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Accelerometer–measured physical activity levels before and after total hip arthroplasty: A cohort study

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Abstract

Background: Higher physical activity levels following total hip arthroplasty has multiple benefits, including decreased morbidity and mortality. To this end, accelerometers have grown in popularity due to their accurate measurement of exercise duration, frequency, and intensity. **Aims and Objectives:** The purpose of this study is to assess pre-and-post operative physical activity levels amongst total hip arthroplasty recipients utilizing prospectively-collected accelerometer data. **Study Design:** Retrospective Review. **Setting:** Publically available database. **Materials and Methods:** The Osteoarthritis Initiative database was queried for all patients who underwent total hip arthroplasty and who had preoperative accelerometer readings. Specifically, inclusion criteria included patients who consented to wear an ActiGraph GT1M uniaxial accelerometer and then underwent a primary unilateral total hip arthroplasty after the 48-month visit (n=44). **Statistics:** Categorical variables were assessed using descriptive statistical analysis. Paired-Samples t-tests were utilized to compare continuous variables before and after THA. **Results:** There was no difference in average daily activity count for patients pre- and post-procedure (t=0.3625; P=0.72). The difference in mean daily minutes of light activity was non-significant (t=0.0572; P=0.95), as was the difference in mean daily minutes of moderate activity (t=1.2829; P=0.23). There was no difference found for the mean daily bout minutes of moderate-vigorous activity (t=1.1744; P=0.47), the mean daily minutes of moderate-vigorous activity (t=1.17; P=0.27), the mean daily bout minutes of vigorous activity (t=0.2173; P=0.83), and the mean daily minutes of vigorous activity (t=0.2943; P=0.77). There was no difference in the number of patients who met general physical activity requirements or requirements for people with arthritis (P=0.753). **Conclusions:** While total hip arthroplasty is effective at mitigating symptoms of osteoarthritis, most patients maintain a post-operative activity level similar to their pre-operative state. There is no difference in physical activity levels before and after surgery. Further studies should include larger sample sizes in prospective studies, and investigate patient motivation and desire for activity levels.

Keywords: Accelerometer, Total Hip Arthroplasty, Physical Activity, Osteoarthritis Initiative, Exercise.

INTRODUCTION

The assessment of physical activity (PA) levels in total hip arthroplasty (THA) recipients is commonly performed and an essential measure of postoperative improvement. Recently, the methodology by which we measure PA levels has significantly evolved due to innovative technological advancements. Currently, a variety of PA monitoring tools are available and have been studied in the areas of health outcomes, performance enhancement, and rehabilitation [1]. Pedometers, heart rate monitors, and load transducers are examples of the distinct classes of wearable monitors accessible today. Pedometers measure step counting; however, their accuracy and precision highly varies among different models [2, 3]. Heart rate monitors are subject to stimuli other than PA such as prescription drugs and therefore, are not ideal for the elderly THA population [1]. Finally, load transducers have not yet been validated for ordinary PA. Several newer technologies have emerged to more accurately record motion.

Accelerometers comprise another category of PA monitors and are readily utilized today. These devices are portable, lightweight sensors that have the potential of recording frequency, duration, and intensity of PA [4]. Their distinction from the more commonly-used pedometers (i.e. Fitbit) lies in that they measure vertical acceleration-deceleration moments in patient movement [1, 5]. This is achieved because of the method by which they are engineered. Some accelerometers consist of an enclosure that contains a

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piezoelectric element and seismic mass configured as a cantilever beam [6]. As the sensor undergoes acceleration, the seismic mass causes the piezoelectric element to move in a bending direction (vertical to ground up). These changes in conformation generate an output voltage proportional to the acceleration, which is then converted to numerical counts [6]. Levels of PA are grouped into categories such as sedentary, light, moderate, or vigorous intensity based on thresholds of the accelerometer counts yielded from the sensor output [7]. As accelerometers become popular, first generation accelerometers become more apparent in the literature. Previous studies have validated accelerometer accuracy and reliability in correctly calculating metabolic expenditure [7, 8].

Multiple studies have compared patient PA levels pre- and post-arthroplasty. However, many of these studies have utilized technology that is less than current or have utilized a control group for comparing levels of PA [9–12]. As such, the purpose of this study is to assess pre- and post-operative levels of PA level amongst THA recipients utilizing prospectively-collected accelerometer data. We hypothesize that there is no difference in PA levels between pre- and post-operative THA periods.

MATERIALS AND METHODS

Database and Patient Selection

The Osteoarthritis Initiative (OAI) database was utilized for this study. This data repository is available through the OAI, a multicentre observational study sponsored by the National Institutes of Health, and involved 4,796 participants. Patients within the database were stratified into three groups: 1) a progression sub-cohort of patients with symptomatic osteoarthritis (OA) (n=1,389); 2) an incidence sub-cohort representing patients at high risk of developing OA (n=3,285); and 3) a control cohort (n=122). Each participant attended a baseline visit and a subsequent annual visit during which joint biomarkers, radiological, and clinical data was recorded. During their fourth annual visit, a total of 2,127 patients were invited and consented to participate in a PA reading using an accelerometer. We utilized the OAI database to query for patients who underwent a primary unilateral THA for definitive treatment of OA. Patients were included if a PA reading was performed and documented at the 48-month visit prior to the surgical intervention. Patients who underwent the procedure prior to the PA reading or who did not consent to participate in the PA assessment were excluded. This yielded a total of 44 patients (43.8% male, mean BMI= 28.6 kg/m^2) (Table 1).

