

Association of Accelerometer-Measured Moderate-to-Vigorous Physical Activity with Knee/Hip Osteoarthritis Across Body Mass Index Categories

Che Zheng

Shanghai Sixth People's Hospital

Jiewei Chen

Shanghai Sixth People's Hospital

Chen Zhu

China Agricultural University

Kai Li

Donghua University

Ping Li

Donghua University

Mengxin Xue

Shanghai Sixth People's Hospital

Jianzheng Zhang

Chinese PLA General Hospital

Qiang Tong

Beijing Jishuitan Hospital

Dajiang Du

dudajiang@sjtu.edu.cn

Shanghai Sixth People's Hospital

Research Article

Keywords: Accelerometer, Moderate-to-Vigorous Physical Activity, Knee Osteoarthritis, Hip Osteoarthritis, Body Mass Index

Posted Date: October 6th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11019327/v1>

License: © ⓘ This work is licensed under a Creative Commons Attribution 4.0 International License. [Read Full License](#)

Additional Declarations: No competing interests reported.

Abstract

Aims

The effect of moderate-to-vigorous physical activity (MVPA) on knee/hip osteoarthritis (OA) remains inconclusive. We aimed to examine the association of accelerometer-measured MVPA and different MVPA patterns with OA.

Methods

We performed a prospective cohort study of 85,196 individuals from the UK Biobank. Participants were grouped according to BMI. MVPA were measured by wrist-worn accelerometers over a 7-day period. Restricted cubic spline (RCS) was used to evaluate dose-response associations between MVPA and OA. Based on RCS curves, intensity of MVPA were categorized as low, moderate, and high levels. Light physical activity (LPA) was also categorized into three levels for joint association analysis. Individuals achieving $\geq 50\%$ of MVPA within 1–2 days were defined as weekend warriors (WW).

Results

During a median follow-up of 10.11 years, 5,017 knee/hip OA cases were identified. Among overweight and obese participants, MVPA showed a U-shaped association with knee/hip OA; among normal-weight and underweight participants, a J-shaped association was observed. In overweight and obese participants, moderate MVPA level was associated with the lowest OA risk compared with low and high levels. In underweight and normal-weight participants, low, moderate, and high MVPA levels showed comparable OA risk. The joint association analysis showed that the combination of moderate MVPA and moderate LPA conferred the lowest OA risk in overweight and obese participants, while in underweight and normal-weight participants, the combination of low MVPA and moderate LPA was associated with the lowest OA risk. At the same MVPA level, there was no significant difference in OA risk between the WW pattern and the regular pattern.

Conclusions

Among underweight and normal-weight individuals, OA risk gradually increased with higher MVPA levels. Moderate MVPA is recommended for overweight/obese individuals. Adding moderate LPA further reduces OA risk. Both WW and regular patterns are acceptable.

Introduction

Knee/hip osteoarthritis (OA) is a leading cause of physical disability in older adults [1]. Over 300 million people are affected globally [2], with OA-related disability rising 34% from 1990 to 2015 [3]. OA causes joint pain, stiffness, swelling, and progressive loss of function, imposing significant health and economic burdens [4]. While risk factors like age, sex, obesity, injury, and osteoporosis are well-studied [5], modifiable factors for prevention remain a priority.

Physical activity (PA) is a crucial modifiable lifestyle, and guidelines from the World Health Organization and American Heart Association recommend 150 min or more of moderate-to-vigorous physical activity (MVPA) per week. Many studies have confirmed that MVPA ≥ 150 minutes per week can reduce the incidence of many major diseases, including cardiovascular diseases [6], diabetes [7], and mortality [8]. However, the association between physical activity and hip/knee OA remains largely inconclusive. Specifically, high level of physical activity can raise the risk for knee arthroplasty [9], while another study observed beneficial effects of vigorous activity on knee articular cartilage in healthy adults [10]. Furthermore, although several studies have attempted to identify the most beneficial modes of physical activity [11, 12], all of them are based on self-reported PA, which is prone to recall bias, insensitive to light-intensity PA, and unable to classify specific types of PA. In contrast, accelerometers are promising wearable devices that can objectively record PA intensity and duration under free-living conditions over time.

The relationship among BMI, physical activity, and OA is multifaceted. Several studies found OA patients who engaged in appropriate exercise achieved weight loss and symptom relief [13, 14], while others showed that participants in an exercise program experienced weight loss and improved OA symptoms [15, 16]. We hypothesized that the relationship between PA and OA might differ across populations with different BMI, and it is crucial to tailor PA patterns to different populations.

To address the above gaps in knowledge, we conducted a prospective cohort analysis using data from the UK Biobank to clarify the associations between accelerometer-measured MVPA and incident knee/hip OA in populations with different BMI.

