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Relationship of Meeting Physical Activity Guidelines with Health-Related Utility

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Abstract

Objective—Health-related utility measures overall health status and quality of life and is commonly incorporated into cost-effectiveness analyses. This study investigates whether attainment of federal physical activity guidelines translates into better health-related utility in adults with or at risk for knee osteoarthritis (OA).

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Methods—Cross-sectional data from 1908 adults with or at risk for knee OA participating in the accelerometer ancillary study of the Osteoarthritis Initiative (OAI) were assessed. Physical activity was measured using 7 days of accelerometer monitoring and was classified as 1) Meeting Guidelines (≥150 bouted moderate-to-vigorous [MV] minutes per week); 2) Insufficiently Active (≥1 MV bout[s] per week but below guidelines); or 3) Inactive (zero MV bouts per week). A Short Form 6D (SF6-D) health-related utility score was derived from patient-reported health status. Relationship of physical activity levels to median health-related utility adjusted for socioeconomic and health factors was tested using quantile regression.

Results—Only 13% of participants met physical activity guidelines; 45% were inactive. Relative to the Inactive, median health-related utility scores were significantly greater for the Meeting Guidelines (0.063; confidence interval [CI] 0.055–0.071) and Insufficiently Active (0.059; CI 0.054–0.064) groups. These differences showed a statistically significant linear trend and strong cross-sectional relationship with physical activity level even after adjusting for socioeconomic and health factors.

Conclusions—We found a significant positive relationship between physical activity level and health-related utility. Interventions that encourage adults, including persons with knee OA, to increase physical activity even if recommended levels are not attained may improve their quality of life.

INTRODUCTION

New healthcare challenges fueled by the aging population and obesity epidemic are on the horizon. By 2030, one in five people living in the United States (US) will be over the age of 65 and one in three adults will be obese (1). A significant and sustained increase in arthritis-associated disability is anticipated in the US largely due to this oncoming wave of aging and obesity. Nearly 50% of all adults and two-thirds of obese adults are likely to develop symptomatic knee osteoarthritis (OA) at some point in their lives (2–3). Approximately 40 million Americans are currently living with OA, and this number is expected to increase by 50% over the next decade (4). OA affecting the knee is a primary cause of disability (4–6) and jeopardizes a person's ability to live independently (7–10). Disability due to arthritis is costly to society, not only increasing health care costs, but also elevating risks of hospitalization, institutionalization, and mortality (6, 11–12).

Engaging in physical activity promotes arthritis-specific health benefits that include reduced disability, depression, pain, and fatigue (13–20), in addition to general health benefits (21). Since physical activity is critical to attaining optimal health outcomes, the US Department of Health and Human Services (DHHS) developed guidelines in 2008 recommending that adults, including those with arthritis, engage in at least 150 minutes per week of moderate-to-vigorous (MV) activity done in sessions lasting at least 10 minutes (22).

Although the health benefits of physical activity have been well documented, the value and fiscal viability of physical activity programs that use the DHHS Physical Activity Guidelines as goals need to be evaluated by cost-effectiveness analyses. Health-related utility is an entity developed for measuring overall health status and health-related quality of life, which is a standard measure of cost-effectiveness. This study investigated differences in

health-related utility associated with physical activity level and guideline attainment in adults with or at risk for radiographic knee OA. Specifically, we evaluated the difference in health-related utility among three activity groups - inactive individuals participating in no sessions of MV activity, insufficiently active individuals participating in MV activities but not meeting federal guidelines, and active individuals meeting federal guidelines.

METHODS

Study Sample

This study used cross-sectional data from participants of the accelerometer ancillary study of the Osteoarthritis Initiative (OAI) conducted at the OAI's 48-month follow-up. The OAI is a multi-center prospective study investigating risk factors and biomarkers for the progression and/or onset of knee OA (see http://www.oai.ucsf.edu/datarelease/About.asp). At enrollment, the OAI recruited 4796 men and women aged 45–79 with or at higher risk for developing symptomatic, radiographic knee OA (Figure 1). Knee OA risk factors considered include age, weight, prior knee injury, knee surgery, family history of total knee replacement for OA, Heberden's nodes, and repetitive knee bending (23). The OAI excluded participants with rheumatoid or inflammatory arthritis, severe joint space narrowing in both knees or unilateral total knee replacement and severe joint space narrowing in the other knee, bilateral total knee replacement or plans to have bilateral knee replacement in the next 3 years, inability to undergo a 3.0T MRI exam of the knee because of contraindications or inability to fit in the scanner or in the knee coil, positive pregnancy test, inability to provide a blood sample for any reason, use of ambulatory aides other than a single straight cane for more than 50% of the time in ambulation, comorbid conditions that might interfere with the ability to participate in a 4-year study, and current participation in a double-blind randomized trial. Knee radiographs were acquired annually using a "fixed-flexion" knee radiography protocol (24), including bilateral, standing, posteroanterior knee films with knees flexed to 20–30° and feet internally rotated 10° using a plexiglass positioning frame. Longitudinal radiographic changes were assessed by a single vendor (25).

