Disability and Rehabilitation

ISSN: 0963-8288 (Print) 1464-5165 (Online) Journal homepage: https://www.tandfonline.com/loi/idre20

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To cite this article: Niek Koenders, Mariska Weenk, Tom H. van de Belt, Harry van Goor, Thomas J. Hoogeboom & Sebastian J. H. Bredie (2019): Exploring barriers to physical activity of patients at the internal medicine and surgical wards: a retrospective analysis of continuously collected data, Disability and Rehabilitation, DOI: 10.1080/09638288.2019.1685013

To link to this article: https://doi.org/10.1080/09638288.2019.1685013

DISABILITY AND REHABILITATION
https://doi.org/10.1080/09638288.2019.1685013

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Exploring barriers to physical activity of patients at the internal medicine and surgical wards: a retrospective analysis of continuously collected data

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ABSTRACT

Purpose: To analyse physical activity of patients during their hospital stay and to explore the relationship between physical activity and barriers to physical activity.

Methods: This was a secondary analysis of physical activity data for patients admitted to the internal medicine and surgical wards. Physical activity data, collected with a wireless patch sensor, was operationalized as time spent lying, sitting/standing, and walking. Barriers to physical activity included patients' pain levels, the use of urinary catheters, intravenous tubing, oxygen lines, drains, and level of dependence. Regression analysis explored the relationship between physical activity and barriers to physical activity.

Results: Physical activity data were collected in 39 patients (aged 27–88, mean 54 years) during hospital stay. Patients were admitted for a median of 10 d (interquartile range [IQR]: 7–15 d). These patients were lying for a median of 12.1 h (7.6–17.7), sitting/standing 11.8 h (6.3–15.7), and walking 0.1 h (0–0.3) per day. Time lying during the day related to pain levels ($\beta = 0.4$ h per unit increase in pain, $p < 0.01$) and drain use ($\beta = 3.1$ h, $p < 0.01$).

Conclusions: Patients spent the most time during the hospital stay lying in bed. Improved pain management and decreased drain use may be worth exploring to increase inpatient physical activity.

ARTICLE HISTORY
Received 1 November 2018
Revised 16 October 2019
Accepted 22 October 2019

KEYWORDS
Physical activity; hospitalization; early ambulation; disability evaluation; mobility limitations

➤ IMPLICATIONS FOR REHABILITATION

- Continuous monitoring of physical activity in patients during hospital stay is an important tool for health care professionals to improve multidisciplinary care and rehabilitation.
- Health care professionals should be aware of the necessity of adequate pain management and critically review the use of drains in order to improve physical activity of patients during hospital stay.
- Patients need extra support of health care professionals to increase physical activity during consecutive days of their hospital stay.

Introduction

Low physical activity of patients during a hospital stay is common, even though its relationship with adverse outcomes is well-documented [1–4]. Several studies have implicated low physical activity during a hospital stay as a risk factor for the onset of hospitalization-associated disability [5–8]. In healthy adults, international guidelines recommend minimizing sedentary behaviour (i.e., no lying during the daytime and less sitting) [9], and walking briskly for 30 min a day [10]. These recommendations are rarely met by patients during hospital stay [11,12].

Several barriers seem to negatively influence the physical activity behaviour of patients during a hospital stay, including potentially modifiable barriers such as disease symptoms and use of medical devices (e.g., urinary catheters and intravenous tubing) [7,13]. An important first step to changing clinical practice and improving inpatient physical activity is understanding which of these modifiable barriers is the most strongly related to poor inpatient physical activity [14]. To date, there is limited information regarding physical activity and barriers to engaging in physical activity during the hospital stay.

The measurement of inpatient physical activity is challenging. However, physical activity monitors have become widely available in recent years and potentially allow for continuous monitoring of patients' activity during a hospital stay without limiting mobility [11]. However, the feasibility of physical activity monitors for use in hospitalized adults is largely unknown [15]. It is important to

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Supplemental data for this article can be accessed here.

address the technical feasibility of physical activity monitors when used in research practice. Technical feasibility contains the expected and unexpected problems which appear during the collection of physical activity data and should be evaluated to provide information on the quality of data collection and possible use in future healthcare [16,17].

