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Total joint replacement: A multiple risk factor analysis of physical activity level 1–2 years postoperativelyElizabeth W PAXTON¹, Andy TORRES¹, Rebecca M LOVE¹, Thomas C BARBER², Dhiren S SHETH³, and Maria C S INACIO^{1,4}¹ Surgical Outcomes and Analysis Department, Southern California Permanente Medical Group, San Diego, CA; ² Department of Orthopaedic Surgery, Permanente Medical Group, Oakland, CA; ³ Department of Orthopaedic Surgery, Southern California Permanente Medical Group, Orange County, CA, USA; ⁴ Medicine and Devices Surveillance Centre of Research Excellence, Sansom Institute, School of Pharmacy and Medical Sciences, University of South Australia, Adelaide, SA, Australia.

Correspondence: Liz.W.Paxton@kp.org

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Background and purpose — The effect of total joint arthroplasty (TJA) on physical activity is not fully understood. We investigated the change in physical activity after TJA and patient factors associated with change.**Patients and methods** — Using a total joint replacement registry, primary total hip arthroplasty (THA) patients (n = 5,678) and knee arthroplasty (TKA) patients (n = 11,084) between January 1, 2010 and December 31, 2012 were identified. Median age at THA was 68 and median age at TKA was 67. Change in self-reported physical activity (minutes per week) from before TJA (within 1 year of surgery) to after TJA (1–2 years) was the outcome of interest. Patient demographics and comorbidities were evaluated as risk factors. Multiple linear regression was used.**Results** — Median physical activity before surgery was 50 min/week (IQR: 0–140) for THA patients and 58 (IQR: 3–143) for TKA patients. Median physical activity after surgery was 150 min/week (IQR: 60–280) for both THA patients and TKA patients. Following TJA, 50% of patients met CDC/WHO physical activity guideline criteria. Higher body mass index was associated with lower change in physical activity (THA: –7.1 min/week; TKA: –5.9 min/week). Females had lower change than males (THA: –11 min/week; TKA: –9.1 min/week). In TKA patients, renal failure was associated with lower change (–17 min/week), as were neurological disorders (–30 min/week).**Interpretation** — Self-reported minutes of physical activity increased from before to after TJA, but 50% of TJA patients did not meet recommended physical activity guideline criteria. Higher body mass index, female sex, and specific comorbidities were found to be associated with low change in physical activity. Patient education on the benefits of physical activity should concentrate on these subgroups of patients.

Recognizing benefits for overall health and management of chronic diseases, the Centers for Disease Control and Prevention (CDC) (Pate et al. 1995) and the World Health Organization (WHO) (2010) recommend 150 minutes of moderate activity per week for adults. However, certain patients, such as those with osteoarthritis, may be limited in their physical activity because of pain and stiffness. The purpose of total joint arthroplasty (TJA) is to improve function and reduce pain associated with osteoarthritis, and should therefore allow these patients to increase their physical activity levels after the procedure. However, there have been conflicting results on physical activity levels following TJA (Vogel et al. 2011). While some studies have suggested improved physical activity similar to the levels in non-osteoarthritis matched controls (de Groot et al. 2008, Wagenmakers et al. 2008, Brandes et al. 2011, Tsonga et al. 2011, Lütznier et al. 2014), others have found little or no increase in daily physical activity levels after TJA (de Groot et al. 2008, Harding et al. 2014). Most of these studies that examined physical activity following TJA were based on small sample sizes, were conducted in countries outside the USA, and varied in their physical activity assessment methods, limiting the comparability of the results and the generalizability of the findings to a US population.

In addition to the conflicting findings, changes in physical activity levels after TJA in specific patient groups are not fully understood. While males, younger patients, patients with higher income and education levels, those living with a partner or children, and patients without other lower extremity problems report having higher levels of activity after TJA, specific patient comorbidities have not been thoroughly examined in relation to post-TJA activity levels (Stevens et al. 2007, Wagenmakers et al. 2008, 2011). We therefore evaluated changes in physical activity levels after TJA, determined the

proportion of patients who did not meet CDC recommended physical activity guideline criteria after TJA, and identified patients who were less likely to report increased physical activity levels after TJA.