Table 1: Patient demographics.

		***P*-value**
Mean age at surgery (range) (years)	69.95 (54.81 to 82.74)	
Gender (% male)	43.8%	
Race (% of study population):		
White	44 (91.67%)	
Black or African-American	3 (6.25%)	
Asian	1 (2.27%)	
Other	0 (0%)	
Pre-THA BMI (SD) (kg/m^2)	28.66 (3.51)	0.477
Post-THA BMI (SD) (kg/m^2)	28.03 (3.61)	
Mean time until THA (SD) (days)	1836.05 (21)	

Kg=kilogram, m=meter, SD=standard deviation, THA=total hip arthroplasty

Physical Activity Measures

Physical activity levels were measured with the GT1M ActiGraph accelerometer (ActiGraph; Penacola, FL, USA), a small uniaxial device that utilizes vertical acceleration as a proxy for PA. The voltage signal derived from the accelerometer during motion was filtered, processed, and digitally stored in numerical fashion to obtain functional data for analysis. Non-wear periods were defined as 90 minutes or greater with zero activity counts. A validated monitoring day was defined as 10 hours or greater of accelerometer wear during a 24-hour period. All accelerometer data included at least four valid days of activity monitoring.

Activity level threshold stratification was adopted from Troiano *et al*. [13] on a minute-by-minute basis to classify accelerometer counts into four intensity levels: none to very light (0–99 counts), light (100–2019 counts), moderate (2020–5998 counts), and vigorous (5999 counts). Physical activity was stratified according to the 2008 Physical Activity Guidelines for Americans PA levels: Meeting Recommendations (≥150 bouted moderate-to-vigorous activity minutes per week), Low Active (1–149 bouted moderate-to-vigorous activity minutes per week), or Inactive (zero bouted moderate-to-vigorous activity minutes per week) [14].

Statistical Analysis

Patient age, gender, and race were assessed using descriptive statistical analysis. Paired-Samples t-tests were utilized to compare body mass index and activity levels before and after THA. A p-value of 0.05 was set as the threshold for statistical significance. All analyses were conducted using SPSS version 25 (IBM Corporation; Armonk, NY, USA).

RESULTS

Patients pre-THA achieved an average daily activity count of 166,040 (Standard Deviation [SD] = 91,615), while patients post-THA had an average daily activity count of 177,579 (SD=103,732), which yielded a non-significant difference ($t = 0.3625$; P=0.72) (Table 2).

The difference in mean daily minutes of light activity was not significant between patients pre-THA (244, SD=77) and post-THA (251, SD=79; t = 0.0572; P=0.95), nor was there a significant difference in mean daily minutes of moderate activity pre-THA (10.4, SD=11.9) and post-THA (14.3, SD=14.3; t = 1.2829; P=0.23). The mean daily bout minutes of moderate-vigorous activity was 5.5 (SD=7.8) in patients pre-THA, and 7.7 (SD=8.5) in patients post-THA, with no significant difference between the groups (t = 1.1744; P=0.4703). Similarly, the mean daily minutes of moderate-vigorous activity were 10.8 (SD=12) pre-THA, and 14.7 (SD=14.6) post-THA, with no significant difference found (t = 1.17; P=0.27). Patients pre-THA had 0.3967 (SD=1.6829) mean daily bout minutes of vigorous activity, which was nonsignificant to the 0.4673 (SD=1.5498) mean daily bout minutes of vigorous activity patients post-THA had (t = 0.2173; P=0.8324). The mean daily minutes of vigorous activity was also nonsignificant between patients pre-THA (0.4844, SD=1.3994) and post-THA (0.4192, SD=1.8465; t=0.2943; P=0.7740) (Table 2).

There was no difference in the number of patients who met the Department of Health and Human Services (DHHS) PA requirements for all patients or DHHS PA requirements for people with arthritis (P=0.753).

Table 2: Results.

