoretical approaches used to address various implementation and evaluation challenges in BBM [27,30,32,34]. Lastly, an important strength of this study is the implementation in usual care in a heterogeneous hospital population.

This study also has some limitations. Firstly, our uncontrolled before-after study design does not allow us to conclude direct causation [52]. Secondly, the limited power of our before-after evaluation of physical activity and time spent lying in bed may have caused a type II error (i.e., false negative results) [29]. Thirdly, although BBM may have been effective on individual hospital wards, lack of statistical power in this quality improvement project did not allow a ward-specific analysis. Fourthly, this is a single-site study in a university hospital in the Netherlands, limiting the generalizability of the results.

Conclusions

We have comprehensively evaluated BBM, a new theory-informed multifaceted intervention to improve physical activity during hospital stay. Although BBM did not result in significant improvements in patient outcomes, our findings have clear practical implications for healthcare professionals, researchers and policymakers seeking to improve physical activity during hospital stay. Firstly, implementation teams should consider to closely monitor reach and adoption during implementation to enable timely adaptations of the intervention components and implementation strategies, if required. Secondly, it is advised to include a limited number of intervention components with a clear hierarchical structure as this ensures more attention and effort can go to implementing the intervention components adequately. Thirdly, it is advised to consider the support in terms of priority, resources and involvement – both at staff and ward level – as an active component that can be influenced during intervention' development and implementation. Future research might focus on investigating the effectiveness of using a more flexible and iterative approach to improve physical activity during hospital stay.

Clinical Messages

- Although implementation of Better By Moving did not lead to better patient outcomes, important lessons for implementation are learned.
- It is advised to monitor reach and adoption during implementation in order to timely adapt the intervention or implementation process;
- It is advised to consider support in terms of priority, resources and involvement as an active component that can be influenced.

Supplementary Information

Appendix 1 can be found on page 201 to 206.

Acknowledgments

None to report.

Appendix 1. An overview of the perceived barriers and enablers with linked intervention functions and BCTs

COM-B domain	TDF domain	Barriers and enablers	Intervention function	Policy Categories	Behaviour Change Techniques
Capability (physical)	Skills	**Patients** lack the skills to ambulate with functional restraints	Training	Service provision	4.1 Instruction on how to perform the behaviour 8.1 Behaviour practice / rehearsal 8.3 Habit formation
	Skills	**Nurses and nursing assistants** lack the skills to physically assist patients	Training	Service provision	4.1 Instruction on how to perform the behaviour 8.1 Behaviour practice / rehearsal 8.3 Habit formation
Capability (psychological)	Knowledge	**Healthcare professionals** differ in how they define physical activity	Education	Communication / marketing; Guidelines	5.1 Information about health consequences 9.1 Credible source
	Knowledge	**Nurses and physicians** lack knowledge on how to formulate physical activity goals	Education	Communication / marketing; Service provision	2.2 Feedback on behaviour 8.1 Behaviour practice / rehearsal 8.2 Behaviour substitution 8.4 Habit reversal
	Knowledge	**Patients** are not aware of 'what to do' and 'where to go'	Education	Communication / marketing	7.1 Prompts / cues
	Knowledge	**Patients** are not aware of the physical inactivity-related complications	Education	Communication / marketing	5.1 Information about health consequences
	Knowledge	**Nurses** lack knowledge on how to motivate unmotivated patients	Education	Communication / marketing; Service provision	2.2 Feedback on behaviour 8.1 Behaviour practice / rehearsal 8.2 Behaviour substitution 8.4 Habit reversal

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Knowledge	**Nurses and nursing assistants** lack knowledge about safety and physical activity	Education	Communication / marketing; Service provision	2.2 Feedback on behaviour 5.3 Information about social and environmental consequences
Memory, Attention, and Decision processes	Encouraging physical activity is not a high priority to **nurses and physicians**	Enablement; Training	Guidelines; Regulation	1.7 Review the outcome goal 2.2 Feedback on behaviour 3.1 Social support (unspecified) 5.1 Information about the health consequences 8.3 Habit formation
Memory, Attention, and Decision processes	**Patients** are rarely reminded to be physically active	Environmental restructuring	Environmental / social planning	7.1 Prompts / cues 12.5 Adding objects to the environment
Behavioural Regulation	**Patients** do not participate in the self-monitoring of in-hospital physical activity	Enablement; Modelling	Environmental / social planning	1.4 Action planning 2.2 Feedback on behaviour 2.3 Self-monitoring of behaviour 7.1 Prompts / cues 12.5 Adding objects to the environment
Behavioural Regulation	**Nurses and physicians** do not determine physical activity goals on a structural basis	Enablement; Modelling	Environmental / social planning; Regulation	1.2 Problem solving 1.4 Action planning 2.1 Monitoring of behaviour by others without feedback 2.2 Feedback on behaviour 7.1 Prompts / cues 12.5 Adding objects to the environment
Behavioural Regulation	Physical therapy recommendations are often not followed	Education; Modelling	Communication / marketing	1.2 Problem solving 2.2 Feedback on behaviour

Opportunity (physical)	Environmental Context and Resources	Sufficient, adequate equipment that supports **patients** in physical activity is rare	Environmental restructuring	Environmental planning	12.5 Adding objects to the environment
	Environmental Context and Resources	Sufficient, adequate equipment that supports **healthcare professionals** in encouraging physical activity is rare	Environmental restructuring	Environmental planning	12.5 Adding objects to the environment
	Environmental Context and Resources	**Nurses** lack time to invest in encouraging physical activity	Training; Enablement	Guidelines; Service provision	1.2 Problem solving 2.2 Feedback on behaviour 3.1 Social support 8.1 Behaviour practice/ rehearsal 15.2 Mental rehearsal of successful performance
	Environmental Context and Resources	There is a lack of physical therapy consultations	Environmental restructuring	Guidelines; Regulation	7.8 Associative learning 12.1 Restructuring the physical environment
	Environmental Context and Resources	The hospital environment entices physical inactivity	Environmental restructuring	Environmental planning	7.1 Prompts/cues 7.3 Reduce prompts/cues 12.1 Restructuring the physical environment 12.5 Adding objects to the environment
Opportunity (social)	Social influences	**Patients** are not regularly encouraged by nurses	Enablement; Modelling	Environmental / social planning	1.2 Problem solving 3.1 Social support 6.1 Demonstration of the behaviour 10.5 Social incentive 10.9 Social reward

	Social influences	**Patients** are rarely encouraged by physicians	Enablement; Modelling	Environmental / social planning	1.2 Problem solving 3.1 Social support 6.1 Demonstration of the behaviour 10.5 Social incentive 10.9 Social reward
	Social influences	**Healthcare professionals** rarely involve family to encourage patients	Enablement	Communication / marketing; Guidelines	1.4 Action planning 6.1 Demonstration of behaviour 6.3 Information about others' approval 7.1 Prompts / cues 12.5 Adding objects to the environment
	Social influences	**Healthcare professionals** rarely assess and discuss physical activity during interprofessional meetings	Enablement; Education	Regulation; Environmental / social planning	1.9 Commitment 2.2 Feedback on behaviour 7.1 Prompts / cues 12.5 Adding objects to the environment
Motivation (automatic)	Reinforcement	There is no reinforcement for walking	Incentivisation; Environmental restructuring	Environmental / Social planning	12.5 Adding objects to the environment 14.5 Rewarding completion
	Reinforcement	Using the cycle ergometer on the hospital ward is boring	Incentivisation; Environmental restructuring	Environmental / Social planning	12.5 Adding objects to the environment 14.5 Rewarding completion
	Reinforcement	The harmful effects of bedrest are invisible to **patients**	Incentivisation; Environmental restructuring	Environmental / Social planning; Communication / marketing	12.5 Adding objects to the environment

	Reinforcement	The harmful effects of bedrest are rarely visible to **nurses and physicians**	Incentivisation; Environmental restructuring	Environmental/ Social planning; Communication / marketing	12.5 Adding objects to the environment
	Emotion	None identified			
Motivation (reflective)	Social / Professional Role and Identity	**Patients** rarely take responsibility for physical activity	Education; Persuasion	Communication/marketing;	2.2 Feedback on behaviour 4.1 Instruction on how to perform the behaviour
	Social / Professional Role and Identity	**Patients** wear pyjama's during hospital stay	Education; Persuasion	Communication/marketing;	2.2 Feedback on behaviour 4.1 Instruction on how to perform the behaviour 12.5 Adding objects to the environment
	Social / Professional Role and Identity	**Physicians** do not feel sufficiently responsible for encouraging physical activity	Education; Persuasion	Guidelines	1.2 problem solving 1.5 Review behaviour goal
	Social / Professional Role and Identity	**Physical therapists** do not feel sufficiently responsible for encouraging physical activity	Education; Modelling	Regulation; Guidelines	1.2 problem solving 1.5 Review behaviour goal
	Social / Professional Role and Identity	**Healthcare professionals** have no shared responsibility for improving physical activity	Modelling	Communication/marketing;	1.2 problem solving 1.5 Review behaviour goal
	Beliefs about capabilities	**Patients** have no confidence in general to be physically active	Persuasion; Enablement	Environmental/ Social planning	12.6 Body changes 15.1 Verbal persuasion of capacity 15.2 Mental rehearsal of successful performance
	Beliefs about capabilities	**Patients** feel impaired by physical complaints	Enablement	Environmental/ Social planning	12.6 Body changes 15.1 Verbal persuasion of capacity

Beliefs about capabilities	**Healthcare professionals** have rarely confidence that they are able to encourage physical activity	Education; Modelling	Communication / marketing; Service provision	6.1 Demonstration of the behaviour 8.1 Behaviour practice / rehearsal 9.1 Credible source 15.1 Verbal persuasion of capacity
Optimism	None identified			
Intentions	**Patients** are not motivated to be physically active in general	Education; Persuasion;	Communication / marketing; Environmental/ Social planning	1.1 Goal setting 1.2 Problem solving 1.4 Action planning 7.1 Prompts / cues
Intentions	**Nurses** are not aware that improving physical activity might save time on the long term	Education; Persuasion	Communication / marketing	2.2 Feedback on behaviour 2.6 Biofeedback 10.1 Material incentive (behaviour) 15.3 Focus on past success
Goals	**Healthcare professionals** rarely use goal setting to encourage patients	Education; Modelling; Enablement	Service provision; Communication / marketing; Guidelines	2.2 Feedback on behaviour 5.3 Information about social and environmental consequences 6.1 Demonstration of the behaviour 7.1 Prompts / cues 12.5 Adding objects to the environment
Beliefs about Consequences	**Patients** are afraid to ambulate because they relate it to falling	Education	Communication / marketing	2.2 Feedback on behaviour 8.1 Behaviour practice / rehearsal 15.1 Verbal persuasion about capacity

COM-B = the Capability, Opportunity, Motivation – Behaviour system which forms the hub of the Behaviour Change Wheel (BCW); TDF = the Theoretical Domains Framework determinant framework

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Chapter 9

General discussion

Physical inactivity during hospital stay is harmful for adult patients. Obviously, adults are hospitalized for a medical illness necessitating medical treatment or surgery, which may explain why patients are physically inactive during hospital stay [1-4]. However, mounting evidence suggests that the large amount of time patients are physically inactive leads to unnecessary physical deconditioning during hospital stay [5-8]. This hospitalization-associated physical deconditioning may lengthen hospital stay, contribute to institutionalization, increase mortality, and result in impairments in activities of daily living (ADL) that hinder societal participation [9-11].

In the last decade, various intervention studies showed that physical inactivity during hospital stay can be reduced, thereby preventing hospitalization-associated physical deconditioning and other negative patient outcomes [12-21]. However, adults are still routinely put to bed when admitted [22]. The hospital bed remains the centerpiece [23-25], which is substantiated by recent studies that still report very low physical activity levels during hospital stay [1,2,4,26]. Apparently, there is a discrepancy between what is known from the literature and what actually happens in a hospital. To bridge this gap, this thesis aims to expand knowledge on how to improve physical activity in hospitalized patients.

In this final chapter, the main findings are presented and discussed, methodological strengths and limitations are considered, and clinical recommendations and future perspectives are presented.