Patients and methods

Study design, sources of data, and patient sample

Using the Kaiser Permanente Total Joint Replacement Registry (KPTJRR) patients who underwent THA and TKA procedures between January 1, 2010 and December 31, 2012 were included in the study. The KPTJRR covers the population of a large integrated healthcare system composed of over 10 million members in 7 geographical regions of the USA. Briefly, the registry collects intraoperative information on patients who undergo THA and TKA, using paper and electronic forms completed by the operating surgeon. Demographic data, patient characteristics (e.g. body mass index (BMI), diabetes, and physical activity), surgeon information, information about the facility, and outcomes associated with the procedures are collected by the registry using several sources within the system, including the patients' electronic medical records (EMRs), administrative claims data, the Geographically Enriched Member Socio-demographics Database, and membership and mortality files. The electronic data are extracted on a quarterly basis from the healthcare system's EMRs and the paper forms are sent to a data repository for entry and quality control. Voluntary participation in the registry was 95% in 2011 (Paxton et al. 2013).

The study sample included adult patients (≥ 18 years old) with osteoarthritis who underwent primary unilateral THA or TKA, and who did not have a postoperative complication (e.g. infection, deep vein thrombosis, or pulmonary embolisms), revision within 3 years of the index procedure, or termination of membership or death within 2 years of the index procedure. If a patient had bilateral THA or TKA procedures within 3 years of each other, neither procedure was included in the analysis—as this could affect the patient's physical activity level. The study sample included data from 230 surgeons at 36 medical centers of the Southern and Northern California regions covered by the KPTJRR.

Outcome of interest

The outcome of interest in this study was the change in reported physical activity measured in minutes per week up to 1 year before surgery and within 1–2 years after TJA surgery. This information, which is extracted from the EMRs of the integrated healthcare system, was originally introduced to the EMR outpatient encounters "vital signs" recordings in 2009 and is recorded by nursing staff during patient outpatient encounters (Coleman et al. 2012). This information is collected by asking the patients 2 questions: (1) "On average, how many days per week do you engage in moderate to stren-

uous exercise (like a brisk walk)?" for which the response can be 0–7 days; and (2) "On average, how many minutes do you engage in exercise at this level?" for which the response can be in minutes from 10–150 in blocks of 10 minutes, or 150+ if more than 150 per day. This information is recorded in the EMR and used to calculate minutes per week of exercise for the healthcare provider to review during consultation.

This measure has been successfully implemented in the outpatient encounters of this patient population (86% completion rate) (Coleman 2012). When a patient had multiple outpatient encounters and therefore multiple physical activity levels reported before TJA, the average of the minutes per week reported at each visit was used to capture the average activity level. When the patient had multiple postoperative encounters with multiple physical activity measures reported, we chose the maximum level of minutes per week to represent the greatest improvement in activity level during this period.

Exposures of interest

Patient demographic information and clinical information collected by the KPTJRR were evaluated as risk factors for the change in physical activity. Patient characteristics evaluated were age, race (white, hispanic, black, asian, other, and unknown), and sex. Clinical information included BMI and comorbidities. In addition to diabetes, which is identified by the KPTJRR from the KP diabetes registry, all other comorbidities were identified using the Elixhauser comorbidity algorithm (Elixhauser et al. 1998, Quan et al. 2005). The comorbidities evaluated included: congestive heart failure, valvular disease, pulmonary circulation disease, peripheral vascular disease, paralysis, other neurological disorders, chronic pulmonary disease, diabetes without chronic complications, diabetes with chronic complications, hypothyroidism, renal failure, liver disease, peptic ulcer, acquired immune deficiency syndrome, lymphoma, metastatic cancer, solid tumor without metastasis, rheumatoid arthritis, coagulopathy, weight loss, fluid and electrolyte disorders, chronic blood loss anemia, deficiency anemias, alcohol abuse, drug abuse, psychoses, depression, and hypertension.