In summary, the aim of this study was two-fold: 1) to examine feasibility of inpatient monitoring of physical activity with a wearable sensor, and 2) to analyse physical activity (i.e., lying, sitting/standing, and walking) of patients during hospital in relation to barriers to physical activity.

Methods

Design

This study was a secondary analysis of prospectively collected physical activity data in patients admitted at the internal medicine or surgical nursing wards of the Radboud University Medical Centre, Nijmegen, the Netherlands [18]. Physical activity data were continuously collected between December 2014 and September 2016 with the HealthPatch® (VitalConnect, San Jose, CA) [19], a wireless sensor which is capable of continuously monitoring the time lying, sitting/standing, or walking. Collection of physical activity data in the previous study started on the first day of hospital admission or on the first day after surgery and ended at hospital discharge or after four consecutive days of data collection. This study followed guidelines provided by the Strengthening The Reporting of OBservational Studies in Epidemiology (STROBE) statement and its checklist (Supplementary Table S1) [20]. Retrospective use of the data was approved by the Ethics Committee of the Radboud University Medical Centre (registration number 2014-1434). All patients gave written informed consent before taking part in this study. Methods were carried out in accordance with The Code of Ethics of the World Medical Association (Declaration of Helsinki).

Participants

Patients in this study were admitted at the internal medicine ward for a variety of medical conditions (e.g., pericarditis) or surgical ward for elective gastrointestinal cancer surgery. Eligible patients demonstrated a stable clinical condition, were aged 18–75 years, were deemed mentally competent and able to understand instructions, and were able to provide written informed consent. Usual care for the participants included the support by nurses and physical therapists according to an early mobilization protocol (internal medicine ward) [21] or enhanced recovery after surgery programme (surgical ward) [22]. Data of all patients who consented were used to evaluate the technical feasibility of the HealthPatch®. Data of patients who were monitored for less than 24 h were excluded from the regression analysis of physical activity data and barriers to physical activity.

Outcome measures

Demographics and technical feasibility

Demographic and process data were extracted from the electronic medical records and included the following variables: age, sex, length of hospital stay, admission diagnosis, level of dependence (i.e., dependent on other persons to get in and out of bed), and use of walking aid(s) at admission. Outcomes related to the technical feasibility of the HealthPatch® were rates of missingness and reasons for missing or incorrect data such as technical errors or user errors. Trained medical students registered the reason for technical problems and fixed them if necessary [18].

Physical activity data

The patients were continuously monitored (i.e., 24 h a day) to collect data on physical activity *via* a Conformité Européenne (CE) marked and Federal Drug Administration (FDA) approved device, the HealthPatch® sensor. Monitoring began at the first available noon hour during hospitalization. Physical activity of patients during hospital stay was operationalized as the time lying, sitting/standing, or walking. The HealthPatch® provided data on body posture, step counts, single-lead electrocardiogram, heart rate, respiratory rate, and skin temperature [19]. In accordance with the HealthPatch® manual, the sensor was placed by trained medical students at one of three possible locations on the chest [19]: 1) diagonally on the left midclavicular line over the intercostal space, 2) vertically over the upper sternum, or 3) horizontally on the left midclavicular line under the pectoralis minor muscle. A 3-axis micro-electro-mechanical systems accelerometer was used to detect body movement with a frequency of 1 Hertz, and a wireless sensor transmitted these data to an iPod *via* Bluetooth. Subsequently, data were stored instantly on an online secured cloud. Previous research on the HealthPatch® in an experimental and hospital setting showed adequate validity for measuring time lying and sitting/standing [23]. The posture detection accuracy of the HealthPatch® was less accurate during walking.

Barriers to physical activity

A pragmatic systematic review [24] was performed to identify published articles with information on barriers to physical activity. The information gleaned from this systematic review allowed us to operationalize barriers to inpatient physical activity for the purposes of the regression analysis. Details of the search are provided in Supplementary Table S2. Ultimately, six barriers to physical activity were derived from previous work [11,13,25–27]: 1) level of pain (Numeric Pain Rating Scale [NPRS], 0 no pain, 10 worst imaginable pain); 2) use of urinary catheter (yes or no); 3) use of intravenous tubing (yes or no); 4) use of oxygen line(s) (yes or no); 5) use of drain(s) (yes or no); and 6) level of dependence, i.e., dependent on other persons to get in and out of bed (yes or no).