Main findings

Part I – Identifying hospitalized patients who are physically inactive

The first step to improve physical activity in hospitalized patients was to identify physically inactive patients during routine hospital care.

In **chapter 2**, we investigated the levels of physical activity in patients admitted to a gastrointestinal surgery, internal medicine, or cardiology hospital ward of the Amsterdam University Medical Centers (Amsterdam UMC), location Academic Medical Center (AMC). Very low levels of physical activity were observed irrespective of the hospital ward. Median (IQR) minutes of light intensity activity (1.4-3 Metabolic Equivalent Tasks [METs]) between 8 am and 8 pm was 26 (13-52) and moderate intensity activity 4 (2-13) minutes (3.0-7.0 METS). These findings are in line with reviews showing that patients are physically inactive for the most part of their hospital stay

[1,2]. Although a physical activity guideline for hospitalized patients is lacking, two concurrently conducted studies suggested that most hospitalized patients should be able to be much more active considering their physical capabilities [3,4]. Supported by these two studies, we confirmed that the vast majority of hospitalized patients is likely far too physically inactive and thus could benefit from physical activity improving interventions.

Patients with the lowest levels of physical activity during hospital stay are most at risk for deconditioning (**chapter 1**) and are therefore considered an important target population for interventions improving physical activity [8]. To identify these patients during routine hospital care, we examined in **chapter 2** the association between physical inactivity and factors that can be systematically assessed (e.g., patient characteristics, muscle strength, functional restraints). The findings revealed an association between physical inactivity and the level of independence in basic mobility activities (i.e., what a patient is capable of doing) and the presence of a urinary catheter. Together, these factors explained 52% of the variance in physical inactivity. Based on these findings, we concluded that systematic assessments of independence of basic mobility and urinary catheter presence may assist healthcare professionals in identifying physically inactive patients most in need for interventions.

Comparable findings were found by Koenders et al. [26], who described that in addition to the level of independence in mobility and urinary catheter, a higher level of pain, drains, oxygen lines, and IV-lines were associated with in-hospital physical inactivity. The amount of explained variance of their model, however, was substantially lower. This difference could be explained by the different definitions of mobility that were used in both studies. Whereas mobility in the study by Koenders et al. [26] was assessed as the patient's level of independence in getting in and out of bed, we assessed the patient's level of independence in rolling in bed, making transfers, standing, and walking using the Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility short form.

To make this tool available for Dutch hospital care, we translated the AM-PAC "6-clicks" Basic Mobility short form from English to Dutch and assessed the construct validity and inter-rater reliability after translation in **chapter 3**. The findings of this chapter indicated that the construct validity was good, as five of the six hypothesis posed a priori were confirmed. Furthermore, the findings indicated that the inter-rater reliability is moderate to excellent, with Intraclass Correlation Coefficients exceeding 0.90 and weighted Kappa's ranging from 0.649 to 0.841. Therefore, we concluded that healthcare professionals can use the Dutch AM-PAC "6-clicks" Basic Mobility short form to validly and reliably assess the independence of basic mobility in Dutch hospital care. This is in line with the studies conducted by Jette et al. [27,28] and Hoyer et al. [29], who found comparable evidence for the validity and reliability of the original English version AM-PAC "6-clicks" Basic Mobility short form.

Another method to identify patients most in need for interventions is to systematically assess the level of mobilization (i.e., what has a patient actually done in the past day) using John Hopkins Highest Level of Mobility (JH-HLM) scale [30]. The advantage of this method is that healthcare professionals can use the scale as a tool to discuss the level of mobilization during inter-professional meetings and as an intervention by setting daily mobilization goals to increase the level of mobilization [31]. Until recently the JH-HLM scale was only used at two General Medicine units in Baltimore, Maryland [30]. Whether this tool could adequately be used in other patient groups such as surgical patients was unknown.

In **chapter 4**, our experience with implementing the JH-HLM at two gastrointestinal and oncological surgery wards was described. Shortly after implementation, healthcare professionals indicated that they often experienced a ceiling effect when they used the JH-HLM in patients admitted for gastrointestinal and oncological surgery. Therefore, we evaluated the ceiling effect and found that 45.2% of the patients scored the highest possible JH-HLM score at the first postoperative day and 87.4% during the first three postoperative days (**chapter 4**). Although ceiling effects are not uncommon when measurement tools are used in new patient populations [32], we did not expect these large numbers. Based on these findings, we concluded this ceiling effect considerably hampered the multidisciplinary team in adequately assessing the level of mobilization, discussing the level of mobilization during inter-professional meetings, and setting mobilization goals after recent gastrointestinal and oncological surgery.

Instead of de-implementing the JH-HLM at our surgical wards, we decided to extend the JH-HLM scale with four additional response categories, which we called the AMsterdam UMC EXtension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale (**chapter 4**). A re-evaluation showed that extending the JH-HLM into the AMEXO scale significantly reduced the ceiling effect, both on the first postoperative day (from 45.2% to 1.7%) and during the first three postoperative days (from 87.4% to 16.8%). Moreover, the four additional response categories were used in

73.3% of the patients during the first three postoperative days. Although a ceiling effect was still present in >15% (16.8%) of the patients during the first three postoperative days [33], we concluded that the AMEXO scale is more appropriate to assess the level of mobilization, to discuss the level of mobilization during inter-professional meetings, and to set daily mobilization goals after gastrointestinal and oncological surgery.

Part II – Understanding why hospitalized patients are physically inactive
The second step to improve physical activity in hospitalized patients was to better understand why they were physically inactive.

Over the past two decades, studies reporting on barriers and enablers to physical activity during hospital stay have grown exponentially. In **chapter 5**, we searched for all patient- and healthcare professional-reported barriers and enablers in previous studies and identified a total of 1316 barriers and enablers. We used the 14-domain version of the Theoretical Domains Framework (TDF) [34] to categorize these barriers and enablers and develop a comprehensive theory-informed overview. This research indicated that to improve physical activity, barriers need to be addressed in 13 TDF domains and enablers need to be enhanced in 11 and 13 TDF domains, respectively for patients and healthcare professionals. The sheer number of barriers and enablers and wide distribution of barriers and enablers across the TDF domains highlighted the need for multifaceted interventions. This research also indicated that the vast majority of both barriers and enablers related to the TDF domain *Environmental Context and Resources*, which included four important topics: patient-related factors (e.g., age, language, illness), care processes and organizational characteristics (e.g., prescribed immobility, bed-centered care), the hospital environment (e.g., hospital room), and resources (e.g., staffing).

While our review provides a comprehensive overview of all barriers and enablers that may be of influence, our methodology did not allow us to determine which barriers might be key to improving physical activity during hospital stay and what might be needed to overcome such barriers. As a result, we performed a mixed-methods study to identify healthcare professionals' perspectives on key barriers to improving physical activity in hospitalized patients and to identify solutions to overcome these key barriers (**chapter 6**). We used the TDF as a basis to ensure all cognitive, affective, social, and environmental influences on behavior were considered during this inquiry [34]. Regardless of the type of hospital ward, this study showed that five themes that warrant attention: (1) the differences in how healthcare professionals define physical activity; (2) the extent to which patients have freedom of choice; (3) the role expectations within the multidisciplinary team; (4) the importance of patients' characteristics and expectations; (5) the hospital bed as a centerpiece. Healthcare professionals indicated they need clear guidelines, roles, and responsibilities when it comes to improving physical activity in hospitalized patients. Healthcare professionals also indicated they need tools to empower hospitalized patients to take a more active role in physical activity during hospital stay. Finally, the healthcare professionals emphasized the need to design and furnish the hospital wards in a way so that patients are encouraged to be more physical activity.

Both **chapter 5** and **6** indicated that many environmental (e.g., hospital room, staffing) and social (e.g., how visitors and healthcare professionals behave towards patients) factors strongly influenced the choice to improve physical activity during hospital stay. These findings are in line with the recent synthesis of qualitative literature performed by Koenders et al. [35], which showed that patients and healthcare professionals considered the hospital culture and environment an incentive for physical inactivity. Also, previous research identifying the factors influencing physical activity behavior in community dwelling older adults and low-income groups highlighted the importance of environmental and social factors on physical activity behavior during everyday life outside the hospital [36,37]. An explanation for the large role of environmental factors during hospital stay is that the environment is currently not designed with physical activity in mind. After all, a hospital is designed as a workplace for healthcare professionals, not a walking space for patients. Furthermore, explanations for the large role of social factors may be the hospital's strong emphasis on promoting and maintaining safety (e.g., preventing falls) and the pervasive culture that hospitalized patients mainly require bed rest for recovery. Because of this emphasis on safety and culture, visitors and healthcare professionals may be more likely to discourage rather than encourage physical activity [35,38,39].

In **chapter 6**, we also discovered that healthcare professionals struggle with the question to what extent patients have freedom of choice when it comes to improving physical activity during hospital stay. While choice of physical activity is typically seen as being ultimately the patient's private matter, healthcare professionals may believe that hospitalized patients may not always be able to properly assess the importance of physical activity at such a time of increased vulnerability and sensitivity [40]. Our finding adds that although many healthcare professionals are committed to improving physical activity in hospitalized patients, opinions also differ on the extent to which healthcare professionals should feel responsible and encourage patients to be physically active when patients choose to be physically inactive. The fact that this was the first study specifically asking medical teams to discuss their perspectives may explain that this key barrier was not exposed so explicitly before.

Part III – Improving physical activity in hospitalized patients through implementation of a multifaceted intervention

The third and last step to improve physical activity in hospitalized patients was to better understand whether and how a multifaceted intervention might result in improved physical activity levels during hospital stay and better patient outcomes. Therefore, we developed and implemented a multifaceted intervention called 'Better By Moving' (BBM) on two gastrointestinal- and oncological surgery wards, one hematology ward, one infectious diseases ward, and one cardiology ward of the Amsterdam UMC (**chapter 7**). BBM entailed 23 intervention components of which a selection was tailored and implemented at each hospital ward by ward-specific working groups using a step-by-step, evidence-based implementation plan informed by Grol and Wensing's Implemenation of Change Model [41] (**chapter 8**).

The outcome evaluation revealed that implementing BBM did not result in significant improvement in the amount of time spent physically active with light, moderate, and vigorous intensity between 8 am and 8 pm (**chapter 8**). Also, the outcome evaluation indicated that implementing BBM did not lead to a reduction of time patients spent lying in bed between 8 am and 8 pm, reduction of length of hospital stay, or an increase in the number of patients who were discharged home instead of transfer to a rehabilitation facility or nursing home. These findings were in contrast to the recently published results of Van Delft et al. [12] showing that the multifaceted intervention called 'Hospital In Motion' resulted in patients spending less time lying in bed and reduced number of discharges to a rehabilitation facility, and Koenders et al. [13] showing that the multifaceted intervention called 'Ban Bedcentricity' resulted on most hospital wards in less sedentary behavior and more patients being discharged home. To understand how these results occurred and how improvements can be made, we concurrently conducted a process evaluation.

The process evaluation showed that the intervention components' reach was moderate among patients (26-78% depending on the intervention component) and healthcare professionals (deemed "sufficient" in qualitative inquiries). Additionally, adoption was low among patients (19-57% depending on the intervention component) and healthcare professionals (deemed "low-to-moderate" in qualitative inquiries) (**chapter 8**). We did not expect these findings, as BBM was based on a local assessment of barriers and solutions (**chapter 6**) and a co-creational approach was used for developing and implementing the intervention (**chapter 7**). Therewith, we aimed to ensure the intervention components were tailored to the perspectives of patients and healthcare professionals and hoped to establish ownership among healthcare professionals, both important elements that increase the likelihood in implementing organizational changes successfully [42,43]. However, that reach was moderate and adoption was low suggested that addressing physical inactivity during hospital stay was still a low priority in daily routines and that sufficient ownership was not established among healthcare professionals [44]. One of the main underlying reasons might have been that the support in terms of priority, resources and involvement at both staff- and ward level was insufficiently provided, which was identified as the primary contextual factor influencing the implementation and outcomes (**chapter 8**).