Baseline for the OAI accelerometer ancillary study was the OAI 48-month follow-up visit. Recruitment required a scheduled OAI 48-month follow-up visit between August 2008 and July 2010. A total of 2127 persons consented to participate in accelerometer monitoring, representing 78.4% of the 2712 total eligible participants. Another 1543 OAI participants had follow-up visits that preceded the physical activity study start date and 541 were deceased, did not return at 48 months, or withdrew from the OAI study. This report was based on the 1908 persons with 4–7 valid days of physical activity monitoring and health-related utility data at 48-month follow-up. Accelerometer data were merged with the OAI public data containing information on participant characteristics.

Outcome Measure: Health-related Utility

Health-related utility was measured using the Short Form 6D (SF-6D) utility score, a preference-based single index measure for health. Based on scoring algorithms developed by Brazier et al., the SF-6D utility is converted from the Short Form 12 (SF-12) using the preference weights estimated from a random sample of the general adult population (26–27).

More specifically, the SF-6D measures the following six health domains: physical functioning, role limitations, social functioning, pain, mental health, and vitality. For example, the pain domain varies from having no pain to having pain that interferes with work (both outside the home and housework) extremely. The SF-6D utility scores range from 0.0 (death, worst health state) to 1.0 (full health, best health state), with estimated minimally important difference (MID) of 0.027 (standard deviation 0.028) (28). In this study, the OAI 48-month data on SF-12 were used to create SF-6D utility scores. An online program (http://www.shef.ac.uk/scharr/sections/heds/mvh/sf-6d) was used to convert SF-12 to SF-6D.

Physical Activity Measures

Physical activity was measured at baseline (OAI 48-month visit) using a GT1M Actigraph accelerometer (Actigraph; Pensacola, FL), a small uniaxial accelerometer that measures vertical acceleration and deceleration (29). The accuracy (30) and test-retest reliability (31) of Actigraph accelerometers under field conditions have been established in many populations including persons with OA (32). Participants were instructed to wear the accelerometer on a belt at the natural waistline on the right hip in line with the right axilla upon arising in the morning and continuously until retiring at night, except during water activities, for seven consecutive days. A daily log was maintained by the participants to record time spent in water and cycling activities to estimate the amount of physical activity not captured by accelerometers. Skipped days reported on the log were excluded from the analysis.

Accelerometer output is an activity count, which is the sum of the number of accelerations measured over a minute weighted by the magnitude of each measured acceleration. Accelerometer data were analytically filtered using methodology validated in patients with rheumatic disease (33–34). Non-wear periods were defined as ≥90 minutes with zero activity counts (34). A valid day of monitoring was identified by recording evidence of 10 or more wear hours per day (35). To provide reliable physical activity estimates, we restricted analyses to participants with 4–7 days of valid accelerometer monitoring (35).

Daily minutes of MV physical activity occurring in bouts were calculated. A bout was defined as 10 or more consecutive minutes above the 2020 count threshold, with allowance for interruptions of up to 2 minutes below threshold, consistent with National Cancer Institute (NCI) methodology (35). Weekly totals were summed from the daily totals for persons with 7 valid days of monitoring or estimated as 7 times the average daily total for persons with 4 to 6 valid days of monitoring. Each person was classified into one of three physical activity groups according to the 2008 US DHHS physical activity guidelines: Meeting Guidelines (≥150 bouted MV activity minutes per week), Insufficiently Active (one or more MV activity bout[s] per week but below guideline), or Inactive (zero MV activity bouts per week) (36).

