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Using accelerometers to characterize recovery after surgery in children☆,☆☆,★

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ABSTRACT

Background: Assessment of recovery after surgery in children remains highly subjective. However, advances in wearable technology present an opportunity for clinicians to have an objective assessment of postoperative recovery. The aims of this pilot study are to: (1) evaluate acceptability of accelerometer use in pediatric surgical patients, (2) use accelerometer data to characterize the recovery trajectory of physical activity, and (3) determine if postoperative adverse events are associated with a decrease in physical activity.
Study design: Children aged 3–18-years-old undergoing elective inpatient and outpatient surgical procedures were invited to participate. Physical activity was measured using an Actigraph GT3X wristworn accelerometer for ≥2 days preoperatively and 5–14 days postoperatively. Time spent performing light (LPA) and moderate-to-vigorous physical activity (MVPA) was expressed in minutes/day. Physical activity for each postoperative day was calculated as a percentage of preoperative activity, and recovery trajectories were produced. Adverse events were reported and mapped against recovery trajectories.
Results: Of 60 patients enrolled, 25 (10 inpatients, 15 outpatients) completed the study procedures and were included in the analysis. For outpatient procedures, LPA recovered to preoperative level on postoperative day (POD) 7 and MVPA peaked at 90% on POD 8. For inpatient procedures, LPA peaked at 70% on POD 11, and MVPA peaked at 53% on POD 10. Adverse events in 2 patients were associated with a decline in activity.
Conclusions: This study demonstrates that objective monitoring of postoperative physical activity using accelerometers is feasible in the pediatric surgical population. Recovery trajectories for inpatient and outpatient procedures differ. Accelerometer technology presents clinicians with a new potential tool for assessing and managing surgical recovery, and for determining if children are not recovering as expected.
Type of study: Diagnostic Study.
Level of evidence: III.

In the United States, approximately 450,000 inpatient and 2.3 million ambulatory pediatric surgical procedures are performed every year [1,2]. Nearly one third of inpatient procedures and more than half of outpatient procedures are performed in children >5 years old, from whom it can be difficult to obtain self-reported information on pain and other complaints [2,3]. While adverse events following surgical procedures are relatively rare in children, complications may result in hospital readmissions, increased costs, and missed school or other activities [4].

Objective measurement of postoperative recovery has been a long-standing challenge for physicians in both the adult and the pediatric surgical populations. A number of instruments, the majority of which were developed in the adult population, have been created to address this need. These instruments primarily include self-administered questionnaires that address a variety of domains such as physical function, symptoms, emotional state, cognition, and satisfaction [3,5–7].

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Systematic reviews of these subjective assessment tools have found a lack of standardization, varying validity, and inconsistent outcomes between instruments [5]. Therefore, no single tool has emerged as a favored instrument.

Wrist-worn devices such as accelerometers (e.g. Fitbit®) have the ability to accurately capture movement and physical activity, and have the potential to be used as an objective measure of surgical recovery. In adults, accelerometer data have been used to evaluate functional recovery as well as postoperative activity levels after open and minimally invasive procedures [8–11]. For children, accelerometers present a means of objectively measuring activity recovery after surgery in a population that is not as communicative as adults. Accelerometers have previously been used to characterize activity levels among children with type 2 diabetes, pediatric oncology patients, and children with limb fractures [12–14]. Additionally, postoperative activity levels compared with healthy controls have been explored for select cardiac and orthopedic procedures [12–16]. However, generalized assessment of overall surgical recovery using physical activity has not yet been attempted in the pediatric population. For pediatric patients undergoing inpatient and outpatient surgery, this pilot study aimed to investigate: (1) the acceptability of accelerometer use, (2) utility of accelerometer data to characterize recovery of physical activity, and (3) if postoperative adverse events were associated with a decrease in physical activity.

1. Methods

1.1. Study population

After Institutional Review Board (IRB) approval, patients undergoing elective inpatient and outpatient general pediatric surgery, urology, orthopedic, and otolaryngology procedures at Ann & Robert H. Lurie Children's Hospital of Chicago were invited to participate. Children ages 3 to 18 years old and undergoing elective surgery between February 2016 and February 2017 were included. Children who were nonambulatory, had preexisting mobility limitations, or had physician-ordered physical activity limitation for >48 h after surgery were excluded. Patients were identified and enrolled in the outpatient clinics during their preoperative visit.