Despite moderate reach and low adoption, it is important to note that implementing BBM did result in statistically significant changes in several mechanisms through which we hypothesized that the intervention would bring about change: patient encouragement from the hospital environment increased, patients indicated they exercised more frequently, and the awareness and confidence among healthcare professionals increased (**chapter 8**). It is possible that these changes in mechanisms of impact, together with a higher reach and adoption of the intervention components, could have resulted in significant improvements in physical activity. However, we cannot determine this at this time and previous research reporting on multifaceted interventions to improve in-hospital physical activity did not investigate these pathways in more detail yet.

Furthermore, almost half the intervention components in BBM aimed to influence the environment of the hospital wards (**chapter 8**). These interventions components included, for example, the purchase of a cycle ergometer with virtual reality routes, the organization of activities to be physically active, and the use of prompts and cues highlighting the harmful effects of bedrest. However, at the same time lack of funding, relocation, and renovation were often mentioned as strong barriers hindering the implementation and improvement in outcomes. Both patients and healthcare professionals indicated that more extensive changes to the environment were required to effectively improve physical activity. The potential of extensively changing the environment to improve physical activity was highlighted by Kolk et al. [4], who showed that step numbers double one day after hospital discharge, and Ramsey et al. [3], who showed that geriatric rehabilitation patients receiving care in the home-based setting were much more physically active than those receiving care in the hospital-based setting.

Methodological considerations

Study design

A major strength of this thesis lies in the use of pragmatism as a research paradigm and stakeholder-oriented research as an engagement strategy [45]. Achievable quantitative and mixed-methods study designs were used to gain useful and actionable knowledge, recognize the interconnectedness of experience, knowledge and action among patients and healthcare professionals, and view the research inquiry that led to the creation of this thesis as an experiential process [46]. This ensured that the findings represent a real-world reflection of what happened (**chapter 2**, **3**, **4**, and **8**) and was perceived (**chapter 6** and **8**) in routine hospital care. In this way, the external validity of the findings can be considered high [46,47].

The disadvantage of using pragmatism as a research paradigm is that in some studies choices had to be made at the expense of their internal validity. A pragmatic before-after study design was considered most appropriate to assess the effect of extending the JH-HLM into the AMEXO scale (**chapter 4**) and the effect of implementing BBM (**chapter 8**). The consequence of using this study design was that it was not possible to control for concurrent changes in patient case mix and other organizational changes at the Amsterdam UMC (i.e., confounders). As a result, it was not possible to conclude a direct cause-and-effect relationship between the changes implemented and the outcomes assessed [48]. However, it remains debatable whether this would have led to a more 'true' effect in these two studies, as the concurrent changes in patient case mix and organizational changes represent the normal conditions into which the interventions must be integrated to be applicable in practice [49,50].

Study population

An important strength of **chapters 2**, **6**, and **8** is that these studies took into account the considerable heterogeneity in hospitalized patients by including patients and healthcare professionals at different hospital wards. This heterogeneity was also taken into account in **chapter 5** by solely excluding studies that reported barriers and enablers from the perspective of patients and healthcare professionals on intensive care and psychiatric wards. Most previous studies that examined the levels of physical activity, barriers and enablers to physical activity, and physical activity improving interventions focused only on hospitalized elderly patients. Even though age is an important factor determining whether hospitalization-associated physical deconditioning leads to permanent impairments in ADL and societal participation,

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recent research [26,51] and the findings in **Chapter 2** suggested that adult patients of all ages are at risk for low physical activity levels during hospital stay.

By contrast, the generalizability of the findings might be limited as most of the studies included in this thesis were conducted in a tertiary university hospital. Tertiary university hospitals provide tertiary care, treating more severely ill patients who cannot be treated adequately in primary and secondary care hospitals. This difference in healthcare and severity of illness among patients could be another explanation why patients were observed to spent less time physically active and more time lying in bed (**chapter 2**) than reported by comparable studies in secondary hospitals [1]. This could also imply that the key barriers to and the solutions for improving physical activity in **Chapter 6** cannot directly be translated to secondary hospitals. However, Hoyer et al. [52] found in their study that barriers to promoting physical activity were common between academic (i.e. tertiary) and community (i.e., secondary) hospital settings. While there will be differences in contextual factors [53,54], it can thus be assumed that the findings of this chapter provide guidance for both community and academic hospitals.

For the study described in **chapter 8** it is also important to note that, due to the aforementioned heterogeneity in patient population, large sample sizes were needed to evaluate the effect of implementing BBM on physical activity. However, due to the limited resources available (**chapter 7**) and the COVID-19 pandemic, it was only possible to include 85 patients before implementation and 85 patients after implementation in the outcome evaluation instead of the intended 110 patients before and 110 patients after. As a result, the before-after analyses on physical activity and time spent lying in bed may have been subject to a type II error.

Outcome measures

To determine which barriers might be key to improving physical activity during hospital stay and what might be needed to overcome such barriers, surveys were distributed and focus group discussions conducted among healthcare professionals (**chapter 6**). In this study, there was a deliberate focus on exploring healthcare professionals' perspectives as clinical practice and previous research [42,54] showed that tailoring hospital-based interventions to the perspectives of healthcare professionals will increase the likelihood to result in successful changes. However, it should be noted that to translate the identified solutions into interventions, the perspectives of patients and visitors should also be incorporated. In BBM these perspectives were incorporated by occasionally inviting patients and caregivers during the development and implementation of the ward-specific implementation plans (**chapter 7** and **8**).

In **chapter 8**, the differences in length of hospital stay and number of discharges home before, during, and after implementation of BBM were assessed. These outcomes were based on the potential influence on costs in hospital care. Although previous interventions to improve in-hospital physical activity suggested that their interventions resulted in changes in length of hospital stay or number of discharges home [12,13,18,30], the relatively poor match between the intervention (i.e., improving physical activity) and these outcomes might be another explanation why the findings of this study contrast those of earlier studies [55].

Theories, models, and frameworks

A particular strength of this thesis in general was the combination of theories, models, and frameworks (TMF's) as a foundation for generalizing our research findings and implementation efforts [56,57]. While theories posit the causal mechanisms of implementation, models are commonly used to guide the process of translating research into practice, and frameworks to point to factors believed or found to influence implementation outcomes [56,57]. In this thesis, the following TMF's were used:

- the TDF [34,57] as a framework to categorize all patient- and healthcare professional-reported barriers and enablers from the literature (**chapter 5**) and to ensure all cognitive, affective, social, and environmental influences on behavior were considered when identifying key barriers and solutions (**chapter 6**);
- the Implementation of Change model by Grol and Wensing [41,57] as a model to guide the development and implementation of BBM (**chapter 7** and **8**);
- the COM-B (Capability, Opportunity, Motivation – Behavior) theory as part of the Behavioral Change Wheel (BCW) framework [57,58] to characterize the content of BBM (**chapter 7** and **8**);
- and the UK Medical Research Council (MRC) framework [53] to conduct and report the process evaluation of BBM (**chapter 7** and **8**).

Although the use of TMF's in implementation science has been advocated by many researchers for generalizing research findings and implementation efforts, this does not necessarily mean that it will result in more effective implementation [57]. In addition, a limitation of specifically using the TDF in **chapter 5** was that it did not provide us with an explanation of how the categorized barriers and enablers were related and influenced one another.

The multifaceted intervention "Better By Moving"

The various intervention components of BBM were selected, tailored, and implemented by ward-specific working groups consisting of a physician or physician assistant, nurses, a nursing assistant, physical therapists, a program manager, and a senior nurse or team leader (**chapter 8**). Moreover, convenience samples of patients, caregivers, team leaders, and policymakers on each hospital ward were occasionally invited to provide input. This resulted in a ward-specific, evidence-based implementation plan to break barriers and enhance enablers. However, due to the limited financial and logistic resources available (**chapter 7**), it was not possible to evaluate the implementation of BBM on each hospital ward separately [59]. Although implementing BBM was not effective on overall physical activity, time spent lying in bed, length of hospital stay, and the number of patients who were discharged home, it might have been effective on hospital wards separately. This was substantiated by comparable studies showing that implementing a multifaceted physical activity improving intervention results in differences in outcomes between hospital wards, even if the intervention components were largely the same [12,13]

Furthermore, by empowering working groups as part of a co-creative approach to select, tailor, and implement the intervention components (**chapter 7**), the researchers hoped to establish ownership [43,54]. The consequence of this approach is that the working groups were all in control, which increased the number and variability of intervention components. In BBM this resulted in 23 intervention components of which a different selection was tailored and implemented at each hospital ward (**chapter 8**). Although the process evaluation provided insight into the potential mediators and unintended consequences, the effect of each intervention component separately on physical activity was not assessed. While this might be interesting for the generalization of the individual intervention components, it is questionable whether it would be of added value because each patient experiences different barriers that also change over time. Thus, it is hypothesized that each intervention component has a different effect on individual level.

Clinical recommendations

In this section, recommendations are given how healthcare professionals, researchers, and policymakers can improve physical activity in hospitalized patients.

Measure physical activity as one of the vital signs

How can you improve something that you do not measure? Like a vital sign, such as heart rate, physical activity should be measured during routine hospital care. As long as tri-axial accelerometers are not available for large scale implementation in routine hospital care, systematic assessments using the AMEXO scale will allow healthcare professionals to quantify what patients actually do [60]. For implementation, healthcare professionals should be trained to use this tool on a daily basis, Electronic Medical Records (EMRs) must be adapted so that healthcare professionals can easily document their findings, and documentation policies must be developed to ensure the documentation compliance is sufficient [60].

Identify the patients most in need for physical activity improving interventions

Despite the conclusion that all patients admitted to a hospital can benefit from interventions to improve physical activity, those most in need should be systematically identified as patients for whom tailored interventions should be implemented as soon as possible. As with fall prevention policies [61], every patient may fall during hospital stay; however, those most at risk of falling warrant the immediate implementation of tailored interventions to prevent a fall (e.g., ensure the room is free of clutter, provide non-skid footwear). Adding the AM-PAC "6-clicks" Basic Mobility short form and presence of urinary catheter to the systematic assessments described above will help healthcare professionals to better identify this patient group most in need for interventions.

Use a common language for physical activity during hospital stay

To overcome the variation in how healthcare professionals define physical activity during hospital stay, an interdisciplinary common language should be used. To provide healthcare professionals with this common language, interdisciplinary agreement should first be reached on a common measure for physical activity during hospital stay. Systematically assessing of what patients *actually do* using the AMEXO scale and what patients *can do* using the AM-PAC "6-clicks" Basic Mobility short form can be supportive in this regard [60].

Make significant adjustments to the physical and social hospital environment

Based on the findings of this thesis, it can also be assumed that it is nearly impossible to ensure that hospitalized patients are more physically active during routine hospital care without making significant adjustments to the physical and social environment of the patient. Which adjustments these should be depends on the barriers and enablers perceived in local clinical practice. From our findings, we recommend to at least develop intervention strategies breaking barriers related to care processes and organizational characteristics (e.g., communication, hospital culture), physical environment of the hospital (e.g., room, hospital ward), resources (e.g., staff, equipment), and the interpersonal processes between patients, visitors, and healthcare professionals (e.g., degree of encouragement).

Ensure patient and healthcare professionals understand their role and take responsibility

The findings presented in this thesis also showed that the extent to which healthcare professionals perceived improving physical activity to be their responsibility strongly determines whether they decide to encourage patients to be physically active during hospital stay. Multidisciplinary approaches to improve physical activity have proven to be effective [18,30]. However, these studies highlighted that clear delineation of roles within the multidisciplinary team is required and tools should be available that encourage healthcare professionals to take responsibility. The same accounts for the patients: what could be their role during hospital stay and how could they take responsibility with respect to physical activity? This should be clear to patients admitted to a hospital.

Make physical activity during hospital stay a matter of course

The struggle with the question to what extent patients have freedom of choice concerns the feeling among healthcare professionals that they often have to impose physical activity on the patient. This issue can only be overcome if the hospital culture is fundamentally changed, from the basic assumption "*it is normal that patients lie in bed during hospital stay*" to "*it is normal that patients are physically active during hospital stay*". Measuring physical activity as one of the vital signs and ensuring there is a clear delineation of roles and responsibilities may, in addition to their aforementioned benefits, also be the first step to change the hospital culture fundamentally.