Covariates

Socioeconomic factors measured at the OAI baseline included ethnicity, age, gender, education, and income. Ethnicity classification was based on self-report. Health factors

included general health and knee specific factors. Body mass index (BMI) was calculated from measured height and weight (kg/m^2). Participants were classified as normal weight (BMI 18.5–24.9), overweight (BMI 25.0–29.9), or obese (BMI ≥30). Presence of comorbidities was defined by a score > 0 from a modified Charlson comorbidity index (37). Evidence of depressive symptoms was based on a score ≥16 from the 20 item Center for Epidemiological Studies Depression (CESD) scale (38). Presence of radiographic knee OA was defined by a Kellgren-Lawrence (KL) grade ≥2 in at least one knee at the 48-month or an earlier visit. Person-level knee pain was evaluated using the highest Western Ontario and McMaster University OA Index (WOMAC) score of each knee (range = 0–20, with higher numbers representing worse symptoms). A positive response to the question, "Did you have pain, aching, or stiffness on most days of a month during the past year?" was used to ascertain presence of chronic knee symptoms. Prior knee injury severe enough to limit ability to walk for at least two days was based on self-report. Health factors missing at the 48-month visit were substituted by data from the most recent OAI annual visit.

Statistical Analysis

Descriptive analyses of characteristics were presented by physical activity level. Univariate analyses of baseline trend effects were evaluated by a Mantel Haenszel test for ordinal variables, chi-square test for nominal variables, and analysis of variance for continuous variables.

Differences in median health-related utility associated with physical activity levels were tested by quantile regression analyses, due to asymmetrically distributed outcomes in this sample. Quantile regression is robust to outliers and does not require assumptions regarding the underlining distribution of the outcome to obtain valid inference tests. Analyses controlled for socioeconomic and health factors. Stratified analyses were performed in those with and without radiographic knee OA. Analyses were performed using SAS software version 9.3. Statistical testing was conducted at a nominal 5% alpha significance level.

RESULTS

Of the 2127 persons who consented to participate in accelerometer monitoring, 219 (10.3%) were excluded from the analysis (199 due to fewer than 4 valid days of physical activity monitoring, and 20 due to missing 48-month SF-12 utility score), leaving 1908 available for analysis. This analytical sample included 1154 with radiographic knee OA in at least one knee and 754 without radiographic knee OA (Figure 1).

Baseline characteristics for each physical activity group are presented in Table 1. Of the 1908 participants, only 13% met the DHHS physical activity guidelines; almost half (45%) were inactive, and the remainder (42%) were insufficiently active. Compared to the more active groups, the Inactive group was more likely to be older, female, ethnically nonwhite, and have lower income and education level. The Meeting Guidelines group was more likely to have lower frequencies of obesity, depression, smoking, hip pain, ankle pain, and other medical comorbidities. The frequency of radiographic knee OA was significantly higher among the Inactive group (64.8%) compared to the Insufficiently Active (58.0%) and the Meeting Guidelines (53.7%) groups. Knee pain and symptoms were present in all groups;

however they were significantly less common in the Meeting Guidelines group. Only 26.8% of the Meeting Guidelines group reported chronic knee symptoms compared to 40.4% of the Insufficiently Active and 42.4% of the Inactive groups.

Higher health-related utility scores were more frequently found among the Meeting Guidelines group (median =0.86) followed by the Insufficiently Active group (median =0.86), and lastly the Inactive group (median =0.80). Figure 2 shows the cumulative frequency curves of health-related utility stratified by activity level. Each point on the graph represents the percentage (vertical axis) of participants within that activity group with a health-related utility score equal to or higher than the value on the x-axis. Notably, the curves in Figure 2 are distinctly separated for a broad range of health-related utility scores, indicating a positive graded relationship between health-related utility and physical activity level. For example, while 0.80 represents the median utility of the Inactive group (vertical line), about 60% of the Insufficiently Active and 70% of the Meeting Guidelines group had a health-related utility score above this value. This demonstrated that adults meeting physical activity guidelines or even those engaged in insufficient physical activity had better health-related utility than inactive individuals.

Table 2 presents the differences in health-related utility between physical activity levels adjusting for socioeconomic and health factors. In the analysis of the full cohort, the median health-related utility when compared to the Inactive group was 0.059 units higher in the Insufficiently Active group and 0.063 units higher in the Meeting Guidelines group. This difference represented a statistically significant increasing trend that persisted in multivariable models controlling for socioeconomic and health factors. Similarly, stratified analyses in participants both with and without radiographic knee OA demonstrated a statistically significant positive graded relationship between physical activity level and median health-related utility score. It is important to note that in all of the analyses, even those participants whose MV physical activity was insufficient to meet guidelines nonetheless had significantly greater health-related utility than those in the Inactive group.