Upon enrollment, the study coordinator explained the purpose of the study and how the accelerometer should be worn. Enrolled patients received a fully charged Actigraph accelerometer device (GT3X or wGT3X-BT model; ActiGraph LLC; Pensacola, FL) in the mail at least 3 days prior to surgery. Patients were instructed to wear the device continuously on either wrist for a minimum of three days preoperatively and 14 days postoperatively to obtain adequate measurements of baseline and recovery activity levels. The device was only to be removed for bathing, and during the surgical procedure itself. Participants were contacted twice by phone to provide instructions on device use and study procedures, first on the day the device was mailed and then 3 days prior to study completion. After 14 days postoperatively, the patients were asked to mail the device as well as the activity log and survey back to research staff in a prepaid envelope. All participants received a $50 Visa gift card as remuneration for their participation in the study.

We also performed a chart review for each participant and identified all complications or significant recovery events that patients experienced, including those reported in follow-up phone calls and emergency department (ED) visits. We then mapped these events against accelerometer readings.

1.2. Analytic plan

In the accelerometer data reduction process, accelerometers were considered as having not been worn if a period of 60 consecutive min of zero accelerometer counts (with an allowance for two non-zero interruptions) was encountered in the accelerometer data array. Patients had to wear the accelerometer for at least 10 h per day to have a reliable estimate of their physical activity on that day [17]. Patients with at least two preoperative days of accelerometer data were included, in order to have a reliable and valid estimate of regular physical activity level before surgery [17]. Inclusion in the analysis also required that patients have ≥5 days of postoperative accelerometer data, in order to accurately assess recovery trajectories.

Two daily physical activity measures were calculated for each eligible patient who met the minimum pre- and postoperative activity tracking criteria detailed above: 1) time spent in light to higher-intensity physical activity (LPA; hours per day), and 2) time spent in moderate and vigorous-intensity physical activity (MVPA; minutes per day). LPA was defined as vertical axis counts ≥1756 counts per minute but <4332 counts per minute. MVPA was defined as vertical axis counts ≥4332 counts per minute. These cutoff points are based on algorithms developed and validated specifically for children [18–20]. Sleep time counts do not affect the LPA and MVPA numbers since they are generally lower than the lower threshold of LPA.

Descriptive analyses for all study variables, including demographics of patients and accelerometer variables, were performed. Chi-square tests were conducted to compare the demographic characteristics of patients who were included in data analysis and those who were excluded. The primary outcome was activity recovery, calculated as percent of preoperative activity level. For example, the percent recovery in LPA on a particular postsurgery day was calculated as LPA at that postsurgery day divided by mean LPA before surgical procedure. Similarly, the MVPA recovery percent for each postsurgery day was calculated for each patient. Using these recovery percentages, LPA an MVPA recovery trajectories for inpatients and outpatients were created. Percentage of preoperative activity level at the end of follow-up period was also determined, including whether or not and when each patient achieved 100% of their preoperative activity level during this period. Student's *t*-tests were used to compare physical activity recovery rates at postoperative day (POD) 7 between inpatients and outpatients. Significance level was set as 0.05. All analyses were conducted using SAS 9.2 (Cary, NC).

2. Results

2.1. Patient demographics

A total of 60 patients were enrolled in the study (16 inpatients and 44 outpatients). Of those enrolled, 25 total patients (10 inpatients and 15 outpatients) completed the study procedures and had usable accelerometer data. The most common reasons for exclusion were incomplete wear time (10 outpatients and 5 inpatients), device malfunction (5 outpatients), and canceled surgery (7 outpatients) (Fig. 1). Of the 15 patients with incomplete wear time data, 3 patients were excluded because they had 0 or 1 day of wear time >= 10 h/day during the presurgery period. Their mean wear time during these days was 3.2 h/day (SD 4.7). The remaining 12 patients were excluded because they had less than 5 days of wear time >= 10 h/day during the postsurgery period (2 patients with 0 day, 3 patients with 1 day, 2 patients with 2 days, 4 patients with 3 days, 1 patient with 4 days). Their mean wear time during these days was 5.5 h/day (SD 6.4).

There were no significant differences between included and excluded patients when comparing sex, age, race and insurance status (Table 1). However, patients who underwent inpatient procedures were more likely to complete the study protocol. The average age of included participants was 10 years (standard deviation [SD] = 4.7) and 34% were male. Most participants were white and on Medicaid. Inpatient procedures included retroperitoneal mass excision, complex bladder repair, urethroplasty, pharyngoplasty, and spinal fusion. Outpatient procedures included umbilical and inguinal hernia repair, tonsillectomy, cholecystectomy, cyst excision, breast mass excision, toenail removal, and initial or redo circumcision.