Employ a continuous quality improvement approach to improve in-hospital physical activity

Based on the findings of our BBM process evaluation, such as our intervention components' moderate reach and low adoption, we recommend to employ a continuous quality improvement approach to improve in-hospital physical activity as it allows multidisciplinary teams to reflect on routine hospital care much more frequently. This regular insight can lead to timely adaptations of current intervention components and implementation strategies or be the trigger for developing new ones [54]. Several approaches like Lean Management, Six Sigma, and Plan-Do-Study-Act (PDSA) Cycles have been described in previous research [62].

Future perspectives

Ideally, physical activity should be measured in routine hospital care by providing every patient admitted to the hospital a tri-axial accelerometer, as accelerometers have proven to be the most valid measurement tools to assess physical activity objectively, longitudinal, and continuously during hospital stay [63-65]. Accelerometers also provide patients, healthcare professionals, and researchers more detailed insight into physical activity in terms of intensity, duration, and frequency, as well as activity type. However, as described in **chapter 1**, no accelerometers are currently available that are affordable for such a large population, sufficiently account for the high number of technical requirements, and can be placed in a way it does not limit the patient's willingness to wear them [66]. Future research should focus on developing an accelerometer that meets these requirements and, subsequently, how these accelerometers can support healthcare professionals in improving physical activity in routine hospital care.

Meanwhile, more psychometric research is needed to support the use of the AM-PAC "6-clicks" Basic Mobility short form and AMEXO scale in routine hospital care. In addition to the evidence for the validity and reliability of the AM-PAC "6-clicks" Basic Mobility short form [27,28], previous research showed that the AM-PAC "6-clicks" Basic Mobility short form can be used as an instrument to estimate where rehabilitation personnel should be deployed [27] and determine discharge destination [67,68]. Apparently, systematically assessing level of independence in mobility using the valid and reliable AM-PAC "6-clicks" Basic Mobility short form yields important information for healthcare professionals to organize the best care, to the right person, in the right setting, at the right time. Further research is necessary to provide evidence for the validity and reliability of the Dutch AM-PAC "6-clicks" Basic Mobility short form when used in other hospital wards than the internal medicine and its predictive value when used in the Dutch healthcare system. Furthermore, we recommend to investigate the validity, reliability, and responsiveness of the AMEXO scale when used to assess mobilization in different populations of hospitalized patients.

While it is acknowledged that “more is better” in the case of in-hospital physical activity, it is still unknown *how much* physical activity hospitalized patients should engage in to achieve positive patient outcomes (e.g., being discharged home without functional decline). This insight could be used to develop normative values and define clear physical activity goals for both patients and healthcare professionals and, therewith, help them overcome many barriers currently perceived to improve physical activity during hospital stay. Therefore, we highly recommend to conduct a large cohort study in which the relationship between the number of minutes spent on physical activity and changes in patient outcomes can be further investigated.

Besides investigating *how much* physical activity hospitalized patients should engage in, knowledge should be expanded on *how* physical activity can be improved. Future research does this by closely examining ‘what works, for whom, in what context, why – or why not – and with what results’ instead of focusing mainly on the effectiveness of interventions [69]. This would improve the generalizability of key lessons learned to different sites or other cultures with different healthcare systems. Therefore, we recommend that all physical activity improving interventions currently under study should add a detailed process evaluation using an established evaluation framework [57]. For future physical activity improving interventions yet to start, we recommend to use more innovative approaches instead of a traditional hybrid (effectiveness-process) design to examine ‘what works, for whom, in what context, why – or why not – and with what results’, such as a Realist Evaluation [69]. The advantage of this particular approach is that it assists researchers in embracing the complexity of changing the patients’ and healthcare professionals’ behavior regarding in-hospital physical activity and provides opportunities to develop, test and refine theory about *why* an intervention aimed at improving in-hospital physical activity might work [35,69].

Although this topic has not been investigated in this thesis, it is important to note that the level of physical activity is inextricably linked to the hospitalized patients’ nutritional status as malnutrition is one of the other two reasons for acquiring hospitalization-associated physical deconditioning (**chapter 1**). Moreover, like physical activity during hospital stay, nutritional status can be influenced by behavioral change interventions [70,71]. Future intervention studies that aim to prevent hospitalization-associated physical deconditioning may therefore best focus on investigating the effectiveness of behavior change interventions targeting both physical activity level and nutritional status.

How is Mrs. Petersen doing?

In the general introduction we met Mrs. Petersen, who was lying in bed with a fever in the nearby hospital. The longer her hospital stay took, the more help Mrs. Petersen needed to get out of bed and the more discussions it took to motivate her to walk. Now, let us review Mrs. Petersen's situation with the knowledge we have gained with this thesis in mind.

Mrs. Petersen, a 69-year old woman, is lying in bed with a fever in the nearby hospital. Five days ago she was admitted through the emergency ward with a mitral valve insufficiency. The mitral valve should be replaced, but due to the fever, surgery could not be performed. Instead, Mrs. Petersen was admitted to the Cardiology ward for antibiotic treatment.

From the moment Mrs. Petersen was admitted to the Cardiology ward, she was provided with information to ensure she knew her role and responsibility when it comes to physical activity. While having an IV line and urinary catheter, physical activity goals were set every day as part of her treatment and she received help from nurses and nursing assistants if she couldn't achieve them on her own. To support Mrs. Petersen in meeting her physical activity goals, the amount of physical activity was also made visible using the AMEXO scale at the patient communication board hanging next to her bed. All meals were served at a central buffet and since she still was able to walk she picked them up herself. Once a day the physician and nurse visited her and discussed, among other important medical topics, her current level of mobilization and revised her mobilization goals.

Despite her efforts to achieve her goals, Mrs. Petersen partially lost the ability to independently walk due to the fever she had. Using the AM-PAC "6-clicks" Basic Mobility short form, the nurses identified Mrs. Petersen's inability to walk on her own. The nurses, nursing assistants, physicians, and physical therapists recently carried out a local quality improvement project and therewith ensured immediate actions could be initiated in response to the newly acquired need for assistance of Mrs. Petersen. In her case, nurses composed a daily activity program, the physical therapist was asked to help her regain her strength and independence in walking, the physicians encouraged her mentally and reassessed the need for a urinary catheter, and the nursing assistants supported her in walking to the central buffet for her meals. In a matter of days these actions resulted in Mrs. Petersen regaining her ability to walk independently and, therewith, she was ready to be discharged home.

For Mrs. Petersen, it was quite normal to be physically active during her hospital stay.

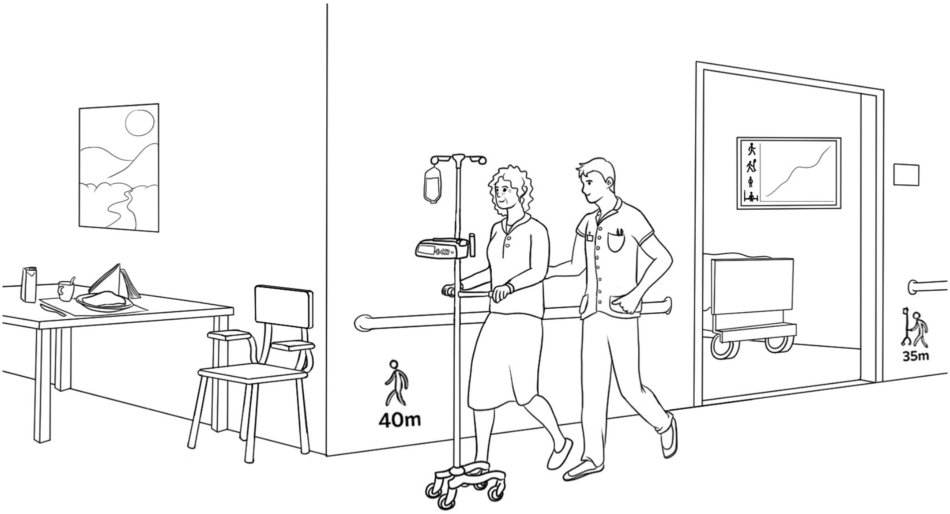

Figure 1. Mrs. Petersen is recovering.

Conclusion

In this thesis, we aimed to expand knowledge on how to improve physical activity in hospitalized adult patients. Through the research in this thesis, we now understand that current physical activity levels can be improved in routine hospital care by:

- Measuring physical activity as one of the vital signs;
- Systematically identifying the patients most in need for physical activity improving interventions;
- Using a common language for physical activity;
- Making significant adjustments to the physical and social hospital environment;
- Ensuring patient and healthcare professionals understand their role and take responsibility;
- Making physical activity during hospital stay a matter of course;
- Employing a continuous quality improvement approach to support multidisciplinary teams in planning, implementing, studying, and evaluating physical activity improving intervention components.

The findings, instruments, and experiences described in this thesis can be used as a starting point to implement these clinical recommendations in local hospital care and change the hospital culture fundamentally. Future research should focus on developing an accelerometer suitable for broad use in routine hospital care, investigating the psychometric properties of presented instruments, providing insight into how much physical activity should be engaged in, and continue examining what works, for whom, in what context, why – or why not – and with what results.

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IMPROVING PHYSICAL ACTIVITY DURING HOSPITAL STAY

Towards bridging the research-practice gap

Although the relationship between physical activity during hospital stay and positive health outcomes is well-documented, adult patients are still routinely put to bed when admitted. The hospital bed is the centerpiece, which is substantiated by recent studies that still report very low physical activity levels during hospital stay. There is therefore a discrepancy between what is known from the literature and what actually happens in a hospital. To bridge this gap, this thesis aims to expand knowledge on how to improve physical activity in hospitalized patients.

In **chapter 1**, the background and rationale underlying the aims of this thesis are introduced. This thesis is divided in three different parts.

In **part I** of this thesis, the studies aim to expand knowledge on how to identify physically inactive patients during routine hospital care. Two easy-to-implement methods have been explored: systematically assessing the factors associated with physical inactivity and systematically assessing the level of mobilization (i.e., what a patient has actually done in the past day).

In **chapter 2**, the results are described of a cross-sectional study exploring the factors associated with physical inactivity in 114 hospitalized adults of all ages. In this observational study, the time spent on physical activity was assessed using the Physical Activity Monitor (PAM) AM400 accelerometer on a random day during hospital stay. In addition, the time patients spent lying in bed, sitting, standing and walking was assessed using behavioral mapping protocols. The factors examined in this study were age, comorbidities, the type of admission, length of hospital stay, preadmission independence in activities of daily living (ADL), independence in mobility and ADL at the day of observation, muscle strength, mobility-related self-efficacy, and various types of functional restraints such as IV-lines. Patients were observed to be physically active for median (IQR) 26 (13-52) minutes between 8 am and 8 pm. The mean (SD) percentage of time patients spent on each type of activity was distributed as followed: lying in bed 67.3% (23.5), sitting 25.2% (19.9), standing/transfer 2.5% (2.6), and walking/ergometer 5.0% (5.6). After performing univariable and multivariable regression analyses, physical inactivity appeared to be 159.87% (CI = 89.84-255.73) higher in patients who were dependent in basic mobility, and 58.88% (CI = 10.08-129.33) higher in patients with a urinary catheter (adjusted $R^2 = 0.52$, $p < 0.001$). These findings were valid regardless of the hospital ward where patients were admitted. Systematic assessments of both factors during routine hospital care may therefore assist healthcare professionals in identifying these physically inactive patients throughout the hospital.

In **chapter 3**, the results are described of a two-phased cross-sectional study aiming to make the Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility short form available for Dutch hospital care. The AM-PAC "6-clicks" Basic Mobility short form is the only tool designed to be easy to use within routine hospital care. The instrument has previously been validated for the general hospital population. In brief, healthcare professionals can use the AM-PAC "6-clicks" Basic Mobility short form to determine the patient's level of independence by observing six basic mobility activities using a scale of one (unable to do or total assistance required) to four (no assistance required). The six basic mobility activities are: turning in bed, transfers in bed, transfers out of bed, standing, walking and climbing stairs. In phase 1, the AM-PAC "6-clicks" Basic Mobility short form was translated from English to Dutch using a forward-backward translation method. In phase 2, the newly developed Dutch version of the AM-PAC "6-clicks" Basic Mobility short form was used to assess the construct validity and to assess the inter-reliability. We found the construct validity to be good and the inter-rater reliability to be moderate to excellent (ICC's exceeding 0.90; weighted Kappa's ranging from 0.649 to 0.841). The findings of this study indicate that the Dutch AM-PAC "6-clicks" Basic Mobility short form is an adequate tool to assess independence in basic mobility during hospital stay and, therefore, can assist healthcare professionals in identifying physically inactive patients during routine hospital care in the Netherlands.

