The Association Between Clinical Outcomes and Physical Activity Outcomes through Wearable Sensors in Patients Awaiting Knee Arthroplasty Surgery

Kaitlin J Genge[1], AF Laudanski[1], CG Richardson[2], MJ Dunbar[1,2], JL Astephen Wilson[1,2]
[1]Dalhousie University, Halifax NS Canada, [2]Nova Scotia Health, Halifax NS Canada
Presenting Author: kgenge@dal.ca

Disclosures: K.J. Genge: None. A. Laudanski: None. C.G. Richardson: 3B; Stryker, DePuy Synthes, HIT Orthopaedics. M.J. Dunbar: 1; Stryker. 3B; Stryker. 5; Stryker, DePuy. 8; BJJ Editorial Board. J.L. Astephen Wilson: 3B; Stryker.

INTRODUCTION: Despite the known health benefits and symptom management benefits of physical activity (PA), individuals with knee osteoarthritis (OA) are significantly less active than healthy age-matched individuals[1], most failing to achieve daily physical activity targets altogether[2]. PA levels are often captured using self-report surveys, however these may not reflect true activity levels[3]. The relationships between PA, clinical disease state, and patient outcomes are complex, and it has been shown that there is added value in including PA levels when characterizing the symptomatic and clinical state of patients[4]. Previous studies have reported objectively-measured step-counts in arthroplasty patients[5], however the use of objective tools in this space has been limited and few have explored how pre-arthroplasty PA outcomes relate to patient characteristics and clinical outcomes. The purpose of this study was to characterize step count and sedentary behaviors of an end stage knee OA population awaiting knee arthroplasty surgery through wearable accelerometry and to examine the association between these objective PA outcomes and clinically relevant patient-specific variables (BMI, pain, self-reported PA, and mental health) in individuals awaiting knee arthroplasty surgery.

METHODS: Patients with end stage knee OA were recruited from the participating surgeons' arthroplasty wait lists and provided informed consent to participate in the study according to the Nova Scotia Health Research Ethics. Inertial measurement units (Axivity, AX6) were anatomically placed and covered with a waterproof adhesive on the shin of the surgical limb of patients during a pre-operative clinical visit. Tri-axial free-living accelerometry data were captured over a 7-day period. Questionnaires were used to capture demographic and patient-reported outcome measures (PROMs), including pain (OKS-PCS), patient-reported PA (UCLA Activity Score), and mental health (PHQ8). From the raw accelerometer data, step-counts were calculated in a custom MATLAB (v.9.13) code and represented as average daily step counts over the collection period. Mean amplitude deviation (an established activity intensity classification technique)[6] was used to calculate the percentage of time spent sedentary. Means and standard deviations for each participant and the group were calculated for the central 6 full collection days. Correlation analyses were used to examine associations between objective PA outcomes (step-counts and % sedentary) and BMI and PROMs outcomes (α=0.05); and PA outcomes were compared between male and female patients using t-tests.

RESULTS: Twenty-one participants (13M/8F) were included in study (Table 1). The average daily step count was 6051±2844 steps which is consistent with published step-count averages and variability in similar populations[7], and the average percent of day spent sedentary was 78.8±6.6% which is higher than that recommended by public health guidelines[8]. Twelve participants (57%) did not achieve the recommended daily step count average of 7000 steps[2]. Higher BMI and lower self-reported physical activity levels were significantly associated with lower step counts ($p=0.013$, $r^2=0.28$ and $p=0.011$, $r^2=0.29$, respectively) and higher percentage of the day spent sedentary ($p=0.17$, $r^2=0.26$ and $p=0.012$, $r^2=0.29$, respectively). Percent time spent sedentary was found to be significantly higher in females ($t(19) = -2.52$, $p = 0.021$), but there were no significant differences in step counts between males and females.

DISCUSSION: PA levels in an end stage knee OA patient population awaiting knee arthroplasty surgery varied significantly, with the majority of patients not achieving the daily recommended levels of PA. This, combined with a high percent of time spent sedentary highlights the challenges faced by this population in being active, and the potential negative consequences that sedentary time can have on other aspects of their health and well-being. While not all hypotheses of associations between PA and other clinical characteristics were supported, we did identify relationships between objectively measured PA outcomes and patient characteristics including BMI, sex and self-reported PA levels. Despite the positive correlation between objective and self-report PA outcomes, the PROMs lacked specificity in this sample, with several patients demonstrating highly variable daily step counts yet self-reporting a 3/10 activity level. As such, these findings demonstrate the advance of collecting objective PA outcomes and additionally suggest that there is a heterogeneity in the challenges faced by particular patient groups which must be further investigated to better understand how end-stage knee OA management and interventions, such as total knee arthroplasty, can be tailored to meet patient- or group-specific needs. Further research will be aimed at exploring longitudinal changes in PA outcomes during the wait time for arthroplasty surgery and how activity decline relates to other relevant clinical outcomes to advance our understanding of the importance of PA considerations in end stage knee OA care.

SIGNIFICANCE/CLINICAL RELEVANCE: Incorporating objective PA measurement with other relevant outcomes into pre-operative assessment of knee arthroplasty candidates may provide valuable insight into patient variability that should be considered in surgical management and decision-making. Ultimately, this information will be used by clinicians to inform patient-specific surgical planning and decision making with the goal of optimizing knee arthroplasty outcomes on an individual patient level.

REFERENCES: [1] de Groot et al., 2008 *OAC*, 16(4);436–442 [2] Tudor-Locke et al. 2011 *Inter. J of Beh. Nutr. and Phys Act*, Vol 8(79);1-17 [3] Prince et al., 2008 *IJBNPA*, 5(56);1-24 [4] Lo et al. 2015 *Arthr and Rheum*, Vol 67(11);2897-2904.; [5] Sašek et al., 2021 *J. Clin. Med*, 10(24);5885 [6] Vähä-Ypyä et al., 2015 *Clin Phys Funct Imag*, 35(1); 64-70 [7] Lützner et al., 2014 *CORR*, 472(12); 3933-40 [8] CSEP, "Can 24-Hour Movement Guidelines for Adults aged 65+"

Table 1: Sample population demographics and relationships between average daily step-count, % time spent sedentary and patient characteristics; $\alpha = 0.05$.

n = 21	Mean (SD)	Steps			% Sedentary		
		r	r^2	p	r	r^2	p
Age (years)	69.1 (6.1)						
Average Daily Step Count	6051 (2844)						
Average Daily % Sedentary	78.8 (6.6)						
Sex (M:F)	13:8			0.079			**0.021***
BMI (kg/m^2)	32.8 (7.3)	-0.53	0.28	**0.013***	0.51	0.26	**0.017***
Self-Reported PA (/10)$^+$	4.5 (1.8)	0.54	0.29	**0.011***	-0.54	0.29	**0.012***
Self-Reported Pain (/28)$^{++}$	12.7 (5.3)	0.017	<0.001	0.94	-0.13	0.016	0.58
Mental Health (/24)$^{+++}$	4.8 (4.8)	-0.11	0.012	0.64	0.25	0.061	0.28

$^+$UCLA scale: 0 little to no movement, 10 regular participation in high intensity activities; $^{++}$OKS-PCS: 0 constant severe pain related to knee OA, 28 no pain at all; $^{+++}$PHQ: 0 no signs of poor mental health, 24 severe signs of depression; *$p < 0.05$