Data on barriers to physical activity were recorded by nursing staff in electronic medical records during routine care. Data from each participants' medical records were then retrospectively extracted for this analysis by the primary author (N.K.) using a standardized electronic data extraction form. Briefly, medical records were queried each hour of the day during the entire period of physical activity data collection. Prior to data extraction, the standardized extraction form was pilot tested in medical records of five patients showing no missing data. To ensure complete data extraction, all missing values were double-checked (M.W.).

Data analysis

Demographics and feasibility outcomes were summarized with appropriate descriptive statistics. A median percentage of available HealthPatch® data was also calculated to provide information on the amount of missing data per hour of data collection (total possible data points = 3600/h). Median percentages of time spent lying, sitting/standing, and walking were calculated for each day after the application of the HealthPatch® to analyse daily physical activity [11]. Multivariable linear regression analysis (backward stepwise elimination at $p > 0.10$) was used to examine the variance in time spent lying accounted for by known barriers to physical activity [28]. Lying in bed during the nighttime, between 12 a.m. and 6.59 a.m., was considered natural behaviour and, therefore, we removed nighttime data from the regression analysis. The dependent variable was, consequently, time spent lying during the daytime (between 7 a.m. and 11.59 p.m.). Independent variables included barriers to physical activity: 1) level of pain; 2) use of urinary catheter; 3) use of intravenous tubing; 4) use of oxygen line(s); 5) use of drain(s); and 6) level of dependence. Multicollinearity of independent variables was defined as variance inflation factor >5 in all cases [29]. Outliers were examined with a standardized residuals plot and checked in case of standardized residual values greater than |3.3| [30]. In addition, the scatterplot of residuals was checked for normality, linearity, and homoscedasticity [30]. Beta weights were analysed to present the relative importance of barriers to physical activity. Partial correlation was used to explore the relationship between time spent lying and each individual barrier to physical activity, while controlling for other barriers. The adjusted R^2 was calculated to estimate how much of the variance in time spent lying was explained by the identified barriers. p-values < 0.05 were considered statistically significant. All data were analysed using IBM Statistical Package for the Social Sciences version 22.0 (IBM SPSS Statistics, Armonk, NY) [31].

Results

A total of 50 patients were included in this study ($n = 25$ internal medicine ward, $n = 25$ surgical ward). Ultimately, data were available for 39 patients (78%) at the internal medicine ($n = 23$) and surgical ($n = 16$) wards. Data of six patients were excluded as they were monitored for less than 24 h. Reasons for less than 24 h of monitoring were: acute admission to the intensive care unit ($n = 2$), study withdrawal without reason ($n = 2$), discharge to another hospital ($n = 1$), and discharge to home ($n = 1$). In addition, data of five patients were unavailable as the accelerometer was not activated or data were not appropriately saved. Characteristics of the study population are presented in Table 1. The patients (aged 27–88, mean 54 years, SD: 15 years) were admitted to the hospital for a median of 10 d (range: 4–24 d). Before hospital admission, 34 patients (87%) were independently physically active (i.e., not dependent on another person to get in and out of bed) and only 3 patients (8%) used walking aids. No patient had a bed rest order. At the internal medicine ward, patients were admitted with complaints such as pneumonia or pericarditis, and at the surgical ward mainly after upper gastrointestinal surgery.

Physical activity data

Physical activity was measured for a median of 3 d (interquartile range [IQR]: 3–4 d) per patient. The minimum and maximum time daily lying, sitting/standing, and walking were respectively 0.2–22.3 h lying, 1.7–23.4 h sitting/standing, and 0–1.4 h walking. Seven patients did not show any walking activity. Detailed information is provided in Supplementary Table S3.

Table 1. Characteristics of the study population.

