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BRIEF REPORT

Fitbit step counts during inpatient recovery from cancer surgery as a predictor of readmission

Carissa A. Low, PhD • Dana H. Bovbjerg, PhD • Steven Ahrendt, MD • M. Haroon Choudry, MD • Matthew Holtzman, MD • Heather L. Jones, PA-C • James F. Pingpank, Jr. MD • Lekshmi Ramalingam, MD • Herbert J. Zeh III, MD • Amer H. Zureikat, MD • David L. Bartlett, MD

Abstract

Background Postoperative ambulation is encouraged to promote timely recovery but is rarely monitored objectively or examined as a predictor of clinical outcomes, despite growing availability of wearable devices that allow passive quantification and remote real-time monitoring of the number of steps taken during recovery.

Purpose To determine whether the number of steps taken during inpatient recovery predicts 30- and 60-day readmission risk after metastatic cancer surgery.

Methods Patients diagnosed with metastatic peritoneal cancer and scheduled for surgical resection were enrolled in this observational cohort study at their preoperative clinic visit. Fitbits were placed on patients' wrists upon transfer from the ICU following surgery and worn for the duration of their inpatient stay. Information about hospital readmission was extracted from electronic medical records.

Results Seventy-one patients participated in the study (mean age = 57.14, range = 31–80 years; 42% female; 51% diagnosed with appendiceal cancer). Mean steps per day were calculated for each participant over the entire inpatient recovery period (mean stay = 12.12 days, 4–37 days). Readmission within 30 and 60 days was medically indicated for 34% and 39% of patients, respectively. After statistically adjusting for age, body mass index, comorbidity, and length of postoperative stay, higher mean steps per day predicted lower 30-day and 60-day readmission risk.

Conclusions Higher Fitbit step counts during inpatient recovery predicted lower risk of 30- and 60-day readmission after surgery for metastatic peritoneal cancer. Results suggest that passively monitoring perioperative ambulation may identify patients at risk for readmission and highlight opportunities for behavioral intervention.

Keywords Cancer • Surgical oncology • Physical activity • Readmission

Carissa A. Low
lowca@upmc.edu

Departments of Medicine (Hematology/Oncology) and Psychology, University of Pittsburgh, 5200 Centre Avenue, Suite 614, Pittsburgh, PA, 15232

Introduction

Readmission is common after complex cancer surgeries, with 15%–50% of patients readmitted within 30 days of discharge following abdominal cancer resections [1,2,3]. Preventable readmissions are associated with increased health care costs, poor long-term outcomes including early mortality, and patient and family stress and suffering. The Affordable Care Act highlighted readmission as a target for quality improvement by establishing the Hospital Readmissions Reduction Program, which penalizes hospitals for excess 30-day readmission rates [4]. Prior analyses have identified demographic and medical predictors of 30- and 60-day readmission risk such as older age, comorbidity, and length of hospital stay [5,6], but the role of patient-centered behavioral processes such as physical activity has received relatively little research attention. Identifying modifiable behavioral factors predictive of readmission could highlight opportunities for behavioral intervention and empower patients to take a more active role in their recovery.

Early ambulation is encouraged after surgery and is a key component of Enhanced Recovery After Surgery multimodal interventions [7], but postoperative ambulation is rarely monitored systematically as part of clinical care or examined as a predictor of important clinical outcomes such as readmission. The recent emergence and growing popularity of commercially available, low cost, reliable wearable devices (e.g., "Fitbits") permit simple, objective, and continuous quantification of physical activity and remote real-time monitoring of patient ambulation, but whether these passively sensed data can predict subsequent clinically important outcomes remains unclear. Previous research with a cardiac surgery population suggests that higher numbers of Fitbit-assessed steps during postoperative hospitalization are associated with shorter length of inpatient stay [8]. Lower accelerometer-assessed step counts have also been associated with higher patient-reported 1 year readmission risk after cardiac surgery [9] and higher 30-day readmission in older hospitalized medical patients [10].

The goal of this study was to determine whether mean Fitbit-assessed daily steps taken during inpatient recovery predicts 30- and 60-day readmission risk after metastatic peritoneal cancer surgery.