In **chapter 4**, our experiences with implementing the John Hopkins Highest Level of Mobility (JH-HLM) scale at two gastrointestinal and oncological surgery wards are outlined. The JH-HLM is a validated 8-point ordinal scale and can be used by healthcare professionals to reliably assess the level of mobilization, to discuss the level of mobilization during inter-professional meetings, and to set daily mobilization goals. The JH-HLM ranges from minimal score 1 = lying passively in bed to maximal score 8 = walking 76.2 meters / 225 feet. Shortly after implementation, however, healthcare professionals indicated that they often experienced a ceiling effect when they used the JH-HLM in patients admitted for gastrointestinal and oncological surgery. Therefore, we evaluated the ceiling effect and found that 45.2% of the patients scored the highest possible JH-HLM score at the first postoperative day and 87.4% during the first three postoperative days. Here, in our effort to provide the healthcare professionals with a tool that can be used after recent gastrointestinal and oncological surgery without ceiling effect, we extended the JH-HLM scale by adding four additional response categories up to 1125 meters / 3750 feet and called it the AMsterdam UMC EXtension of the JOhn HOpkins Highest Level of mObility (AMEXO) scale. In the following year, the AMEXO scale was used. In contrast to the JH-HLM scale, 1.7% of the patients scored the highest possible AMEXO score at the first postoperative day (OR = 0.021, CI = 0.007-0.059, $p < 0.001$) and 16.8% during the first three postoperative days (OR = 0.028, CI = 0.013-0.060, $p < 0.001$). Also, a change in score was observed in more patients after extending the JH-HLM into the AMEXO scale (OR = 9.101, CI = 4.046-0.476, $p < 0.001$) and the four newly added response categories were used in 73.3% patients. These results suggest that extending the JH-HLM into the AMEXO scale decreased the ceiling effect significantly, making the tool more appropriate for use in daily clinical practice after recent gastrointestinal and oncological surgery.

In **part II**, the studies aim to expand our understanding why hospitalized adult patients are physically inactive during hospital stay.

Chapter 5 concerns a scoping review, in which a comprehensive overview has been provided of all patient-reported and healthcare professional-reported barriers and enablers to physical activity during hospital stay. The Theoretical Domains Framework (TDF) – a theoretical lens through which to view cognitive, social and environmental influences on behavior – was used to categorize all identified barriers and enablers. Fifty-six quantitative, qualitative, and mixed-methods studies were included in this review. In total, 264 barriers and 228 enablers were reported by hospitalized patients, and 415 barriers and 409 enablers by healthcare professionals. The majority of patient-reported and healthcare professional-reported barriers and enablers were assigned to the TDF domains *Environmental Context & Resources* and *Social Influences*. This highlights the need for interventions that target physical environment, hospital care processes, characteristics of the hospital organization, the resources available for patients and healthcare professionals, patient-related factors, and the social influence on patients and healthcare professionals. The comprehensive TDF-based overview provided in this study can support healthcare professionals, researchers, and policymakers in developing and implementing physical activity improving interventions in local hospital care.

In **chapter 6**, the results are described of an explanatory sequential mixed-methods study among local healthcare professionals to identify the barriers to improving physical activity and to identify what the multidisciplinary team needs to overcome these barriers. In phase 1, TDF-based surveys were used to identify the most important barriers from the individual perspective of healthcare professionals. In total, 15 physician/physician assistants, 106 nurses, four nursing assistants, and four physical therapists from two gastrointestinal and oncological surgery, one hematology, one infectious diseases, and one cardiology ward completed the survey. The results of phase 1 formed the basis for three focus group discussions in which 30 healthcare professionals participated. These focus group discussions were held to determine which barriers were key and which solutions may help multidisciplinary teams to overcome these key barriers. The results of this study show that healthcare professionals need clear guidelines, roles, and responsibilities when it comes to improving physical activity in hospitalized patients. Moreover, healthcare professionals need tools to empower hospitalized patients to take a more active role in physical activity during hospital stay. Finally, the healthcare professionals indicated that the hospital wards need to be designed and furnished so that patients are encouraged to be active.

In **part III**, the studies aim to better understand whether and how multifaceted interventions might result in improved physical activity levels during hospital stay and better patient outcomes. Based on the acquired knowledge of part I and II, we developed and implemented the theory-informed, multifaceted intervention called “Better By Moving” (BBM) in a tertiary university hospital in the Netherlands.

In **chapter 7**, the study protocol of BBM is presented. BBM aimed to improve physical activity in adult patients admitted to two gastrointestinal and oncological surgery, one hematology, one infectious diseases, and one cardiology hospital ward of the Amsterdam UMC, location Academic Medical Center, in the Netherlands. In this study protocol, the step-by-step, evidence-based plan to develop and implement intervention components in co-creation with patients and healthcare professionals are described. Further, the theories, models, and frameworks used to support the development and implementation of BBM and the different measures used to evaluate the effectiveness and process of BBM are described.

In **chapter 8**, the results of developing and implementing BBM at the aforementioned hospital wards of the Amsterdam UMC are described. BBM entailed 23 intervention components of which a selection was tailored and implemented at each hospital ward. The outcome evaluation shows that implementing BBM did not result in a significant improvement in minutes patients spent physically active, reduction in time patients spent lying in bed or length of hospital stay, and increase in discharges home. At the same time, the process evaluation shows that among patients and healthcare professionals the intervention components' reach was moderate and adoption was low. Based on these findings, we hypothesize that moderate reach and low adoption contributed to the lack of effectiveness of BBM. Therefore, implementation teams should consider to closely monitor reach and adoption during implementation of future multifaceted interventions to enable timely adaptations of the intervention components and implementation strategies, if required. Furthermore, implementation teams should consider including a limited number of intervention components with a clear hierarchical structure as this ensures that more attention and effort can go to implementing the intervention components adequately. The findings of our process evaluation also show that the level of support in terms of priority, resources and involvement – both at staff- and ward level – was a key contextual factor influencing the implementation and outcomes of BBM. This likely explains why sufficient reach and adoption was not achieved. To further increase the effectiveness of implementation, it is therefore also important for implementation teams to consider the support in terms of priority, resources and involvement as an active component that can be influenced during multifaceted intervention development and implementation.

In **chapter 9**, the main findings, methodological considerations, clinical recommendations, and future perspectives are discussed. Through the research in this thesis, we now understand that current physical activity levels can be improved during routine hospital care by: 1) measuring physical activity as one of the vital signs; 2) systematically identifying the patients most in need for physical activity improving interventions; 3) using a common language for physical activity; 4) making significant adjustments to the physical and social hospital environment; 5) ensuring patient and healthcare professionals understand their role and take responsibility; 6) making physical activity during hospital stay a matter of course; 7) employing a continuous quality improvement approach to support multidisciplinary teams in planning, implementing, studying, and evaluating physical activity improving intervention components. The findings, instruments, and experiences described in this thesis can be used as a starting point to implement these clinical recommendations in local hospital care.

VERBETERING VAN DE FYSIEKE ACTIVITEIT TIJDENS OPNAME IN HET ZIEKENHUIS

Op weg naar het overbruggen van de kloof tussen onderzoek en praktijk

Hoewel de relatie tussen fysieke activiteit tijdens ziekenhuisopname en positieve gezondheidsresultaten goed gedocumenteerd is, worden volwassen patiënten zodra ze in het ziekenhuis opgenomen nog steeds op bed gelegd. Het ziekenhuisbed staat centraal, wat onderbouwd wordt door recente onderzoeken die nog steeds rapporteren dat patiënten hoofdzakelijk fysiek inactief zijn tijdens de ziekenhuisopname. Er is dus een discrepantie tussen hetgeen bekend is uit de literatuur en wat er daadwerkelijk in het ziekenhuis gebeurt. Het doel van dit proefschrift is om deze kloof tussen onderzoek en praktijk te overbruggen door de kennis te vergroten over hoe fysieke activiteit bij patiënten in het ziekenhuis verbeterd kan worden.

In **hoofdstuk 1** worden de achtergrond en de rationale van de doelstellingen van dit proefschrift geïntroduceerd. Dit proefschrift is opgedeeld in drie verschillende delen.

In **deel I** van dit proefschrift zijn de onderzoeken gericht op het vergroten van de kennis over hoe fysiek inactieve patiënten geïdentificeerd kunnen worden tijdens routinematige ziekenhuiszorg. Twee eenvoudig te implementeren methoden werden geëxploreerd: (1) het systematisch beoordelen van de factoren die samenhangen met fysieke inactiviteit en (2) het systematisch beoordelen van het niveau van mobilisatie (d.w.z. wat een patiënt werkelijk heeft gedaan in de afgelopen dag).

In **hoofdstuk 2** staan de resultaten beschreven van een dwarsdoorsnede onderzoek naar de factoren die samenhangen met fysieke inactiviteit bij 114 in het ziekenhuis opgenomen volwassenen van alle leeftijden. In dit observationele onderzoek werd de tijd besteed aan fysieke activiteit gedurende een willekeurige dag tijdens de ziekenhuisopname gemeten met behulp van de Physical Activity Monitor (PAM)

AM400-versnellingsmeter. Bovendien werd de tijd die patiënten liggend in bed, zittend, staand of lopend doorbrachten beoordeeld met behulp van gedragsobservatieprotocollen. De factoren die in dit onderzoek werden onderzocht waren leeftijd, comorbiditeiten, type ziekenhuisopname, opnameduur, onafhankelijkheid in de algemene dagelijkse levensverrichtingen (ADL) voorafgaand aan de opname, onafhankelijkheid in basale activiteiten zoals het verplaatsen naar de stoel en lopen en onafhankelijkheid in ADL op de dag van observatie, spierkracht, mobiliteit gerelateerde zelfeffectiviteit en verschillende soorten functionele beperkingen zoals infuuslijnen. Er werd geobserveerd dat patiënten tussen 8 uur 's ochtends en 8 uur 's avonds mediaan (interkwartielafstand) 26 (13-52) minuten fysiek actief waren. Het gemiddelde (standaarddeviatie) percentage van de tijd die patiënten aan elk type activiteit besteedden was als volgt verdeeld: in bed liggen 67,3% (23,5), zitten 25,2% (19,9), staan/transfer 2,5% (2,6) en lopen/ergometer 5,0% (5,6). Fysieke inactiviteit bleek 159,87% (betrouwbaarheidsinterval = 89,84-255,73) hoger bij patiënten die afhankelijk waren in het uitvoeren van (basale) activiteiten en 58,88% (betrouwbaarheidsinterval = 10,08-129,33) hoger bij patiënten met een urinekatheter (aangepaste R^2 = 0,52, p < 0,001). Deze resultaten golden, ongeacht de ziekenhuisafdeling waar patiënten waren opgenomen. Systematische beoordeling van beide factoren tijdens de routinematige ziekenhuiszorg kan zorgverleners daarom ondersteunen bij het identificeren van deze lichamelijk inactieve patiënten in het hele ziekenhuis.