Statistics

All analyses were procedure-specific (THA and TKA). Physical activity per week, in minutes, was reported as an ordinal variable, with the following groups: 0, 10, 20, 30, 40, 50, 60, 90, 120, and 150 or greater. Multiple linear regression was used to evaluate the effect of the risk factors on the change in physical activity. 2 key assumptions of our multiple linear regression model pertain to the distribution of the residuals, namely normality and constant variance. With respect to normality, a histogram of the residuals and a qq-normal plot indicated only slight deviations from normality. Furthermore, a plot of the residuals against the predicted values demonstrated random scattering about the $y = 0$ line, indicative of meeting the constant variance assumption.

Crude and adjusted (for sex, age, BMI, race, and diabetes status) associations of the risk factors of interest and change in physical activity are presented. Because both individual comorbidity conditions and comorbidity burden were modeled, 2 models were created. Maximum likelihood estimates and p-values are presented. A sensitivity analysis was conducted, by comparing the cases with and without physical activity that fit our study criteria, because out of the sample identified ($n = 27,878$), 11,116 (40%) of the patients did not have physical activity measures for the study periods of interest (change could not be calculated). This was conducted to ensure that our study cohort was representative with respect to physical activity data. Other missing data in our study were excluded from the final models (752 THA patients (2.7%) and 1,678 TKA patients (6.0%) did not have comorbidity data, and 6 TKA patients did not have BMI data). Data were analyzed using SAS version 9.2, and $\alpha = 0.05$ was used as the threshold for statistical significance.

Ethics

This study was approved by the Southern California Kaiser Permanente Institutional Review Board (#5488) prior to its commencement.

Results

Of the 27,878 TJA patients who fulfilled the study criteria, 16,762 (60%) had a physical activity value within a year before the surgery and within 1–2 years after surgery, which could be used for this study. This involved 5,678 THA and 11,084 TKA procedures. Compared to the patients without measures of physical activity, the group included in the final sample was similar with regard to gender, BMI (THA), hypertension, and hypothyroidism—but not with regard to race, peripheral vascular disease, chronic blood loss anemia, and deficiency anemias.

In the sample evaluated, the median age was 67 (IQR: 60–75) for THA patients and 68 (IQR: 62–75) for TKA patients. A higher proportion of patients were female (THA: 59%; TKA: 62%), white (THA: 76%; TKA: 63%), and had a BMI of less than 30 (THA: 62%; TKA: 49%). The prevalence of diabetes was 19% in THA patients and 27% in TKA patients. The most common comorbidities included: hypertension (THA: 52%; TKA: 59%), chronic pulmonary disease (THA: 13%; TKA: 14%), hypothyroidism (THA: 12%; TKA: 13%), and deficiency anemia (THA: 10%; TKA: 10%) (Table 1).

Prior to TJA, the median time of physical activity (in min) per week was 50 (IQR: 0–140) for THA and 58 (IQR: 3–143) for TKA. After TJA, there was an increase in physical activity and the median time of physical activity (in minutes) was 150 (IQR: 60–280) in patients with THA and 150 (IQR: 60–280) in patients with TKA. 50% of both THA and TKA patients met the CDC/WHO physical activity recommendations 1–2

years postoperatively (Table 1). Patients who were hispanics and patients with valvular disease, weight loss, or anemia were among the groups that had the greatest increase in physical activity from before to after surgery.

In models where parameters were adjusted for other covariates, female TKA patients had a lower change in physical activity than male TKA patients (–9.1 min/week, 95% CI: –13 to –4.8; $p = 0.04$). Increasing BMI levels were associated with lower change in physical activity in patients with THAs (–7.1 min/week, 95% CI: –10 to –4.2; $p = 0.02$) and TKAs (–5.9 min/week, 95% CI: –7.9 to –3.9; $p = 0.003$). In models adjusted for other covariates, THA patients with deficiency anemia had greater changes in physical activity (25 min/week, 95% CI: 17–34; $p = 0.004$) and those with psychoses had lower changes in physical activity (–38 min/week, 95% CI: –50 to –27; $p < 0.001$). In TKA patients, those with neurological disorders had a lower change in physical activity (–30 min/week, 95% CI: –41 to –19; $p = 0.006$) while those with chronic blood loss anemia had an increase in physical activity (27 min/week, 95% CI: 17–37; $p = 0.007$) (Tables 2 and 3).