DISCUSSION

Despite known benefits of physical activity, the vast majority of US adults fail to meet federal activity guidelines (35, 39–40). In this sample of adults with or at risk for knee OA, 87% did not meet federal guidelines. We demonstrated significantly better health-related utility scores not only among persons who attained physical activity guidelines, but also those who did some MV activity although below guideline recommendations when compared to the Inactive group. This statistically significant linear trend between increased activity level and higher health-related utility persisted after adjusting for socioeconomic and health factors. It is arguable that because health factors are intrinsic to the measure of health-related utility, controlling for them in the multivariate model may be an over-adjustment. If so, the actual difference in health-related utility scores may be even more pronounced than the reported results. However, we took the conservative approach of adjusting for health factors because they may also influence physical activity.

A large body of literature exists on the beneficial relationships between physical activity and health outcomes including reduced risk of cardiovascular disease and early mortality as well as maintenance of functional status (41–44). Beneficial effects of physical activity on health outcomes have been described in the general adult population as well as in patients with or at risk for osteoarthritis (41, 45). However, few studies specifically examined physical activity in relation to cost-effectiveness or quality of life outcomes. Our findings strengthen the case for public health interventions to increase physical activity by examining its relationship with health-related utility.

A similar but smaller study on physical activity and health-related utility was conducted by Manheim and colleagues (46). In that study, 142 knee OA participants were divided into tertiles by accelerometer-measured physical activity levels. Higher health-related utility scores were found in the most active group compared to the least active group. However, there was no significant difference between the most active and the middle tertiles. In comparison to the Manheim study, we used the DHHS physical activity guideline categories as objective benchmarks to define activity groups. We not only confirmed the Manheim findings, but we also demonstrated a graded increase in health-related utility with higher levels of physical activity. Furthermore, the differences observed were clinically significant. Those differences (Meeting Guidelines versus Inactive: 0.063; Insufficiently Active versus Inactive: 0.059) exceeded the minimally important difference SF-6D health-related utility benchmark of 0.027 (28). Lastly, our study included patients without radiographic knee OA (KL grade <2) who were at risk for developing it. Our results thus extend Manheim findings to the at-risk population.

Several public health implications can be drawn from our findings. First, we showed that meeting DHHS physical activity guidelines is associated with better health-related utility. Meeting these guidelines may be a challenging goal for some, but evidence that any effort to increase physical activity level may result in additional benefit is encouraging to both the clinician and patient. Second, our findings support interventions to increase physical activity even when recommended level is not fully attained because participants with insufficient activity still had significantly greater health-related utility than the inactive group. Studies examining factors associated with physical inactivity (47–48) have identified socioeconomic factors, obesity, quality of diet, severe pain, and severe dysfunction as barriers, and these will need to be better defined in future studies and should be considered in designing interventions that target arthritis populations with low physical activity levels.

Strengths of our study include the large sample size, objective measurement of physical activity by accelerometer monitoring, and assessment of physical activity using the benchmark DHHS physical activity guidelines. However, several limitations should be considered. Causation cannot be inferred from these cross-sectional data. Also participants in the accelerometer study within the OAI are not a probability sample, and the generalizability merits consideration.

In conclusion, our study of more than 1900 participants with or at risk for knee OA showed a strong relationship between greater physical activity and better health-related utility. Our results lend support to the health benefits of current physical activity guidelines and provide

evidence for increased physical activity even when recommended levels are not fully achieved.

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Significance and Innovations

- We examined the relationship between meeting federal guidelines for physical activity and health-related utility in a large sample of patients with or at risk for knee osteoarthritis.
- Physical activity meeting guidelines was associated with significantly higher health-related utility, and the relationship remained strong after adjusting for covariates. Results were similar for participants stratified by the presence of knee osteoarthritis.
- Even the Insufficiently Active had significantly better health-related utility compare to the Inactive. Therefore, our study supports intensified public health interventions to increase physical activity among adults even if recommended levels are not fully attained.