In **hoofdstuk 3** staan de resultaten beschreven van een dwarsdoorsnede onderzoek met twee fases wat tot doel had de Activity Measure for Post-Acute Care (AM-PAC) "6-clicks" Basic Mobility short form beschikbaar te maken voor de Nederlandse ziekenhuiszorg. De AM-PAC "6-clicks" Basic Mobility short form is het enige instrument dat ontworpen is om gemakkelijk gebruikt te kunnen worden binnen de routinematige ziekenhuiszorg. Het instrument is eerder gevalideerd voor de gehele ziekenhuispopulatie. In het kort, zorgverleners kunnen de AM-PAC "6-clicks" Basic Mobility short form gebruiken om het niveau van onafhankelijkheid van de patiënt te bepalen door zes (basale) activiteiten te observeren op een schaal van één (niet in staat om te doen of volledige hulp vereist) om vier (geen hulp vereist). De zes activiteiten zijn: draaien in bed, verplaatsen in bed, verplaatsen uit bed, staan, lopen en traplopen. In fase 1 werd de AM-PAC "6-clicks" Basic Mobility short form eerst vertaald van het Engels naar het Nederlands met behulp van een voorwaarts-achterwaartse vertaalmethode. Vervolgens werd in fase 2 de nieuw ontwikkelde Nederlandse versie van de AM-PAC "6-clicks" Basic Mobility short form gebruikt om de constructvaliditeit en de interbeoordelaarsbetrouwbaarheid te beoordelen. De constructvaliditeit bleek goed en de interbeoordelaarsbetrouwbaarheid matig tot uitstekend (Intraclass Correlatie Coëfficiënten boven de 0,90; gewogen Kappa's variërend van 0,649 tot 0,841). De bevindingen van dit onderzoek geven aan dat de Nederlandse AM-PAC "6-clicks" Basic Mobility short form een adequaat instrument is om de onafhankelijkheid in (basale) activiteiten tijdens ziekenhuisopname te beoordelen en zodoende zorgverleners kan ondersteunen bij het identificeren van fysiek inactieve patiënten tijdens de routinematige ziekenhuiszorg in Nederland.

In **hoofdstuk 4** zijn onze ervaringen met het implementeren van de John Hopkins Highest Level of Mobility (JH-HLM) schaal op twee gastro-intestinale en oncologische chirurgie afdelingen uiteengezet. De JH-HLM is een gevalideerde 8-punts ordinale schaal en kan door zorgverleners gebruikt worden om het niveau van mobiliseren betrouwbaar te beoordelen, te bespreken tijdens multidisciplinair overleg en om dagelijkse mobilisatiedoelen te stellen. De JH-HLM loopt van de minimale score 1 = passief in bed liggen tot de maximale score 8 = 76.2 meter / 225 voet lopen. Kort na de implementatie gaven zorgverleners echter aan dat zij vaak een plafondeffect ervoeren wanneer zij de JH-HLM gebruikten bij patiënten die opgenomen waren voor gastro-intestinale en oncologische chirurgie. Daarom evalueerden wij het plafondeffect en ontdekten dat 45,2% van de patiënten de hoogst mogelijke JH-HLM-score scoorden op de eerste postoperatieve dag en 87,4% tijdens de eerste drie postoperatieve dagen. In ons streven om de zorgverleners een hulpmiddel te bieden dat kan worden gebruikt na recente gastro-intestinale en oncologische chirurgie zonder plafondeffect, breidden we de JH-HLM schaal uit door vier extra categorieën toe te voegen tot 1125 meter / 3750 voet en noemde het de AMsterdam UMC EXtension of the JOhn HOpkins Level of mObility (AMEXO) schaal. In het daarop volgende jaar werd de AMEXO-schaal gebruikt. In tegenstelling tot de JH-HLM-schaal scoorden 1,7% van de patiënten de hoogst mogelijke AMEXO-score op de eerste postoperatieve dag (odds ratio = 0,021, betrouwbaarheidsinterval = 0,007-0,059, $p < 0{,}001$) en 16,8% tijdens de eerste drie postoperatieve dagen (odds ratio = 0,028, betrouwbaarheidsinterval = 0,013 - 0,060, $p < 0{,}001$). Ook werd bij meer patiënten een verandering in score waargenomen na uitbreiding van de JH-HLM naar de AMEXO-schaal (odds ratio = 9,101, betrouwbaarheidsinterval = 4,046-0,476, $p < 0{,}001$) en werden de vier nieuw toegevoegde categorieën gebruikt bij 73,3% van de patiënten. Deze resultaten suggereren dat het uitbreiden van de JH-HLM naar de AMEXO-schaal het plafondeffect aanzienlijk verminderde, waardoor het instrument geschikter is voor gebruik in de dagelijkse praktijk na recente gastro-intestinale en oncologische chirurgie.

In **deel II** zijn de onderzoeken gericht op het vergroten van ons begrip waarom in het ziekenhuis opgenomen volwassen patiënten fysiek inactief zijn tijdens de ziekenhuisopname.

Hoofdstuk 5 betreft een literatuuronderzoek, waarin een uitgebreid overzicht wordt gegeven van alle door patiënten en zorgverleners gerapporteerde belemmerende en bevorderende factoren voor fysieke activiteit tijdens de ziekenhuisopname. Het Theoretical Domains Framework (TDF) – een theoretische model waarmee cognitieve, sociale en omgevingsinvloeden op gedrag onderscheiden kunnen worden – werd gebruikt om alle geïdentificeerde belemmerende en bevorderende factoren te categoriseren. Zesenvijftig studies met kwantitatieve, kwalitatieve en gemengde methoden werden opgenomen in dit onderzoek. In totaal werden 264 belemmerende en 228 bevorderende factoren gemeld door in het ziekenhuis opgenomen patiënten, en 415 belemmerende en 409 bevorderende factoren door zorgverleners. De meeste door patiënten en zorgverleners gerapporteerde belemmerende en bevorderende factoren werden toegewezen aan de TDF-domeinen *Environmental Context & Resources* en *Social Influences*. Dit benadrukt de noodzaak voor interventies die gericht zijn op de fysieke omgeving, zorgprocessen in het ziekenhuis, kenmerken van de ziekenhuisorganisatie, de beschikbare middelen voor patiënten en zorgverleners, patiënt gerelateerde factoren en de sociale invloed op patiënten en zorgverleners. Het uitgebreide, op TDF gebaseerde overzicht uit dit onderzoek kan zorgverleners, onderzoekers en beleidsmakers ondersteunen bij het ontwikkelen en implementeren van interventies ter verbetering van fysieke activiteit in de lokale ziekenhuiszorg.

In **hoofdstuk 6** staan de resultaten beschreven van een verklarend onderzoek met verschillende methoden onder lokale zorgverleners om de belemmerende factoren voor het verbeteren van fysieke activiteit te identificeren en om vast te stellen wat het multidisciplinair team nodig heeft om deze belemmerende factoren te overwinnen. In fase 1 werden op het TDF gebaseerde enquêtes gebruikt om de belangrijkste belemmerende factoren te identificeren vanuit het individuele perspectief van zorgverleners. In totaal hadden 15 arts-assistenten, 106 verpleegkundigen, vier verpleegassistenten en vier fysiotherapeuten van twee gastro-intestinale en oncologische chirurgie, een hematologie-, een infectieziekten- en een cardiologieafdeling de enquête ingevuld. De resultaten van fase 1 vormden de basis voor drie groepsdiscussies waaraan 30 zorgverleners deelnamen. Deze groepsdiscussies werden gehouden om te achterhalen welke belemmerende factoren het belangrijkst zijn en welke oplossingen multidisciplinaire teams kunnen helpen deze factoren te overwinnen.

De resultaten van dit onderzoek laten zien dat zorgverleners duidelijke richtlijnen, rollen en verantwoordelijkheden nodig hebben als het gaat om het verbeteren van fysieke activiteit bij in het ziekenhuis opgenomen patiënten. Bovendien hebben zorgverleners hulpmiddelen nodig om in het ziekenhuis opgenomen patiënten in staat te stellen een actievere rol te spelen ten aanzien van fysieke activiteit tijdens de ziekenhuisopname. Tot slot gaven de zorgverleners aan dat de ziekenhuisafdelingen zo ontworpen en ingericht moeten worden dat patiënten aangemoedigd worden om actief te zijn.

In **deel III** zijn de onderzoeken gericht op het vergroten van ons begrip of en hoe veelzijdige interventies kunnen leiden tot meer fysieke activiteit tijdens de ziekenhuisopname en betere uitkomsten voor de patiënt. Op basis van de opgedane kennis van deel I en II hebben we de theorie-geïnformeerde veelzijdige interventie genaamd "Beter Bewegen" (ofwel "Better By Moving" [BBM]) ontwikkeld en geïmplementeerd in een tertiair academisch ziekenhuis in Nederland.

In **hoofdstuk 7** wordt het onderzoeksprotocol van BBM gepresenteerd. BBM had tot doel de fysieke activiteit te verbeteren in volwassen patiënten die waren opgenomen op twee gastro-intestinale en oncologische chirurgie-, één hematologie-, één infectieziekten- en één cardiologie afdeling van het Amsterdam UMC, locatie Academisch Medisch Centrum, in Nederland. In dit onderzoeksprotocol staat het stapsgewijze, op evidentie gebaseerde implementatieplan beschreven om de verschillende interventiecomponenten te ontwikkelen en implementeren in co-creatie met patiënten en zorgverleners. Verder staan in het studieprotocol de theorieën, modellen en raamwerken beschreven die gebruikt zijn om de ontwikkeling en implementatie van BBM te ondersteunen en staan in het studieprotocol de verschillende uitkomstmaten beschreven die gebruikt zijn om de effectiviteit en het proces van BBM te evalueren.

In **hoofdstuk 8** staan de resultaten beschreven van het ontwikkelen en implementeren van BBM op de eerder genoemde ziekenhuisafdelingen van het Amsterdam UMC. BBM bestond uit 23 interventiecomponenten waarvan een selectie op maat werd gemaakt en geïmplementeerd op elke ziekenhuisafdeling. Uit de uitkomstenevaluatie blijkt dat de implementatie van BBM niet heeft geleid tot een significante verbetering van het aantal minuten dat patiënten fysiek actief zijn, een vermindering van de tijd dat patiënten in bed liggen of van de opnameduur in het ziekenhuis, en een toename van het aantal patiënten dat naar huis werd ontslagen. Tegelijkertijd laat de procesevaluatie zien dat het bereik van de interventiecomponenten onder patiënten en zorgverleners matig was en de adoptie laag. Op basis van deze bevindingen veronderstellen wij dat het matige bereik en lage adoptie heeft bijgedragen aan het gebrek aan effectiviteit van BBM op patiënten uitkomsten. Implementatieteams zullen daarom moeten overwegen om het bereik en de adoptie tijdens de implementatie van toekomstige veelzijdige interventies nauwlettend in de gaten te houden. Indien nodig kunnen de interventiecomponenten en interventiestrategieën dan tijdig worden aangepast. Verder zullen implementatieteams moeten overwegen om een beperkt aantal interventiecomponenten op te nemen met een duidelijke hiërarchische structuur, omdat dit ervoor zorgt dat er meer aandacht en inzet kan worden besteed aan het adequaat implementeren van de interventiecomponenten. De bevindingen van onze procesevaluatie laten ook zien dat de mate van ondersteuning in termen van prioriteit, middelen en betrokkenheid – zowel op personeels- als op afdelingsniveau – een belangrijke contextuele factor was die van invloed was op de implementatie en de resultaten van BBM. Dit verklaart waarschijnlijk waarom het bereik en de adoptie niet voldoende waren. Om de effectiviteit van de implementatie verder te vergroten is het zodoende ook belangrijk dat implementatieteams de ondersteuning in termen van prioriteit, middelen en betrokkenheid beschouwen als een actieve component die kan worden beïnvloed tijdens de ontwikkeling en implementatie van een veelzijdige interventie.

In **hoofdstuk 9** komen de belangrijkste bevindingen, methodologische overwegingen, klinische aanbevelingen en toekomstperspectieven aan bod. Door het onderzoek in dit proefschrift begrijpen we nu dat de huidige niveaus van lichamelijke activiteit tijdens de routinematige ziekenhuiszorg verbeterd kunnen worden door: 1) fysieke activiteit te meten als een van de vitale tekenen; 2) systematisch de patiënten te identificeren die het meest behoefte hebben aan interventies ter verbetering van fysieke activiteit; 3) een gemeenschappelijke taal te gebruiken voor fysieke activiteit; 4) belangrijke aanpassingen te doen aan de fysieke en sociale ziekenhuisomgeving; 5) ervoor te zorgen dat patiënt en zorgverleners hun rol begrijpen en verantwoordelijkheid nemen; 6) fysieke activiteit tijdens de ziekenhuisopname vanzelfsprekend te maken; 7) een aanpak van continue kwaliteitsverbetering te gebruiken om multidisciplinaire teams te ondersteunen bij het plannen, implementeren, bestuderen en evalueren van interventieonderdelen ter verbetering van fysieke activiteit. De bevindingen, instrumenten en ervaringen die in dit proefschrift staan beschreven, kunnen als uitgangspunt gebruikt worden om deze klinische aanbevelingen in de plaatselijke ziekenhuiszorg te implementeren.