Characteristic	
Age in years; mean (SD)	54 (15)
Male; number (%)	28 (72)
Length of hospital stay in days; median (IQR)	10 (7–15)
Length of hospital stay in days; range	4–24
Pre-admission independence getting in and out of bed; number (%)	34 (87)
Pre-admission use of walking aids; number (%)	3 (8)

The number of patients: 39. IQR: interquartile range.

The amount of physical activity differed substantially from patient to patient as well as over the course of the first 4 d of hospital stay. The median percentage of time lying at the first day of hospital admission was 48%, i.e., 11.4 h per day, and increased to 61% (14.5 h) on day 2, 64% (15.5 h) on day 3, and 67% (16.0 h) on day 4. The median percentage of time sitting/standing on day 1 was 52% (12.5 h), which decreased to 39% (9.3 h) on day 2, and 33% (8.0 h) on days 3 and 4. In total, patients were lying for a median time of 12.1 h per day (IQR: 7.6–17.7), sitting/standing 11.8 h per day (IQR: 6.3–15.7), and walking for 0.1 h per day (IQR: 0–0.3).

Figure 1 outlines the mean percentage of time spent lying, sitting/standing, or walking during the daytime (between 7 a.m. and 11.59 p.m.) hospital stay on an hour-by-hour basis. Patients were sitting/standing the most between approximately 8 a.m. and 9.59 p.m. Detailed information is provided in Supplementary Table S4. Figure 2 shows the data on the mean percentage of time lying, sitting/standing, and walking showed several cycles and spikes throughout the first days of hospital stay. The data suggested a trade-off between lying and sitting/standing with less than 10% of the time walking.

Barriers to physical activity

Table 2 shows several barriers to physical activity that significantly related to the time spent lying during the daytime (between 7 a.m. and 11.59 p.m.). None of the independent variables exceeded the elimination threshold (i.e., all p values <0.05), and all variance inflation factors were acceptable ≤ 1.71. Therefore, each of the barriers to physical activity contributed uniquely to the variance in time spent lying. Pain levels and the use of drain(s) were most strongly correlated with time spent lying, with partial correlations of 0.17 and 0.15, respectively. The regression model estimated an increase of 0.4 h lying during the daytime per unit increase in NPRS score (e.g., a 5-units increase in pain would correspond to a 2-h increase in time spent lying). Additionally, drain use was associated with an average increase of 3.1 h lying during the daytime. The adjusted R^2 for the full model was 0.12, indicating a substantial amount of unexplained variance.

Technical feasibility

For patients included in this analysis, data on physical activity were available for a median of 3518 s out of a total possible 3600 s (per hour) which resulted in a median percentage available data of 98% over the first 3 d of the hospital stay. We excluded five patients from this analysis due to errors in data collection. In four patients, the collection of physical activity data was not selected in the settings of the HealthPatch® by the researcher, and in one patient, the HealthPatch® data were incorrectly saved at the cloud server due to Wi-Fi failure.

Discussion

This study illustrates the time spent lying, sitting/standing, and walking during the first 3 d of hospital stay on the internal medicine and surgical wards. Overall, patients spent most time of their days lying (between 48% and 67%) with very few minutes in walking. Additionally, there was a strong positive correlation between time spent lying and 1) patients' pain levels and 2) the use of drains. These are two potentially modifiable barriers to physical activity, which – if addressable – could aid in improving physical activity. Finally, the wireless patch sensor appeared