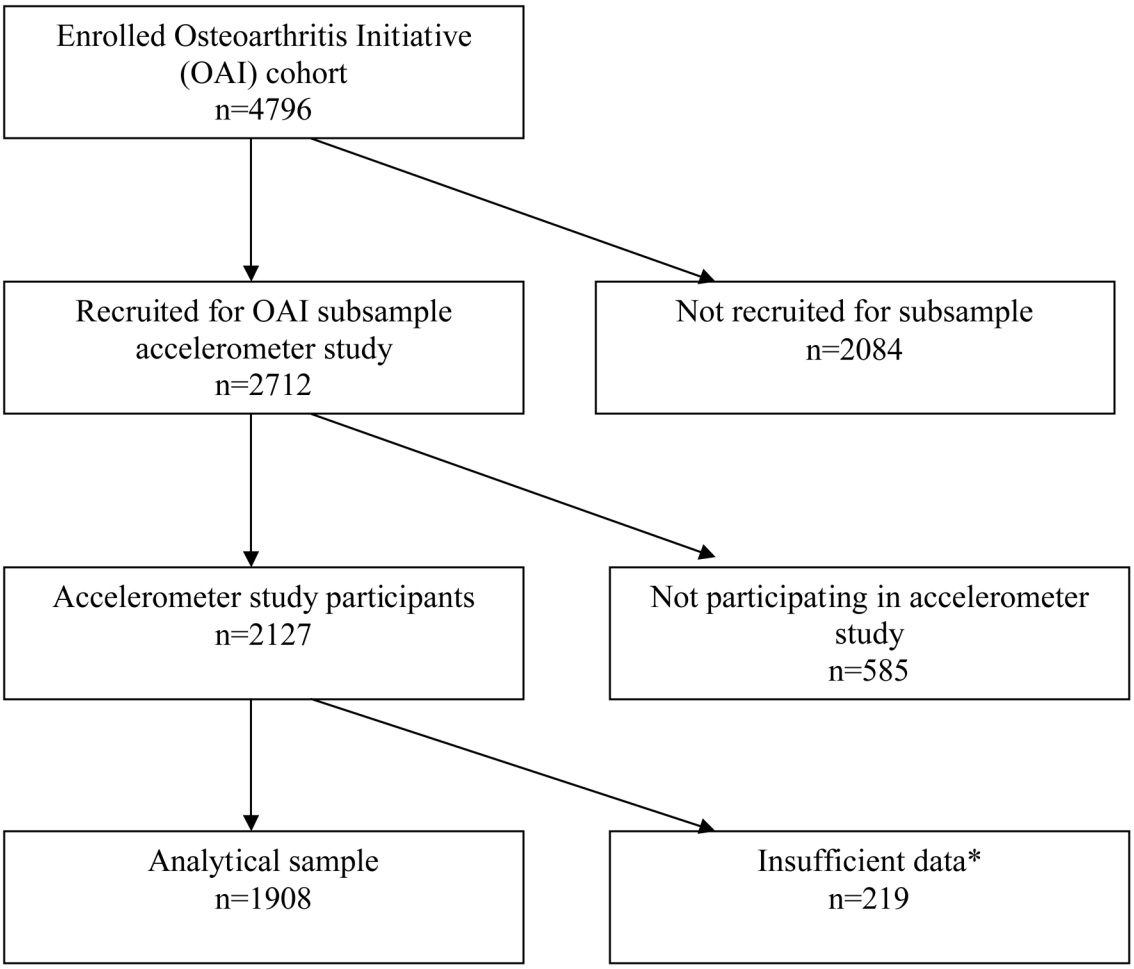

Figure 1.
Flow chart of analytical sample.
*19 had missing SF-12 utility score, and 200 had <4 valid days of accelerometer monitoring.