Discussion

Moderate levels of physical activity are considered important for overall health, management of chronic diseases, and reduction of mortality. TJA offers an opportunity for millions of patients with osteoarthritis to have reduced pain, to have improved function, and to ultimately increase their physical activity levels. In this large US study based on an integrated healthcare system, we found that THA and TKA patients reported increased physical activity from a median of 50 and 58 minutes (respectively) per week preoperatively to 150 minutes per week at 1–2 years after surgery. Changes in reported activity levels are most likely related to increased function and reduced pain associated with the surgery, but they could also be related to additional factors such as rehabilitation, patient expectations, and clinician recommendations for postoperative activity levels. Our findings are similar to those from other longitudinal studies that found increases in self-reported physical activity levels based on step activity monitors/accelerometers (de Groot et al. 2008, Brandes et al. 2011, Tsonga et al. 2011, Lütznier et al. 2014) and self-report questionnaires (de Groot et al. 2008, Tsonga et al. 2011, Jones et al. 2012), but they contrast with studies that found no improvement in physical activity based on accelerometer measurement (Vissers et al. 2013, Harding et al. 2014). Differences in findings are most likely related to variations in patient populations, differences in follow-up periods, and the use of different physical activity measures (Paxton et al. 2015). While self-report questionnaires could possibly overestimate physical activity, our findings provide a patient-based outlook regarding activity levels following TJA in a large US cohort, and they indicate that the perceived physical activity of patients improves after TJA.

Table 1. Characteristics of the study sample and change in physical activity from before to after total joint arthroplasty, according to patient characteristics. Physical activity (PA) values are median and IQR minutes per week