Appendices

About the author
List of publications
Portfolio
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Dankwoord

About the author

Sven Geelen was born on April 1, 1992 in Maasbree, the Netherlands. In 2010 he graduated from secondary school at the College Den Hulster in Venlo. After this, he studied Physical Therapy at the Zuyd University of Applied Sciences in Heerlen (BSc. 2014) followed by Clinical Health Sciences, direction Physical Therapy Science, at Utrecht University (MSc. 2017).

His professional career as a hospital-based physical therapist started in the Meander Medical Center in Amersfoort in August 2014. Here, he initially treated patients after recent orthopedic surgery. In the two years that followed, he gained extensive experience in treating patients admitted to internal medicine, geriatrics, pulmonary, cardiology, intensive care and neurology wards. He used this experience for three months at the regional hospital Rivierenland Tiel, after which he joined the Neurology team at Amsterdam UMC, location Academic Medical Center, in November 2016. His master thesis entitled: "*Construct validity and inter-rater reliability of the Dutch AM-PAC '6-clicks' Basic Mobility short form to assess the mobility of hospitalized patients*" was the starting point of his career as a hospital-based physical therapist at the gastrointestinal- and oncological surgery ward and as a project manager of a major quality improvement project aiming to improve physical activity in hospitalized patients. In January 2018, the position of project manager was effectively converted into his PhD study at the University of Amsterdam.

During the years that followed, he specialized in treating hospitalized patients after gastrointestinal- and oncological surgery and gained expertise in the science behind changing behavior and implementation. His passion to do something about the epidemic of physical inactivity during hospital stay inspired many nurses, physical therapists and physicians to collaborate within the Amsterdam UMC. His enthusiasm to connect with others led him to the position of board member at the youth association of Amsterdam UMC, location Academic Medical Center, and board member at the Amsterdam Movement Sciences research institute 'Ageing and Vitality" program. He supervised and taught numerous students receiving both bachelor and master education in the field of Medicine, Physical Therapy, and Human Movement Sciences, resulting in the University Teaching Qualification in October 2020.

From March 2022, Sven started working as a researcher for the Dutch burn center Martini Hospital, where he aims to optimize the Dutch aftercare for burn survivors through a blended person-centered aftercare program, directed at patients' self-management.

In his spare time, Sven enjoys field hockey, cycling and playing board games with friends. Sven is an avid alpinist and specializes in glacier crossings and high-altitude mountain tours.

List of publications

International scientific publications

Huisstede BM, van den Brink J, Randsdorp MS, **Geelen SJ**, Koes BW. Effectiveness of Surgical and Postsurgical Interventions for Carpal Tunnel Syndrome-A Systematic Review. Arch Phys Med Rehabil. 2018 Aug;99(8):1660-1680.e21.

Franke TP, Koes BW, **Geelen SJ**, Huisstede BM. Do Patients With Carpal Tunnel Syndrome Benefit From Low-Level Laser Therapy? A Systematic Review of Randomized Controlled Trials. Arch Phys Med Rehabil. 2018 Aug;99(8):1650-1659.e15.

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.

Geelen SJG, Giele BM, Nollet F, Engelbert RHH, van der Schaaf M. Improving Physical Activity in Adults Admitted to a Hospital With Interventions Developed and Implemented Through Cocreation: Protocol for a Pre-Post Embedded Mixed Methods Study. JMIR Res Protoc. 2020;9(11):e19000.

Geelen SJG, Giele BM, Engelbert RHH, de Moree S, Veenhof C, Nollet F, van Nes F, van der Schaaf M. Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals. Disabil Rehabil. 2021:1-10. Online ahead of print.

Geelen SJG, Giele BM, Veenhof C, Nollet F, Engelbert RHHE, van der Schaaf M. Physical dependence and urinary catheters both strongly relate to physical inactivity in adults during hospital stay: a cross-sectional, observational study. Disabil Rehabil. 2021:1-8. Online ahead of print.

Geelen SJG, van Dijk-Huisman HC, de Bie RA, Veenhof C, Engelbert R, van der Schaaf M, Lenssen AF. Barriers and Enablers to Physical Activity in Patients during Hospital Stay: a Scoping Review. Syst Rev. 2021;10(1):293.

Boerrigter JL, **Geelen SJG**, van Berge Henegouwen MI, Bemelman WA, van Dieren S, de Man-van Ginkel JM, van der Schaaf M, Eskes AM, Besselink MG. Extended mobility scale (AMEXO) for assessing mobilization and setting goals after gastrointestinal and oncological surgery: a before-after study. BMC Surgery. 2022;22(1):38.

Leeuwerk, ME , Bor, P, van der Ploeg, HP, de Groot, V, van der Schaaf, M, van der Leeden, M, **on behalf of the OPRAH consortium***. The effectiveness of interventions using activity trackers during or after inpatient care: a systematic review and meta-analysis of randomized controlled Trials. Manuscript in press in Int. J. Behav. Nutr. Phys. ***Geelen SJG** is a member of the OPRAH consortium

Other publications

Geelen SJG, van Delft LMM. Bewegen tijdens ziekenhuisopname. Nursing Academy. 2021;2:22-28.

Eskes AM, Boerrigter JL, **Geelen SJG**. Postoperatieve mobilisatie bevorderen. TVZ - Verpleegkunde in praktijk en wetenschap. 2020;130:50-51.

Portfolio

PhD Student: Sven J.G. Geelen

PhD period: January 2018 - February 2022

Name PhD supervisors: dr. M. van der Schaaf; Prof. dr. R.H.H. Engelbert

Name PhD co-supervisors: Prof. dr. F. Nollet; Prof. dr. C. Veenhof

1. PhD Training	Year	Workload (ECTS)
General courses		
e-BROK ('Basiscursus Regelgeving Klinisch Onderzoek')	2018	1.0
Research Data Management	2019	0.7
Innovation Bootcamp	2019	0.3
Project Management	2019	0.6
Qualitative Health Research	2019	1.9
Oral Presentation in English	2019	0.6
Scientific Writing in English	2020	1.5
Specific courses		
Advanced Topics in Biostatistics	2020	2.1
NIHES course on Implementation Science	2021	1.4
Seminars, workshops and master classes		
Seminar 8 'SURPASS' by QI ('Quality improvement') Academy, Amsterdam UMC, Amsterdam, the Netherlands	2019	0.1
Seminar 10 'Briljante mislukkingen' by QI ('Quality improvement') Academy, Amsterdam UMC, Amsterdam, the Netherlands	2019	0.1
Workshop 'Pimp My: Data Visualization' by Amsterdam Movement Sciences, Amsterdam, the Netherlands	2021	0.1
Workshop 'Introduction in Valorization' by IXA, Amsterdam, the Netherlands	2021	0.1

Grant Writing workshop #1, Amsterdam UMC, Amsterdam, the Netherlands	2021	0.1
Grant Writing workshop #2, Amsterdam UMC, Amsterdam, the Netherlands	2021	0.1
Workshop 'Presenting' by Amsterdam Movement Sciences, Amsterdam, the Netherlands	2021	0.1
Workshop 'Research Integrity' by Amsterdam Movement Sciences, Amsterdam, the Netherlands	2021	0.1

Oral presentations

<u>Research meetings, department of Rehabilitation Medicine, Amsterdam UMC, Amsterdam, the Netherlands</u>

Barriers and enablers for improving physical activity in hospitalized patients, as perceived by health care professionals	2018	0.5
Action Research 'Better By Moving' – which conclusions are you allowed to take?	2019	0.5
Factors associated to physical activity in adults who have been admitted to Surgery, Internal Medicine and Cardiology hospital wards.	2019	0.5
Geen systematic review, maar een scoping review! Fysieke activiteit bij ziekenhuispatiënten	2020	0.5
Yes, reviewer commentaar ontvangen… maar hoe reageer ik hierop?	2021	0.5

<u>Research meetings, participating hospital wards, Amsterdam UMC, Amsterdam, the Netherlands</u>

Referaat 'Beter Bewegen'	2017	0.5
Innovate together. Lunch & Learn event: 'Innovate'	2018	0.5
Better By Moving! x4	2018	2.0
Preliminary results of Better By Moving x4	2019-2020	2.0
Mini-symposium 'Beter Bewegen Ontzorgt'	2020	0.5
Reflecting on Better By Moving x4	2020-2021	2.0

<u>Research meetings 'Hospital-ADL', department of Geriatrics, Amsterdam UMC, Amsterdam, the Netherlands</u>

Innovation project Better By Moving	2019	0.5
Barriers and enablers to physical activity in hospitalized patients: a scoping review and translation to the Theoretica Domains Framework	2020	0.5

<u>Client council, Amsterdam UMC, Amsterdam, the Netherlands</u>		
Innovation project Better By Moving	2019	0.5
Oma ligt in het ziekenhuis – Reflecting on Better By Moving	2020	0.5
<u>Other oral presentations</u>		
Physical activity and physical rehabilitation. Patient return day. Department of Surgery, Amsterdam UMC, Amsterdam, the Netherlands.	2018	0.5
Understanding physical activity patterns in hospitalized patients on surgical and internal medicine wards. May 2019. World Physical Therapy Congress, Geneva, Switzerland.	2019	0.5
Oma ligt in het ziekenhuis. Evening symposium Beweegziekenhuizen, The Royal Dutch Society for Physical Therapy (KNGF), OLVG, Amsterdam, the Netherlands	2019	0.5
'Van Kom je uit bed? naar Vandaag AMEXO-score 9! – Implementeren middels een cyclisch verbeterproces.' Webinar Evidence Statement Beweegziekenhuizen, The Royal Dutch Society for Physical Therapy (KNGF), Amersfoort, the Netherlands.	2021	0.5
'Actieonderzoek en Implementatiewetenschap. Twee verschillende werelden?' Webinar Onderzoekers Netwerk, The Royal Dutch Society for Physical Therapy (KNGF), Amersfoort, the Netherlands.	2021	0.5
Evidence-Based Quality Improvement Project: The Extended Early Mobility Scale (AMEXO) to Assess and Promote Mobility after Gastrointestinal Surgery. Science day Surgery Amsterdam 2021, Amsterdam, the Netherlands.	2021	0.5
Bewegen tijdens de ziekenhuisopname, (niet) normaal? Symposium '50 years Rehabilitation Center', University Medical Center Ghent, Ghent, Belgium.	2021	0.5
Attended (inter)national conferences		
The Royal Dutch Society for Physical Therapy Congress, Barneveld, the Netherlands	2017	0.3
The Royal Dutch Society for Physical Therapy Congress, Barneveld, the Netherlands	2018	0.3

3rd Annual Amsterdam Movement Sciences Research Meeting, Amsterdam, the Netherlands	2019	0.3
The Royal Dutch Society for Physical Therapy Congress, Barneveld, The Netherlands	2019	0.3
Move & Match Festival on 'Movement Promoting Hospitals', University Medical Center Utrecht, Utrecht, the Netherlands	2019	0.2
World Physical Therapy Congress, Geneva, Switzerland	2019	0.9
4th Annual Amsterdam Movement Sciences Research Meeting, Amsterdam, the Netherlands	2021	0.3
Science day Surgery Amsterdam 2021, Amsterdam, the Netherlands	2021	0.3
Symposium '50 years Rehabilitation Center', University Medical Center Ghent, Ghent, Belgium	2021	0.2
Other		
Participating member 'National promotors en phd student meetings Beweegziekenhuizen', Utrecht, the Netherlands	2018-2021	1.0
Participating member 'National expert meetings Beweegziekenhuizen', Utrecht, the Netherlands	2018-2021	2.0
Board member 'Young Academic Medical Center', Amsterdam UMC, Amsterdam, the Netherlands	2018-2019	2.0
Participating member research meetings 'Hospital-ADL', department of Geriatrics, Amsterdam UMC, Amsterdam, the Netherlands	2019-2022	1.0
Program Board Member 'Ageing & Vitality', Amsterdam Movement Sciences, Amsterdam, the Netherlands	2020-2022	2.0
Chairman 'Ageing & Vitality PhD & Early Career Researcher Network', Amsterdam Movement Sciences, Amsterdam, the Netherlands	2020-2022	0.5