	Patients Pre-THA (SD)	Patients Post-THA (SD)	T-statistic	*P*-value
Mean average daily count	166,039.6 (91,615.6)	177,578.6 (103,731.9)	t = 0.3625	0.724
Mean daily minutes of light activity	243.8 (77.2378)	251.4008 (78.9)	t = 0.0572	0.956
Mean daily minutes of moderate activity	10.4 (11.8375)	14.3050 (14.3)	t = 1.2829	0.226
Mean daily bout minutes of mod-vigorous activity	5.5 (7.7730)	7.6667 (8.5)	t = 1.1744	0.470
Mean daily minutes of mod-vigorous activity	10.8 (11.9)	14.7 (14.6)	t = 1.1744	0.265
Mean daily bout minutes of vigorous activity	0.4 (1.7)	0.47 (1.6)	t = 0.2173	0.832
Mean daily minutes of vigorous activity	0.5 (1.39)	0.42 (1.9)	t = 0.2943	0.774
Patients who met DHHS guidelines (n)	1 (2.1%)	1 (2.1%)		0.753
Met DHHS guidelines for patients with arthritis (n)	1 (2.1%)	1 (2.1%)		

DHHS=Department of Health and Human Services, SD=standard deviation, THA=total hip arthroplasty

DISCUSSION

The main aim for arthroplasty surgeons performing THA is restoration of function and cessation of pain related to hip arthritis [15–17]. While multiple studies have reported improvements in patient outcome, function, and pain reduction, others have reported that objectively measured improvements in PA may not occur between pre-and-post THA periods [18, 19]. Many studies however, utilized pedometers which has been criticized as a more basic metric of PA [11, 12]. Thus, by utilizing the OAI database we assessed pre- and post-THA PA levels for prospective group of patients who utilized accelerometers as a measure of PA.

There were some limitations to this study. The OAI database is an ongoing project, which is constantly being updated. The cohort selected for this study was small, and only fell between certain dates. It is also likely that there would be more patients that fit the screening criteria if a longer time frame was used to collect accelerometer data. However, an a priori power analysis with study parameters of 95% power with a moderate effect size and an α level of 0.05 revealed the need for 45 patients, which is in line with our sample size. Additionally, this is a retrospective study, and does not carry the same authority a prospective, randomized control trial would. We therefore encourage further studies to conduct larger randomized control trials to confirm what was demonstrated here. Though we did not retrospectively compare PA levels between THA recipients and the control group of the database, we would also encourage future reports to include a control group in order to assess the presence of potential differences. Furthermore, the OAI database incorporates patients with evidence of knee OA which may serve as a confounder to our study results. However, this finding is generalizable to patient populations when considering the fact that many THA recipients will have multiple sites of OA. Nonetheless, future studies should aim to isolate these confounders to better explore the effects of THA on patient PA levels.

Despite these limitations, several studies concur with our results. Arnold *et al.* [19] conducted a systematic review looking at PA levels in 135 THA patients, and found that while improvements in PA were questionable at 6 months post-operatively (standard mean deviations [SMD], –0.20 to 1.80), there were larger improvements at one year (SMDs, 0.39 to 0.79). However, PA levels post-THA did not reached the levels of healthy controls by 1 year (SMDs, –0.25 to –0.77). In addition, a qualitative longitudinal study of 11 THA patients by Gustafsson *et al.* [20] established that, while patients wished to be able-bodied as they were pre-pathology, all patients reported perceiving “recovery from surgery as difficult,” had to “relearn how to move properly,” with some feeling they would never be able to move like they used to.

Likewise, a qualitative systematic review of 134 THA patients by Smith *et al.* [21] demonstrated that patients were fearful of participation in higher PA levels due to limited information, and worries about their recovery and the longevity of their THA. Moreover, Dayton *et al.* [22] showed in prospective study of 23 THA patients that there were disparities in Hip Dysfunction and Osteoarthritis Outcomes Score and actual functional performance, specifically in the timed up and go ($r=0.08$; $P=0.68$) and stair climb test ($r=0.08$; $P=0.72$), which suggests patients may overestimate their functional performance post-THA. Furthermore, Poortinga *et al.* [23] found in a retrospective study of 658 patients that preoperative PA levels had no correlation with degree of recovery after THA (*B*-coefficient = 0.03, CI95% = 0.033–0.093).

It is paramount that arthroplasty surgeons realize the potential public health and economic costs related to a lack of improvement in PA amongst THA recipients. Geriatric patients who increase their PA levels reduce their risk of falls and fall-related injuries such as dislocation, a postoperative complication which can lead to additional procedures costing upward of $28,600 for the patient and provider [24–26]. Increased PA has also been associated with decreased patient morbidity and mortality, particularly amongst elderly populations [27, 28]. Failure to counsel THA patients on how to increase PA may incur penalties in the near future should complications arise, as healthcare reform policies are now moving towards global health reimbursement models such as global budget revenues models and accountable care organizations [29, 30]. This may suggest a need for arthroplasty surgeons and healthcare providers to educate THA recipients on the importance of increasing levels of PA after a THA procedure.

Conclusions

While THA is effective at helping to mitigate some of the symptoms of osteoarthritis, some patients may maintain a post-operative PA level similar to their pre-operative state. The present study found no significant difference in PA levels before and after THA. Further studies should include larger sample sizes, utilize a prospective study design, and investigate patient motivation and desire for activity levels, as this may play a role in the PA level achieved.

> Total hip arthroplasty is effective in relieving pain from end stage osteoarthritis, but post-operative physical activity levels can be variable. This study determined that physical activity did not significantly improve for osteoarthritis patients after replacement of their hip, which may be a reflection of the lack of desire patients have for increased activity, which providers should be cognizant of.

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Authors' Contribution:

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