	THA				TKA			
	n (%)	PA prior to surgery	PA post to surgery	Change in PA	n (%)	PA prior to surgery	PA post to surgery	Change in PA
Total	5,678	50 (0–140)	150 (60–280)	70 (0–170)	11,084	58 (3–143)	150 (60–280)	76 (0–179)
Sex								
Female	3,323 (59)	41 (0–120)	150 (40–240)	68 (0–156)	6,861 (62)	45 (0–120)	150 (60–240)	74 (0–165)
Male	2,355 (41)	64 (0–173)	180 (60–300)	75 (0–190)	4,223 (38)	80 (15–180)	180 (80–300)	80 (0–198)
Age, median (IQR)	67 (60–75)				68 (62–75)			
Age category								
Age < 55	666 (12)	57 (0–150)	150 (40–300)	60 (0–180)	788 (7)	60 (2–148)	150 (60–270)	76 (0–180)
Age ≥ 55	5,012 (88)	50 (0–140)	150 (60–280)	70 (0–169)	10,296 (93)	57 (3–142)	150 (60–280)	76 (0–178)
BMI, median (IQR) ^a	28 (25–32)				30 (27–34)			
BMI category ^a								
< 30	3,519 (62)	68 (0–165)	180 (60–300)	70 (0–180)	5,393 (49)	75 (15–173)	180 (90–300)	80 (0–180)
≥ 30 and < 35	1,407 (25)	33 (0–120)	150 (30–240)	70 (0–166)	3,361 (30)	50 (0–126)	150 (60–250)	73 (0–178)
≥ 35	752 (13)	17 (0–70)	120 (0–210)	60 (0–150)	2,324 (21)	30 (0–95)	120 (20–210)	66 (0–164)
Race								
White	4,310 (76)	52 (0–150)	150 (60–280)	70 (0–168)	7,001 (63)	63 (4–151)	150 (60–300)	72 (0–175)
Hispanic	586 (10)	34 (0–100)	150 (50–240)	90 (0–180)	2,170 (20)	45 (1–116)	150 (60–270)	83 (0–180)
Black	512 (9)	40 (0–115)	150 (60–290)	77 (0–180)	1,035 (9)	42 (3–108)	150 (60–250)	77 (0–180)
Asian	187 (3)	75 (7–150)	150 (30–300)	50 (0–153)	682 (6)	69 (10–146)	180 (70–280)	75 (0–175)
Other	57 (1)	48 (0–138)	200 (80–360)	120 (14–210)	135 (1)	40 (0–150)	150 (20–270)	80 (0–158)
Unknown	26 (0.5)	52 (8–107)	150 (40–250)	26 (–30–150)	61 (0.6)	40 (0–138)	180 (60–300)	80 (0–180)
Diabetes	1,074 (19)	31 (0–100)	140 (30–240)	70 (0–163)	3,022 (27)	42 (0–120)	140 (60–250)	70 (0–175)
Comorbidity ^a								
Congestive heart failure	129 (2)	10 (0–82)	70 (0–210)	30 (0–167)	260 (2)	34 (0–120)	140 (40–270)	80 (0–194)
Valvular disease	203 (4)	54 (0–140)	150 (30–300)	90 (0–180)	347 (3)	60 (3–152)	160 (70–280)	75 (0–165)
Pulmonary circulation disease	39 (0.7)	15 (0–105)	100 (0–300)	30 (0–210)	59 (0.5)	39 (0–110)	100 (40–250)	56 (0–200)
Peripheral vascular disease	424 (8)	35 (0–135)	140 (0–275)	55 (0–180)	776 (7.0)	45 (1–120)	150 (50–280)	82 (0–177)
Paralysis	24 (0.4)	45 (0–130)	90 (0–225)	0 (–29–115)	58 (0.5)	15 (0–85)	60 (0–210)	35 (0–120)
Other neurological disorders	142 (3)	45 (0–120)	120 (40–210)	60 (0–140)	319 (3)	41 (0–133)	140 (0–210)	50 (0–140)
Chronic pulmonary disease	744 (13)	35 (0–120)	140 (40–260)	70 (0–170)	1,561 (14)	47 (0–120)	150 (50–240)	70 (0–172)
Hypothyroidism	658 (12)	40 (0–121)	150 (20–240)	60 (0–159)	1,398 (13)	52 (4–140)	150 (60–240)	70 (0–160)
Renal failure	486 (9)	23 (0–92)	120 (10–210)	56 (0–144)	1,151 (10)	39 (0–120)	120 (40–210)	61 (0–150)
Liver disease	111 (2)	55 (0–173)	180 (60–360)	80 (0–180)	252 (2)	53 (4–145)	150 (50–240)	63 (0–150)
Peptic ulcer	0 (0)	–	–	–	3 (0.0)	0 (0–70)	70 (0–210)	70 (0–140)
AIDS	8 (0.1)	104 (45–155)	435 (270–735)	280 (150–632)	5 (0.0)	13 (0–316)	450 (450–600)	284 (107–450)
Lymphoma	21 (0.4)	60 (23–150)	180 (70–360)	30 (0–230)	25 (0.2)	35 (17–160)	140 (0–210)	40 (–17–140)
Metastatic cancer	19 (0.3)	98 (20–208)	160 (0–270)	50 (–20–150)	25 (0.2)	20 (0–60)	210 (90–300)	129 (0–240)
Solid tumor w/o metastasis	58 (1)	19 (0–120)	155 (40–360)	120 (0–210)	105 (0.9)	65 (15–130)	150 (90–280)	77 (20–180)
Rheumatoid arthritis	161 (3)	27 (0–110)	120 (10–210)	60 (0–144)	305 (3)	47 (0–120)	150 (70–270)	83 (0–180)
Coagulopathy	109 (2)	63 (0–150)	140 (0–280)	30 (–1–145)	195 (2)	56 (6–120)	120 (20–280)	53 (–10–151)
Weight loss	48 (0.8)	5 (0–62)	145 (15–280)	80 (0–225)	78 (0.7)	47 (8–135)	150 (60–280)	91 (0–210)
Fluid and electrolyte disorders	304 (5)	35 (0–120)	150 (50–275)	83 (0–178)	635 (6)	60 (7–150)	150 (60–280)	80 (0–177)
Chronic blood loss anemia	169 (3)	17 (0–72)	120 (30–240)	90 (0–160)	395 (4)	51 (10–120)	180 (70–300)	98 (1–184)
Deficiency anemias	586 (10)	35 (0–112)	145 (40–250)	79 (0–180)	1,137 (10)	49 (0–125)	150 (60–250)	76 (0–169)
Alcohol abuse	119 (2)	35 (0–119)	150 (20–300)	61 (0–168)	197 (2)	60 (12–160)	160 (60–280)	64 (0–154)
Drug abuse	76 (1)	8 (0–70)	140 (0–275)	70 (0–185)	97 (0.9)	53 (0–148)	150 (20–240)	44 (–1–147)
Psychoses	403 (7)	30 (0–105)	120 (0–210)	48 (0–137)	857 (8)	41 (0–118)	150 (40–240)	70 (0–159)
Depression	259 (5)	30 (0–124)	150 (20–270)	77 (0–188)	561 (5)	43 (0–120)	150 (60–240)	73 (0–179)
Hypertension	2,957 (52)	39 (0–120)	150 (40–250)	70 (0–160)	6,494 (59)	50 (0–135)	150 (60–270)	73 (0–173)