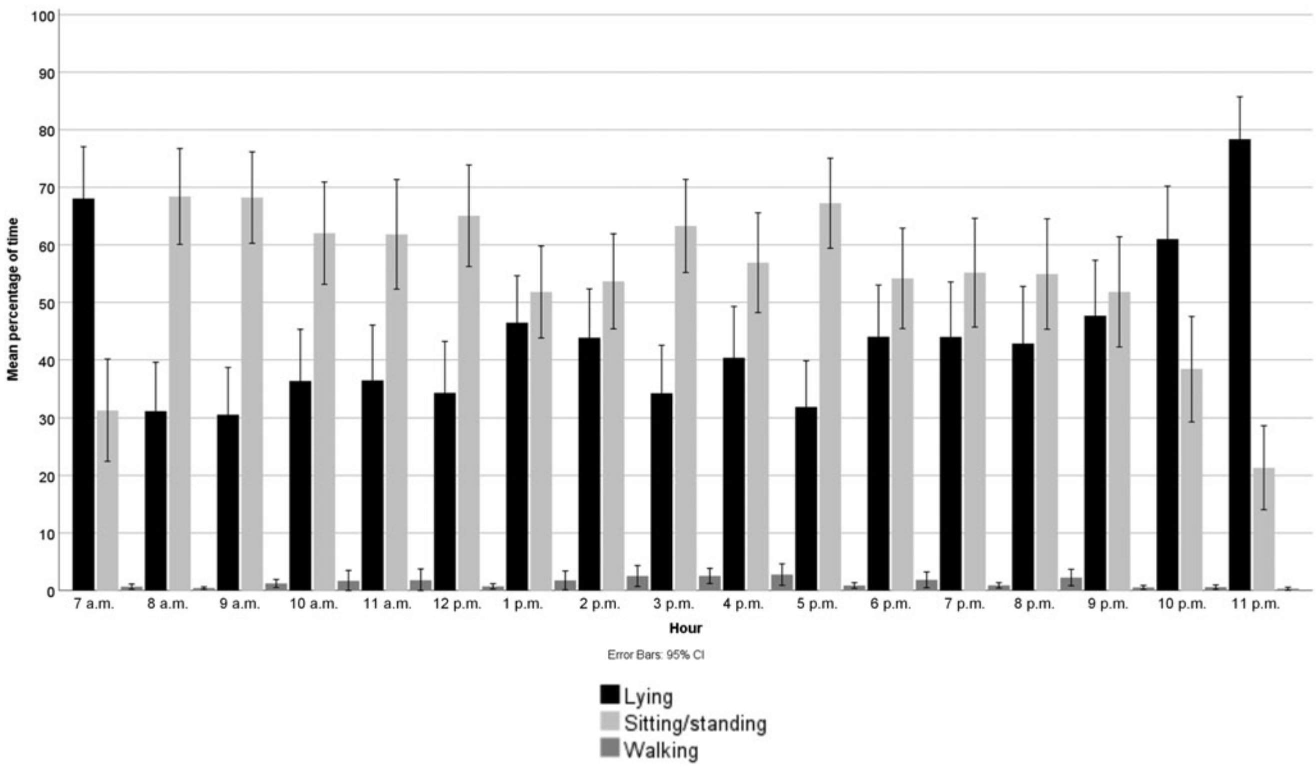

Figure 1. Mean percentage of the time spent lying, sitting/standing, or walking on different hours of a day. The 7 a.m. interval contains information between 7 a.m. and 7.59 a.m. The error bars show 95% confidence intervals.

feasible for continuous monitoring of physical activity in patients during the hospital stay: there were a low number of technical problems during the data collection and data were useable for 98% of the collection period.

Our results are not dissimilar to previous work, which has monitored physical activity during hospitalization in elderly people and determined an average lying time of 17 h per day, sitting 5 h, and standing/walking 1 h [11]. Physical activity levels were somewhat lower in previous work compared to our study which might be a result of the inclusion of acutely admitted elderly people in previous work, whereas our study included a number of patients electively admitting to the hospital. Nevertheless, recommendations for healthy physical activity (i.e., minimizing sedentary behaviour such as lying during the daytime [9] and walking for 30 min a day in bouts of 10 min [10]) clearly remain unmet even in a more active population of hospitalized patients.

Notably, there was no trend for an increase in physical activity of patients throughout the first days of hospital stay. In fact, the median percentage of time lying showed a slight increase each consecutive day. Despite the implementation of early mobilization protocols and programmes for enhanced recovery after surgery [21,22], patients on the internal medicine and surgical wards spent the vast majority of the first 4 d lying or sitting. It seems that unless the acute illness was being treated and improved throughout the hospital stay, patients remained to spent the most time lying due to other hospitalization factors such as the hospital environment and enforced dependence [8]. Additionally, our regression analysis of barriers to physical activity suggests there is a substantial amount of unexplained variance in time spent lying during the day (R^2: 0.12). Thus, there is a need for continued innovation to promote physical activity and combat the deleterious effects of immobilization and hospital-associated disability. Previous research has revealed several cultural and environmental barriers to inpatient physical activity (e.g., forced dependence), and this study adds to previous work by identifying specific barriers (pain levels and use of drains) which may additionally impede physical activity in hospitalized patients [8,27]. Future work to promote inpatient physical activity may consider addressing cultural/environment barriers in combination with protocols to optimize pain management and decrease unnecessary use of surgical drains [32].