2. Teaching	**Year**	**Workload (ECTS)**
Lecturing		
University of Amsterdam, Faculty of Medicine, BSc. Medicine, giving various lectures within the mandatory module Academic Training	2019-2020	1.1

University of Amsterdam, Faculty of Medicine, BSc. Medicine, giving various lectures within the elective Module Diometer	2019-2020	0.9
University of Amsterdam, Faculty of Medicine, BSc. Medicine, giving various lectures within the elective Module Rehabilitation Medicine	2018-2021	0.9
Tutoring, Mentoring		
University of Applied Sciences Amsterdam, Physical Therapy internships on the gastrointestinal surgery hospital wards	2017-2021	2.0
Supervising		
University of Applied Sciences Amsterdam, supervising many BSc Physical Therapy thesis students	2018-2020	7.1
Vrij Universiteit Amsterdam, supervising two MSc Human Movement Sciences thesis students	2019-2021	4.0

Other

University Teaching Qualification, University of Amsterdam, Amsterdam	2020	N/A

3. Parameters of Esteem

	Year
Grants	
-	
Awards and Prizes	
Physical Therapy Science Thesis Award (PhySTA), University Medical Centre Utrecht, Utrecht	2017

4. Publications

	Year
Peer reviewed	
• Franke TP, Koes BW, Geelen SJ, Huisstede BM. Do Patients With Carpal Tunnel Syndrome Benefit From Low-Level Laser Therapy? A Systematic Review of Randomized Controlled Trials. Arch Phys Med Rehabil. 2018 Aug;99(8):1650-1659.e15.	2018

- Huisstede BM, van den Brink J, Randsdorp MS, Geelen SJ, Koes BW. Effectiveness of Surgical and Postsurgical Interventions for Carpal Tunnel Syndrome-A Systematic Review. Arch Phys Med Rehabil. 2018 Aug;99(8):1660-1680.e21. s — 2018
- 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. — 2019
- Geelen SJG, Giele BM, Nollet F, Engelbert RHH, van der Schaaf M Improving Physical Activity in Adults Admitted to a Hospital With Interventions Developed and Implemented Through Cocreation: Protocol for a Pre-Post Embedded Mixed Methods Study. JMIR Res Protoc 2020;9(11):e19000. — 2020
- Geelen SJG, Giele BM, Engelbert RHH, de Moree S, Veenhof C, Nollet F, van Nes F, van der Schaaf M. Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals. Disabil Rehabil. 2021:1-10. Online ahead of print. — 2021
- Geelen SJG, Giele BM, Veenhof C, Nollet F, Engelbert RHHE, van der Schaaf M. Physical dependence and urinary catheters both strongly relate to physical inactivity in adults during hospital stay: a cross-sectional, observational study. Disabil Rehabil. 2021:1-8. Online ahead of print. — 2021
- Geelen SJG, van Dijk-Huisman HC, de Bie RA, Veenhof C, Engelbert R, van der Schaaf M, Lenssen AF. Barriers and Enablers to Physical Activity in Patients during Hospital Stay: a Scoping Review. Syst Rev. 2021;10(1):293. — 2021
- Boerrigter JL, Geelen SJG, van Berge Henegouwen MI, Bemelman WA, van Dieren S, de Man-van Ginkel JM, van der Schaaf M, Eskes AM, Besselink MG. Extended mobility scale (AMEXO) for assessing mobilization and setting goals after gastrointestinal and oncological surgery: a before-after study. BMC Surgery. 2022;22(1):38. — 2022

Other

- Eskes AM, Boerrigter JL & Geelen SJG Postoperatieve mobilisatie bevorderen. TVZ – Verpleegkunde in Praktijk en Wetenschap. 2020;130:50-51 — 2020
- Geelen SJG, Van Delft LMM. Bewegen tijdens ziekenhuisopname. Nurse Academy. 2021;2:22-28 — 2021

Contributions of authors

Chapter 2: Geelen SJG, Giele BM, Veenhof C, Nollet F, Engelbert RHHE, van der Schaaf M. Physical dependence and urinary catheters both strongly relate to physical inactivity in adults during hospital stay: a cross-sectional, observational study. Disabil Rehabil. 2021:1-8. Online ahead of print.

SJGG, RHHE and MvdS were responsible for study conception and study design. SJGG was also responsible for the data collection, data analyses, data interpretation, drafting the manuscript, editing the manuscript, and reviewing the manuscript. BMG contributed to study design, data interpretation, and reviewing the manuscript. CV contributed to study design, data analyses, data interpretation, editing the manuscript, and reviewing the manuscript. FN contributed to study conception, data interpretation, editing the manuscript, and reviewing the manuscript. RHHE contributed to data analyses, data interpretation, editing the manuscript, and reviewing the manuscript. MvdS contributed to data analyses, data interpretation, quality control, editing the manuscript, and reviewing the manuscript. All authors read and approved the final manuscript.

Chapter 3: 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.

SJGG, KV, and CV were responsible for study conception and study design. SJGG was also responsible for data collection, data analyses, data interpretation, drafting the manuscript, editing the manuscript, and reviewing the manuscript. KV contributed to data analyses, data interpretation, editing the manuscript, and reviewing the manuscript. CV contributed to data interpretation, editing the manuscript, and reviewing the manuscript. All authors read and approved the final manuscript.

Chapter 4: Boerrigter JL, Geelen SJG, van Berge Henegouwen MI, Bemelman WA, van Dieren S, de Man-van Ginkel JM, van der Schaaf M, Eskes AM, Besselink MG. Extended mobility scale (AMEXO) for assessing mobilization and setting goals after gastrointestinal and oncological surgery: a before-after study. BMC Surgery. 2022;22(1):38.

JLB and SJGG declare equal first authorship, as both contributed equally to the conceptualization, methodology, data collection, data curation and data analyses. Writing, reviewing and editing was done by all authors (JLB, SJGG, MIvBH, WAB, SvD, JMdMvG, MvdS, AME, MGB). Additionally, SvD participated in the data analysis. MvdS, AME and MGB participated equally in the conceptualization, methodology, supervision and project administration of this research and they therefore declare to share the senior authorship. All authors read and approved the final manuscript.

Chapter 5: Geelen SJG, van Dijk-Huisman HC, de Bie RA, Veenhof C, Engelbert R, van der Schaaf M, Lenssen AF. Barriers and Enablers to Physical Activity in Patients during Hospital Stay: a Scoping Review. Syst Rev. 2021;10(1):293.

SJGG and HCvDH declare equal first authorship, as both contributed equally to conducting the scoping review and writing the manuscript. RAdB, CV, and RE have participated in conceiving the scoping review, commenting on the review process, interpreting the results, and critically reviewing earlier drafts. MvdS and AFL participated equally in designing the scoping review, supervising, commenting on the review process, interpreting the results, and critically reviewing earlier drafts; they therefore declare to share the senior authorship. The authors have read and approved the final manuscript.

Chapter 6: Geelen SJG, Giele BM, Engelbert RHH, de Moree S, Veenhof C, Nollet F, van Nes F, van der Schaaf M. Barriers to and solutions for improving physical activity in adults during hospital stay: a mixed-methods study among healthcare professionals. Disabil Rehabil. 2021:1-10.

SJGG, RHHE, and MvdS were responsible for study conception and study design. SJGG was also responsible for data collection, quality control of data and transcription files, data analysis plan and interpretation, thematic analysis, drafting the manuscript, editing the manuscript, and reviewing the manuscript. BMG contributed to study conception, data collection, data analysis and interpretation, thematic analysis, editing the manuscript, and reviewing the manuscript. RHHE contributed to thematic analysis, editing the manuscript, and reviewing the manuscript. SdM contributed to data collection, thematic analysis, editing the manuscript, and reviewing the manuscript. CV contributed to data analysis plan and interpretation, editing the manuscript, and reviewing the manuscript. FN contributed to study conception, editing the manuscript, and reviewing the manuscript. FvN contributed to study design, data analysis plan and interpretation, thematic analysis, editing the manuscript, and reviewing the manuscript. MvdS contributed to quality control of data and transcription files, data analysis plan and interpretation, thematic analysis, editing the manuscript, and reviewing the manuscript. All authors read and approved the final manuscript.

Chapter 7: Geelen SJG, Giele BM, Nollet F, Engelbert RHH, van der Schaaf M. Improving Physical Activity in Adults Admitted to a Hospital With Interventions Developed and Implemented Through Cocreation: Protocol for a Pre-Post Embedded Mixed Methods Study. JMIR Res Protoc. 2020;9(11):e19000.

BMG and SJGG declare equal contribution, as both provided equal contribution in drafting the protocol. BMG, SJGG, and MvdS designed the framework and methodology, and drafted the protocol. SJGG and MvdS developed the research protocol, database, and data collection tools. FN and RHHE participated in designing the protocol and participated in writing the manuscript. MvdS critically revised the manuscript. All authors read and approved the final manuscript.

Chapter 8: Geelen SJG, Giele BM, Veenhof C, Nollet F, Engelbert RHH, van der Schaaf M. The Better By Moving study: a multifaceted intervention to improve physical activity in adults during hospital stay. 2022 submitted

SJGG, RHHE, and MvdS were responsible for study conception and study design. SJGG was also responsible for data collection, data analyses, data interpretation, drafting the manuscript, and reviewing the manuscript. BMG contributed by collecting process evaluation data, analyzing the process evaluation data, editing the manuscript, and reviewing the manuscript. FN contributed in study conception, editing the manuscript, and reviewing the manuscript. CV and RHHE contributed in study design, data interpretation, editing the manuscript, and reviewing the manuscript. MvdS contributed to data interpretation, quality control, editing the manuscript and reviewing the manuscript. All authors read and approved the final manuscript.

Dankwoord

Auw wieë, dat was het dan! Midden 2017 begon ik aan dit avontuur, gedreven door het geloof dat het onnodig is dat patiënten bijna de gehele ziekenhuisopname in bed doorbrengen. Een probleem waar ik vanaf het begin van mijn carrière als fysiotherapeut mee geconfronteerd werd. Nu, bijna 5 jaar verder, is het zover. Ik mag mijn proefschrift verdedigen op 24 juni 2022.

Het voelt gek. Mijn proefschrift. Zonder een groot aantal bijzondere mensen was dit proefschrift namelijk nooit tot stand gekomen. Uit de grond van mijn hart wil ik dan ook aangeven: **dank jullie wel!** Een aantal mensen wil ik in het bijzonder bedanken.

Allereerst wil ik **alle patiënten** bedanken die ik tijdens mijn werk als fysiotherapeut en onderzoeker heb mogen leren kennen. De gesprekken die ik met jullie heb gehad hebben mij tot de mens gemaakt die ik vandaag de dag ben. Gesprekken die vaak over de ziel en zaligheid van het leven gingen. Jullie drijfveer, wat dat ook mocht zijn, interesseerde en intrigeerde mij. Bewegen tijdens de ziekenhuisopname is namelijk zoveel meer dan stappen zetten op de gang van het ziekenhuis. Hoe ga je met tegenslag om? Wat houdt je staande? Wat motiveert je? Wie ben je? En wie ben ik eigenlijk? Via het werk beschreven in dit proefschrift hoop ik dat toekomstige patiënten zullen profiteren van een betere ziekenhuiszorg. Dank voor de gesprekken, samenwerking, en jullie inzet en betrokkenheid bij de verschillende hoofdstukken van dit proefschrift.

Vervolgens komt uiteraard mijn promotieteam.

Beste dr. M. van der Schaaf, beste promotor, beste **Marike**, vijf jaar geleden gaf je me de kans om onder jouw begeleiding dit promotietraject aan te gaan en daar ben ik je ontzettend dankbaar voor. Ik bewonder je gedrevenheid voor gedegen onderzoek, je kritische houding en je oog voor strategie als het gaat om implementatie in een complexe organisatie, zoals het ziekenhuis. Je hebt het talent me evenwichtig de vrijheid als ook richting te geven om me op mijn manier te laten ontwikkelen tijdens dit promotietraject. Ik heb enorm veel van je geleerd en ik voelde me tijdens dit promotietraject enorm gewaardeerd als aspirant zelfstandig onderzoeker.
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