THA: total hip arthroplasty; TKA: total knee arthroplasty; BMI: body mass index; AIDS: acquired immunodeficiency syndrome; PA: physical activity; IQR: interquartile range.

^a Missing data: comorbidity indicators (13.2%, n = 752) in THA cases; BMI (0.1%, n = 6) and comorbidity indicators (15.1%, n = 1,678) in TKA.

Although self-reported activity levels increased in our study from before TJA to after TJA, less than 50% of total joint patients met the CDC/WHO guidelines for weekly recommended physical activity. The proportion of our patients who

Table 2. Risk factors associated with change in physical activity according to multiple linear regression and p-values — total hip arthroplasty

Parameter Level	Crude ^a		Adjusted ^a	
	Est. (95% CI)	p-value	Est. (95% CI)	p-value
Sex				
Male	Ref.	–	Ref.	–
Female	–10 (–15 to –5)	0.06	–11 (–17 to –5)	0.07
Age per 5-year increment	–1.5 (–3 to –0.3)	0.2	–0.7 (–2 to 0.9)	0.7
BMI per 5-unit increment	–4.2 (–7 to –2)	0.09	–7.1 (–10 to –4)	0.02
Race				
White	Ref.	–	Ref.	–
Hispanic	18 (9 to 27)	0.04	18 (8 to 27)	0.06
Black	15 (6 to 24)	0.1	13 (3 to 23)	0.2
Asian	–20 (–34 to –5)	0.2	–27 (–42 to –11)	0.09
Other	57 (30 to 83)	0.03	73 (43 to 103)	0.02
Unknown	–8.5 (–47 to 30)	0.8	–52 (–127 to 23)	0.5
Diabetes	6.6 (–0.1 to 13)	0.3	11 (3 to 19)	0.2
Comorbidity				
Congestive heart failure	6.5 (–11 to 24)	0.7	7.6 (–11 to 26)	0.7
Valvular disease	–3.7 (–18 to 11)	0.8	–3.8 (–19 to 11)	0.8
Pulmonary circulation disease	13 (–19 to 45)	0.7	21 (–13 to 54)	0.5
Peripheral vascular disease	–9.2 (–19 to 1)	0.4	–9.9 (–20 to 0.6)	0.3
Paralysis	–60 (–19 to 101)	0.1	–58 (–99 to –17)	0.2
Other neurological disorders	–27 (–44 to –10)	0.1	–23 (–41 to –6)	0.2
Chronic pulmonary disease	2.5 (–6 to 11)	0.8	6.7 (–1 to 15)	0.4
Hypothyroidism	–11 (–19 to –2)	0.2	–4.4 (–13 to 4)	0.6
Renal failure	–17 (–27 to –8)	0.08	–14 (–24 to –4)	0.1
Liver disease	21 (2–40)	0.3	16 (–4 to 35)	0.4
Peptic ulcer	–	–	–	–
AIDS	238 (166 to 310)	0.001	224 (152 to 297)	0.002
Lymphoma	29 (–14 to 73)	0.5	15 (–29 to 58)	0.7
Metastatic cancer	–49 (–95 to –3)	0.3	–46 (–92 to –0.6)	0.3
Solid tumor w/o metastasis	54 (27 to 80)	0.04	52 (25 to 78)	0.05
Rheumatoid arthritis	3.4 (–13 to 20)	0.8	5 (–11 to 21)	0.8
Coagulopathy	–10 (–29 to 9)	0.6	–16 (–36 to 3)	0.4
Weight loss	36 (7 to 64)	0.2	27 (–2 to 56)	0.4
Fluid and electrolyte disorders	8.1 (–4 to 20)	0.5	12 (0.2 to 24)	0.3
Chronic blood loss anemia	5.7 (–10 to 21)	0.7	8 (–8 to 24)	0.6
Deficiency anemias	24 (15 to 32)	0.01	25 (17 to 34)	0.004
Alcohol abuse	13. (–5 to 32)	0.5	16 (–3 to 35)	0.4
Drug abuse	6.7 (–16 to 30)	0.8	4.2 (–19 to 28)	0.9
Psychoses	–40 (–52 to –28)	0.001	–38 (–50 to –27)	0.001
Depression	7.2 (–5 to 20)	0.6	4.9 (–8 to 18)	0.7
Hypertension	–8.3 (–14 to –3)	0.2	–6 (–12 to 0.4)	0.3