Strengths and weaknesses of the study

Strengths of this study include the method of measurement: physical activity was continuously monitored during hospital stay with a wearable patch, including an accelerometer with known psychometric properties [23]. Thus, the results were unlikely to be influenced by socially desirable behaviour of patients or researchers, as data were collected more or less invisibly in the context of a feasibility study and analysed retrospectively [28]. Barriers to physical activity were identified prospectively *via* systematic literature search, and these outcomes were operationalized *via* medical record examination and then analysed to explore the relationship with the daytime physical activity (between 7 a.m. and 11.59 p.m.). These results might provide useful information for future implementation activities aiming to increase daytime physical activity of patients during hospital stay.

Limitations of this study include the known error margins (established in previous research) of the HealthPatch® for measuring physical activity [23]. Readers should note that outcomes regarding time walking might be underestimated. For example, it is possible that 0.1 h daily walking (as presented in our study) might actually represent up to 0.4 h daily walking. However, the main conclusions of this study are based on the time spent lying during the daytime, which has been validated in terms of accuracy in previous work [23]. Additionally, our study included a relatively small sample ($n < 50$ patients) [33], and our results will

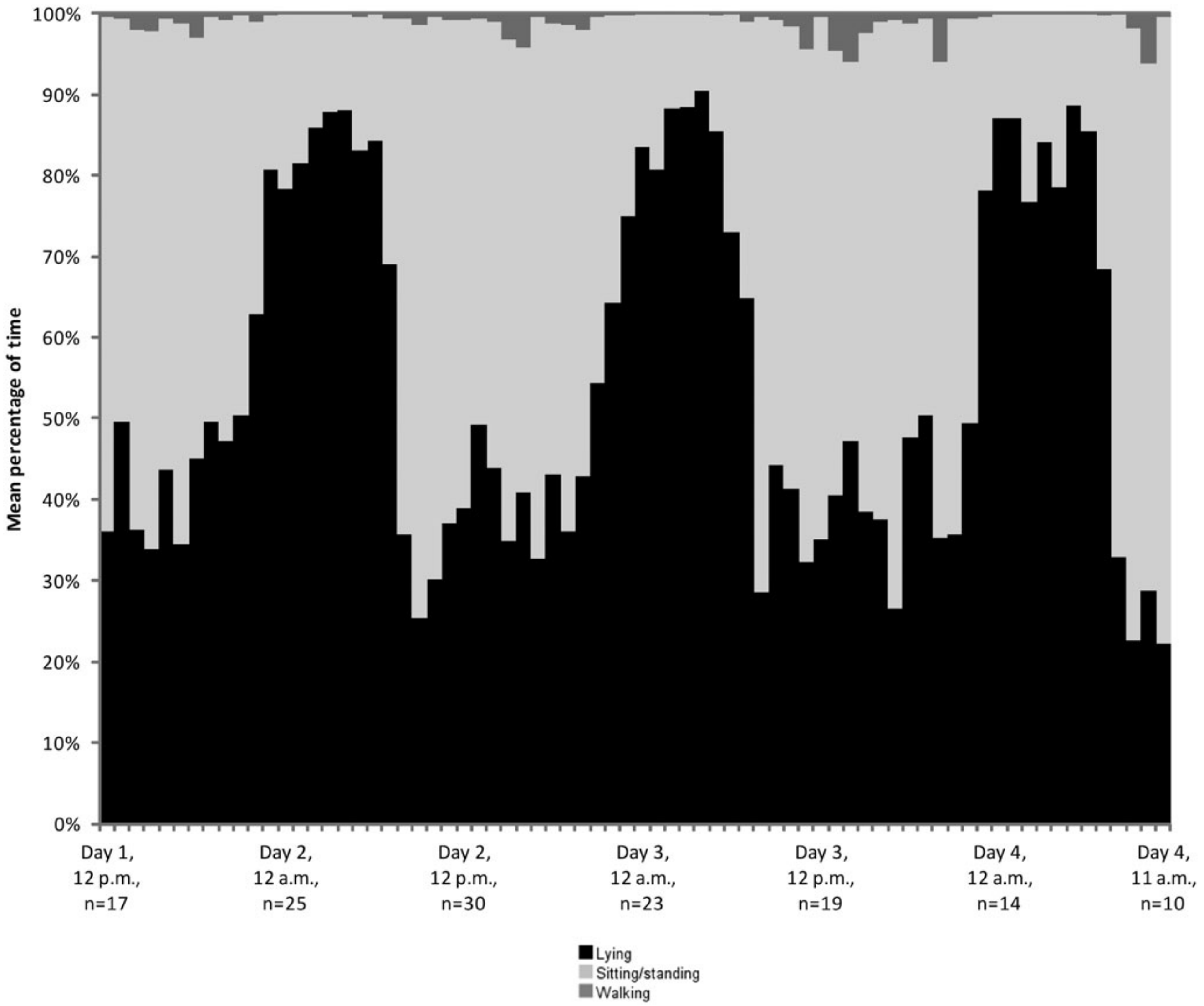

Figure 2. Mean percentage of hour-by-hour lying, sitting/standing or walking by patients at the internal medicine and surgical wards over the first 4 d of hospital stay. Daytime: between 7 a.m. and 11.59 p.m. N: number of patients.

Table 2. Multiple linear regression analysis of identified barriers to physical activity related to more lying during the daytime (between 7 a.m. and 11.59 p.m.) of patients at the internal medicine and surgical wards.

Barriers to physical activity	β-coefficient (in hours)	*p* Value	95% CI (lower bound–upper bound)
Model 1: Adjusted $R^2 = 0.12$			
Higher level of pain (NPRS, 0–10)	0.4	<0.01	0.3–0.6
Drain(s) in use	3.1	<0.01	2.0–4.2