Methods

Participants

A convenience sample of 71 patients with Stage IV peritoneal carcinomatosis who underwent hyperthermic intraperitoneal chemotherapy with cytoreductive surgery (HIPEC + CS) at a large academic center between July 2014 and October 2016 participated in this observational cohort study. Patients were referred to the study by their surgical oncologist at the time of consent to surgery. At this time, written informed consent for the study was obtained. This study was approved by the University of Pittsburgh's Institutional Review Board.

Measures

Fitbit steps

Fitbit Flex or Charge devices were placed on participants' nondominant wrists at the time of their transfer from the ICU to the postoperative recovery floor (typically postoperative day 2). Participants were instructed to wear the device at all times, except during charging (1–2 hours every 5–8 days). Devices were collected on the day of discharge by research staff and reused across participants. Days with incomplete step count data (i.e., the day of placement and the day of discharge) were omitted from analyses. Mean Fitbit step count was computed by averaging the daily step count across all inpatient days for each participant.

Readmission

Information about readmissions within 30- and 60-days postdischarge was extracted from the medical record, including inpatient, outpatient, and telephone contact notes. Readmission was defined as admission to any hospital within 30 or 60 days of index discharge. Patients who died within 30 days of discharge or who did not have postoperative records reflecting the entire postoperative window were not included in analyses.

Covariates

Age, sex, body mass index, diagnosis, preoperative American Society of Anesthesiologists (ASA) physical status, age-adjusted Charlson comorbidity index (CCI), and postoperative length of stay were extracted from the electronic medical record and examined as potential covariates. Covariates were selected on the basis of previously published associations with readmission risk and/or postoperative ambulation (i.e., age, body mass index, length of stay, comorbidities; [3, 9, 10]). In exploratory analyses, we also considered the role of preoperative activity level, which was assessed prior to surgery using the following question from the National Health Interview Survey: "Outside of your normal work or daily responsibilities, how often do you engage in exercise that at least moderately increases your breathing and heart rate, and makes you sweat, for at least 20 min (such as brisk walking, cycling, swimming, jogging, aerobic dance, stair climbing, rowing, basketball, racquetball, vigorous yard work (gardening), etc.?" [11]. Response options ranged from 1 to 4 and included seldom or never, 1–2, 3–4, or 5 or more times per week (mean = 2.53, standard deviation = 0.98).

Statistical Analysis

Data analyses were conducted using SPSS version 24. Descriptive statistics were first performed to characterize the sample and the distribution and frequency of variables. Variables were categorized for analyses using the following groups: sex (male vs. female), diagnosis (appendiceal cancer vs. other), ASA status (2-mild systemic disease vs. 3-severe systemic disease or 4-severe systemic disease that is a constant threat to life), and CCI (6–8 vs. 9 or higher).

Of the 71 participants, 10 were missing Fitbit data due to: device failures (n = 5, due to three malfunctioning Fitbit Flex devices), short postoperative inpatient stays

($n = 1$, i.e., fewer than 2 days of inpatient step count data), syncing issues ($n = 2$), or inability to wear the Fitbit due to swelling or allergy ($n = 2$). Three additional patients died during inpatient recovery or within 30 days of discharge, and four patients lacked readmission data due to lack of postoperative documentation in the electronic medical record. Thus, multivariate analyses included 54 participants. Independent *t*-tests, Pearson correlations, and Chi-square analysis were used to examine bivariate associations among readmission, steps, and demographic and medical variables. Multivariate logistic regressions were used to test relationships between the Fitbit steps during recovery and readmission outcomes after adjusting for demographic and medical covariates. For ease of interpretation, mean steps/day was converted to mean hundreds of steps/day in logistic regression analyses.

Results

Demographic, medical, and step count data from the 71 participants are presented in Table 1.

Participants took an average of 968.22 steps per day during the inpatient recovery period (range 48.86–3185.71). Mean daily steps were inversely correlated with age ($r(60) = -.29$, $p = .026$). Steps were not significantly associated with sex, diagnosis, body mass index, ASA status, CCI, or length of stay (all p's > .10).