BMI: body mass index; AIDS: acquired immunodeficiency syndrome.
^a Crude models, n = 5,678; adjusted model, n = 4,926, due to n = 752 (13.2%) missing comorbidity data.

met these criteria was similar to that in other previously published TJA cohorts (Wagenmakers et al. 2008, 2011, Kersten et al. 2012) and US norms based on self-reported measures (Coleman et al. 2012). However, studies based on accelerometer findings have suggested that less than 20% of TJA patients meet the recommended guidelines (Harding et al. 2014, Lüt-

zner et al. 2014). Despite differences in proportions of patients, both self-reporting-based studies and accelerometer studies highlight that a large proportion of patients do not meet recommended physical activity guidelines, indicating that there is a need for clinicians and healthcare workers to emphasize the importance of physical activity and recommended weekly levels to all patients, including those who undergo TJA.

In addition to evaluating the change in activity reported and determining the percentage of patients who met the CDC/WHO activity guidelines, we also identified specific subgroups of patients who would be less likely to increase their physical activity levels following total joint replacement. Women, obese patients, and those with specific comorbidities (psychosis, renal failure, neurological disorders) were less likely to increase their physical activity time following TJA. Our findings of less improvement in female patients, those with higher BMI, and those with comorbidities confirm the findings of other studies (Stevens et al. 2007, Wagenmakers et al. 2011). To our knowledge, our study findings of white race, psychosis, renal failure, and neurological disorders being associated with limited increase in physical activity levels are the first to be described. The identification of subgroups of patients who are at risk of having lower physical activity levels after TJA provides an opportunity to educate such patients on the health-enhancing benefits of physical activity, and to help them identify and resolve possible hindrances to increasing their physical activity following TJA.

The strengths of our study included the large sample size, the data from an integrated healthcare system, and the detailed information available on patients in our EMR system. Limitations of our study included the reliance on patient-reported physical activity time per week, the lack of evaluation of intensity levels of physical activity, and the availability of physical activity data on only a subset of the patients.

In conclusion, the findings of this study can be used to counsel patients, to establish physical activity expectations, and to address subgroups of patients who are less likely to increase their physical activity following total joint replacement. Previous studies have indicated discrepancies between patient expectations and actual physical activity levels following TJA (Jones et al. 2012), emphasizing the need for patient-specific information.

All the authors contributed to the study design and contributed substantially to collecting the data, to interpreting the results, to drafting the article, and to revising it for important intellectual content. AT conducted the statistical analysis.