Urinary catheter in use	2.0	<0.01	0.8–3.2
Oxygen line(s) in use	−1.7	<0.01	−2.7–0.6
Dependent on others to get in and out of bed	1.3	0.023	0.2–2.4
Intravenous tubing in use	0.8	0.048	0–1.6

CI: confidence interval; NPRS: numeric pain rating scale.

need to be confirmed by larger prospective studies. Finally, the data were collected on patients during the first 4 d of hospital stay which does not reflect the overall physical activity of patients during their entire hospital stay. It is possible that the physical activity of patients during hospital stay increases as hospital discharge approaches.

Recommendations for future research

Future research should focus on distinguishing between patients who need rest as part of their recovery and patients who would benefit from an increase in physical activity. Ultimately, the effect of a multi-component physical activity stimulating intervention should be analysed with clinical outcomes such as independent functioning as primary outcomes.

Acknowledgements

We would like to thank Mats Koeneman for his help in data handling and storage. In addition, we would like to thank the student observers for reporting connectivity issues. We thank Dr. Andrew

Kittelson and Jennifer Cusack for their help in improving English formulation and language.

Ethics approval and consent to participate

Ethical approval was granted by the medical ethics committee of the Radboud university medical centre, Nijmegen, the Netherlands (number 2014-1434). All patients gave written informed consent before taking part in the study.

Authors' contributions

N.K., T.H., and S.B. designed the study. M.W., H.vG., and S.B. recruited the participants and collected the data. T.vdB., T.H., and S.B. supervised the data analysis. All authors participated in data analysis, interpreted the data, and provided critical input into the manuscript revision. All authors approved the final version of this article and are entitled to authorship as listed authors.

Data availability

The data that support the findings of this study are available from the corresponding author, N.K., upon reasonable request.

Disclosure statement

No potential conflict of interest was reported by the authors.

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