Within 30 days of discharge, 34% of patients were readmitted; three additional patients were readmitted during days 31–60 after discharge, resulting in a 60-day readmission rate of 39%. 30-day readmission risk was marginally associated with lower BMI ($t(62) = 1.94$, $p = .056$) and with higher ASA status (χ^2 (1, $n = 63$) = 3.54, $p = .060$); 60-day readmission was significantly associated with higher CCI (χ^2 (1, $n = 64$) = 5.36, $p = .021$); and marginally associated with older age ($t(62) = -1.86$, $p = .067$). Readmission risk was unrelated to sex, diagnosis, and length of stay.

In unadjusted analyses, taking more steps was significantly associated with lower risk of 30-day ($t(52) = 2.77$, $p < .01$) and 60-day readmission ($t(52) = 3.70$, $p < .001$). In logistic regressions adjusting for age, body mass index, comorbidity, and length of postoperative stay, taking more steps during inpatient recovery continued to predict both lower 30-day and 60-day readmission risk (see Table 2). For each 100 additional steps taken per inpatient recovery day, risk of 30-day readmission was 17% lower and risk of 60-day readmission 18% lower.

In exploratory analyses, patient-reported preoperative exercise frequency was significantly correlated with postoperative step counts ($r(50) = 0.31$, $p = .032$) but was unrelated to readmission risk. When preoperative activity level was included as an additional covariate, inpatient step count remained associated with decreased risk of 30-day (odds ratio, OR = 0.79, confidence interval, CI 0.66–0.95, $p = .01$) and 60-day readmission (OR = 0.78, CI 0.65–0.95, $p = .01$).

Discussion

Higher Fitbit mean daily step counts during inpatient recovery predicted lower risk of 30- and 60-day readmission after metastatic cancer surgery. These associations persisted after adjustment for demographic and medical covariates such as age, diagnosis, and length of postoperative stay as well as preoperative patient-reported exercise frequency. Results suggest that commercial activity monitors may provide clinically meaningful information and that passively monitoring perioperative mobility may identify patients at risk for poor postoperative outcomes.

These data highlight the possibility that remotely monitoring real-time patient ambulation using Fitbit devices may provide opportunities to improve postoperative clinical care with minimal burden to patients or clinical providers. Low Fitbit step counts during inpatient recovery could help providers to identify patients

Table 1 Sociodemographic and clinical characteristics of the sample

Variable	Mean ± *SD* (range) or %
Age (years; $n = 71$)	57.14 ± 11.18 (31–80)
Sex ($n = 71$)	57.7% male
Body mass index ($n = 71$)	27.25 ± 5.75 (16.95–45.48)
Diagnosis ($n = 71$)	50.7% appendiceal cancer; 33.8% colorectal cancer; 8.5% mesothelioma; 7.0% other
American Society of Anesthesiologists Physical Status ($n = 71$)	22.5% 2, mild systemic disease; 73.2% 3, severe systemic disease; 4.2% 4, severe systemic disease that is a constant threat to life
Charlson comorbidity index ($n = 71$)	7.73 ± 1.77 (6–13)
Length of postoperative stay (days; $n = 69$)	12.12 ± 6.74 (4–37)
30-day readmission ($n = 64$)	34.4% yes
60-day readmission ($n = 64$)	39.1% yes

SD standard deviation.

Table 2 Multivariate logistic regression models of associations with readmission

		Odds of 30-day readmission (n = 54)		Odds of 60-day readmission (n = 54)	
		OR (95% CI)	p	OR (95% CI)	p
Age (years)		1.01 (.94–1.09)	.79	1.01 (.94–1.10)	.74
Body mass index		0.84 (.70–.99)	.04	0.89 (.77–1.03)	.13
Charlson comorbidity index	9 or higher	1.09 (.22–5.39)	.92	2.51 (.51–12.32)	.26
	8 or lower (referent)	1.00		1.00	
Hospital length of stay (days)		0.93 (.82–1.04)	.20	0.95 (.85–1.07)	.43
Mean steps/inpatient day (hundreds of steps)		0.83 (.72–.96)	.01	0.82 (.71–.95)	<.01

CI confidence interval; OR odds ratio.

in need of additional monitoring or intervention prior to discharge [12]. Results are consistent with previous research in general medicine and cardiac patients indicating associations between accelerometer-assessed steps and readmission risk (e.g., [9,10]). To our knowledge, this is the first study to link Fitbit wristband-assessed step counts to readmission in any clinical sample as well as the first to examine associations between steps and readmission risk after cancer surgery.