Table 3. Risk factors associated with change in physical activity according to multiple linear regression and p-values of total knee arthroplasty

Parameter Level	Crude ^a Est. (95% CI)	p-value	Adjusted ^a Est. (95% CI)	p-value
Sex				
Male	Ref.	–	Ref.	–
Female	–9.5 (–13 to –6)	0.01	–9.1 (–13 to –5)	0.04
Age per 5-year increment	–0.9 (–2 to 0.1)	0.36	–2.3 (–4 to –1)	0.06
BMI per 5-unit increment	–3.2 (–5 to –2)	0.05	–5.9 (–8 to –4)	0.003
Race				
White	Ref.	–	Ref.	–
Hispanic	13 (9 to 18)	0.005	16 (11 to 22)	0.002
Black	9.5 (3 to 16)	0.1	14 (7 to 21)	0.04
Asian	–6.6 (–14 to 1)	0.4	–8.9 (–17 to –0.7)	0.3
Other	–7.2 (–38 to 24)	0.8	11 (–8 to 30)	0.6
Unknown	15 (–10 to 40)	0.5	–59 (–104 to –13)	0.2
Diabetes	2.6 (–2 to 7)	0.5	3.4 (–1 to 8)	0.4
Comorbidity				
Congestive heart failure	5.8 (–6 to 18)	0.6	10 (–2 to 22)	0.4
Valvular disease	–3.6 (–14 to 7)	0.7	–0.2 (–13 to 12)	0.9
Pulmonary circulation disease	3.1 (–22 to 28)	0.9	8.1 (–18 to 34)	0.8
Peripheral vascular disease	9.7 (3–17)	0.2	12 (5 to 20)	0.1
Paralysis	2.8 (–23 to 28)	0.9	6.5 (–19 to 32)	0.8
Other neurological disorders	–31 (–42 to –20)	0.004	–30 (–41 to –19)	0.006
Chronic pulmonary disease	–2 (–7 to 3)	0.7	2 (–4 to 7)	0.7
Hypothyroidism	–9 (–15 to –4)	0.1	–3.7 (–9 to 2)	0.5
Renal failure	–17 (–23 to –11)	0.005	–17 (–23 to –10)	0.009
Liver disease	–15 (–27 to –3)	0.2	–17 (–29 to –4)	0.2
Peptic ulcer	–33 (–144 to 78)	0.8	–37 (–148 to 75)	0.7
AIDS	204 (117 to 290)	0.02	201 (287 to 114)	0.02
Lymphoma	25 (–13 to 64)	0.5	26 (–13 to 64)	0.5
Metastatic cancer	70 (32 to 109)	0.07	74 (34 to 112)	0.06
Solid tumor w/o metastasis	4 (–15 to 23)	0.8	4.1 (–15 to 23)	0.8
Rheumatoid arthritis	–2.6 (–14 to 9)	0.8	–1.1 (–13 to 10)	0.9
Coagulopathy	–12 (–26 to 2)	0.4	–12 (–26 to 2)	0.4
Weight loss	29 (7 to 51)	0.2	32 (10 to 54)	0.2
Fluid and electrolyte disorders	0.2 (–6 to 7)	0.9	0.6 (–8 to 9)	0.9
Chronic blood loss anemia	25 (15 to 35)	0.01	27 (17 to 37)	0.007
Deficiency anemias	2.4 (–4 to 9)	0.7	2.9 (–3 to 9)	0.7
Alcohol abuse	–10 (–24 to 4)	0.5	–8.9 (–23 to 5)	0.5
Drug abuse	–29 (–48 to –9)	0.2	–30 (–50 to –10)	0.1
Psychoses	–6.9 (–14 to 0.0)	0.3	–3.7 (–11 to 3)	0.6
Depression	–3.7 (–12 to 5)	0.7	–2.4 (–11 to 6)	0.8
Hypertension	–1.7 (–6 to 3)	0.7	2.2 (–2 to 7)	0.6

BMI: body mass index; AIDS: acquired immunodeficiency syndrome.

^a Crude models, n = 11,084; adjusted model, n = 9,402 due to n = 1,682 (15.1%) missing comorbidity data and n = 6 (0.1%) missing BMI data.

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