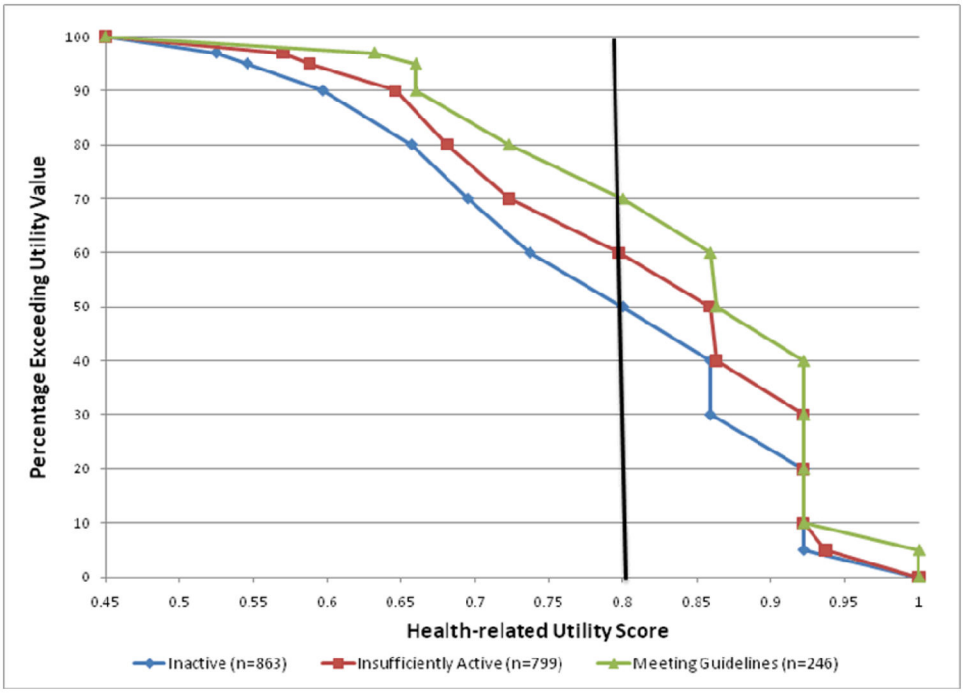

Figure 2.
Health related utility distribution by physical activity groups (n=1908)

Table 1

Characteristics of adults (n=1908) participating in accelerometer monitoring by physical activity level

	Meeting Guidelines [a] (n=246) %	Insufficiently Active (n=799) %	Inactive (n=863) %	p-value [b]
Socioeconomics				
Age in years:				
≤54	18.7	17.3	9.9	<.001
55–64	43.5	40.7	27.9	
≥65	37.8	42.1	62.2	
Female	39.8	50.3	63.9	<.001
Nonwhite	4.2	16.1	20.4	<.001
Education ≤High school	6.5	90.7	81.2	<.001
Income < $50,000	21.5	28.3	47.5	<.001
Health Factors				
Body Mass Index				
<25	41.1	26.5	20.3	<.001
25–29.9	42.3	41.6	36.5	
≥30	16.7	32.9	43.2	
Medical Comorbidities [c]	18.3	24.9	37.5	<.001
Depressive Symptoms [d]	4.9	11.4	13.8	<.001
Current Smoker	1.2	3.4	5.2	0.003
Hip pain	48.8	54.1	56.9	0.025
Ankle pain	4.9	8.9	12.8	<.001
Foot pain	8.1	10.0	12.4	0.033
Radiographic Knee OA	53.7	58.0	64.8	<.001
Knee pain [e]	52.4	63.6	69.0	<.001
Knee Symptoms [f]	26.8	40.4	42.4	<.001
Prior Knee Injury	57.7	53.4	45.0	<.001

[a] US DHHS 2008 physical activity guidelines

[b] Mantel-Haenzel chi-square test for trend (1 d.f.) except for race and gender comparisons, which used chi-square test for overall differences

[c] Charlson comorbidity score >0

[d] CESD score ≥16

[e] WOMAC pain score >0 in one or both knees

[f] Knee symptoms based on report of pain, aching, or stiffness most days of the month during the past year

Table 2

Differences in median health-related utility among physical activity groups.

Sample	Adjustment Factors	Difference [a] Meeting Guidelines vs. Inactive (95% CI)	Difference [a] Insufficiently Active vs. Inactive (95% CI)	p-value [b] (trend)
Full Cohort (n=1908)	Unadjusted Difference	0.063 (0.055, 0.071)	0.059 (0.054, 0.064)	<.001
	Socioeconomics (SES) [c]	0.063 (0.049, 0.077)	0.034 (0.024, 0.043)	<.001
	SES+ Health Factors [d]	0.042 (0.024, 0.059)	0.015 (0.004, 0.027)	<.001
Participants with knee OA (n=1154)	Unadjusted Difference	0.063 (0.052, 0.074)	0.056 (0.048, 0.064)	<.001
	SES [c]	0.046 (0.013, 0.078)	0.024 (0.003, 0.045)	0.002
	SES+ Health Factors [d]	0.030 (0.000, 0.060)	0.008 (−0.011, 0.027)	0.046
Participants without knee OA (n=754)	Unadjusted Difference	0.063 (0.056, 0.070)	0.059 (0.054, 0.064)	<.001
	SES [c]	0.063 (0.015, 0.111)	0.028 (−0.008, 0.064)	0.016
	SES+ Health Factors [d]	0.039 (0.010, 0.068)	0.018 (−0.003, 0.038)	0.004

[a] Difference in median health-related utility compared to the Inactive group from quantile regression

[b] Test of linear trend of median health-related utility across physical activity groups from quantile regression

[c] Socioeconomic factors included age, gender, ethnicity, income, and education.

[d] Health factors included BMI, medical comorbidities, depressive symptom, smoking, hip pain, ankle pain, foot pain, KL grade, WOMAC knee pain, knee symptoms, and prior knee injury.