Although demographic and clinical data (*e.g.*, age, number of admissions in the past year) have proven useful in identifying patients at high risk for readmission [5,6], these risk stratification algorithms suffer from two important limitations. First, demographic and clinical variables are generally not modifiable so provide limited guidance for interventions aimed at reducing preventable readmissions. Conversely, postoperative mobility can be modified via behavioral interventions [13], which may hold promise in optimizing recovery and postoperative outcomes. These behavioral interventions could be targeted to populations known to be at elevated risk for readmission, such as older patients. Second, administrative algorithms typically use data only available upon hospital discharge (e.g., length of stay, lab values at discharge), permitting minimal opportunities to monitor and support at-risk patients during their inpatient recovery. Fitbit steps can be tracked throughout the inpatient stay and may allow for earlier identification of at-risk patients.

Several limitations warrant mention. First, our sample was relatively small and medically homogeneous, and results should be replicated in larger and more heterogeneous clinical populations. Second, although we found similar mean daily Fitbit postoperative step counts when compared to previous inpatient accelerometer studies (mean = 1,158 steps/day, ref. [14]) and Fitbit step counts are generally accurate [15], the reliability and validity of Fitbit step counts has not yet been established for slow or assisted walking and may have underestimated steps for patients moving slowly or with assistance [16]. We also used two different Fitbit devices, the Flex (worn by 54% of participants) and the Charge (worn by 46%), that may have differed in their step counts; note that adjusting for type of device did not affect results (data not shown). Third, given the wide range in length of inpatient stay between patients, we elected to focus on mean steps per inpatient day to capture all available data on ambulation from ICU transfer to hospital discharge, but within-person variability in step counts during inpatient recovery (e.g., slope) should also be examined in future research. There may also be critical periods of recovery (e.g., the first days after surgery or the last days before discharge home) during which individual differences in activity are particularly important. Fourth, patients in our study experienced higher readmission rates than those reported in other samples undergoing cytoreductive surgery with hyperthermic intraperitoneal chemotherapy (e.g., 15% in ref. [1]), suggesting that patients treated at our tertiary academic medical center may be more sick or frail than surgical oncology samples elsewhere. Finally, we assessed steps only during inpatient recovery on the postoperative recovery floor and did not monitor ambulation prior to surgery or after discharge.

Future directions for this area of research include extending assessment of ambulation to include the 60 days after discharge, as steps taken once a patient returns home from the hospital may be even more critical than inpatient steps in predicting readmission risk. Assessment of steps taken prior to surgery reflecting individual differences in baseline activity level or fitness level may further account for additional variance in readmission risk. Collecting data on reasons for lack of ambulation may also inform the design and delivery of interventions, as reasons could include symptom burden such as uncontrolled pain or fatigue, disruption of typical routines and environment while in the hospital, anxiety about falling or irritating surgical incisions, or beliefs about whether activity will help or hinder healing.

Passively sensed data on sedentary behavior may account for additional variance over and above the predictive utility of step counts [17]. Testing whether behavioral interventions aimed at increasing perioperative ambulation influence readmission and other clinical outcomes would shed light on whether activity has a causal influence on readmission. Finally, future research should extend this work to other clinical populations to determine whether findings generalize to predict readmission in the context of other chronic or acute health conditions.

In conclusion, higher postoperative mean daily step counts significantly predicted lower risk of readmission after complex surgery for metastatic peritoneal cancer. After adjustment for demographic and medical covariates, taking 100 additional steps per inpatient recovery day was associated with 17% lower risk of 30-day readmission and 18% lower risk of 60-day readmission. Results highlight the potential of commercial activity monitors to improve postoperative care by identifying patients in need of additional monitoring or intervention after cancer surgery.

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Compliance with Ethical Standards Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval and Informed Consent All procedures, including the informed consent process, were conducted in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

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