Methods

Study design and participants

The datasets used in this study were obtained from the UK Biobank, in which comprehensive data were gathered from each participant during the initial assessment [17]. The UK Biobank was approved by the North West Research Ethics Committee (21/NW/0157) and all participants signed an informed consent.

The current analysis was restricted to a sub-sample of 103,661 participants who responded to emails for the accelerometer sub-study between 2013 and 2015 [18]. Individuals with insufficient accelerometer data quality or less than a full week of available acceleration data ($n = 11,547$) were excluded. Additionally, we excluded participants who had hip or knee OA, hip or knee surgery, or hip or knee injury before the time of accelerometer measurements ($n = 6,917$), resulting in a final analysis of 85,196 participants (Supplementary Figure S1).

Device-measured physical activity

Participants were asked to wear Axivity AX3 (Newcastle upon Tyne, UK) triaxial accelerometers on their dominant hands continuously for 7 days. Details on physical activity (PA) measurement are in the Supplementary Material.

Covariates assessment

We have identified 12 covariates, which may exert an influence on the association between physical activity and knee/hip OA. These included age at PA data collection, sex, ethnicity, education attainment, occupation status, income, smoking status, alcohol consumption, diet quality, history of cardiovascular disease, history of diabetes, history of hypertension, and BMI.

Outcome assessment

In present study, we focused on OA of hip and knee joints, which was identified on the basis of hospital inpatient (UKB data-field 41270) and death data (UKB data fields 40001 and 40002). By using the International Classification of Diseases 10th revision (ICD-10), knee/hip OA was defined as ICD-10 code M16-17 [19]. In sub-analysis, hip OA (ICD-10:M16) and knee OA (ICD-10:M17) were considered separately.

The time-to-event was calculated from the final date of accelerometer wear until the date of death, the first date of outcome diagnosis, the date of loss to follow-up, or the end of follow-up (August, 2025), whichever came first.

Statistical analysis

The baseline characteristics of all participants were summarized as frequency (percentage) for categorical variables and mean (standard deviation, SD) for continuous variables. Differences in characteristics were compared by using independent-sample t tests, Mann-Whitney U test, and Chi-square test.

Participants were classified into obese ($\text{BMI} \geq 30 \text{ kg/m}^2$), overweight ($\text{BMI} 25\text{--}29.9 \text{ kg/m}^2$), and normal/underweight ($\text{BMI} < 25 \text{ kg/m}^2$). Restricted cubic spline (RCS) was performed to test linearity and explore the shape of the dose–response relationship of

MVPA with OA. For U-shaped RCS curves (Fig. 1a-f), threshold was determined as the point in MVPA with the smallest hazard ratio (HR). The 95% confidence interval (CI) was derived by bootstrap resampling. MVPA intensity is classified into three levels: low (below the lower limit of the 95% CI), moderate (within the 95% CI), and high (above the upper limit of the 95% CI). [20]. For J-shaped RCS curves (Fig. 1g-i), the inflection point (i.e., threshold) was determined using the R package “segmented”, based on a likelihood-ratio test and the bootstrap resampling method [21]. MVPA intensity is also classified into three levels (low, moderate, high) based on tertiles of MVPA distribution.

Cox proportional hazards regression models were conducted to estimate the HRs and 95% CIs for the associations of MVPA with the risk of knee/hip OA. Multivariable-adjustment was made for age, sex, ethnicity, household income, occupation, education, smoking status, alcohol consumption, diet, history of cardiovascular disease, history of diabetes, history of hypertension, and BMI. Cumulative risk curves were plotted by MVPA level by using Kaplan–Meier methods (Supplementary Figure S2). A risk matrix was used to investigate the joint associations of different-intensity PA with OA. According to tertiles of LPA distribution, LPA intensity is categorized into three levels: low (< 1785 min/week), moderate (1785–2461 min/week), and high (> 2461 min/week). The combination of the least active groups was set as the reference group. Furthermore, individuals were classified as inactive (low MVPA), active weekend warrior (WW) (moderate MVPA and $\geq 50\%$ of total MVPA achieved within 1–2 days), regularly active (moderate MVPA but not meeting WW status), overactive WW (high MVPA and meeting WW status), and regularly overactive (high MVPA but not meeting WW status) patterns.

Stratified analyses were conducted according to age, sex, ethnicity, smoking status, alcohol consumption, diet quality, cardiovascular disease, diabetes, and hypertension. Several sensitivity analyses were conducted to verify the robustness of our primary results. First, we excluded participants with less than 2 years of follow-up to minimize the influence of potential reverse causation. Second, we created a propensity-score-matched (PSM) cohort to balance participants’ characteristics except MVPA between OA and control groups (a 1:1 match). Third, inverse probability of treatment weighting (IPTW) was used to minimize potential selection bias. Fourth, a Fine and Gray competing-risks regression model was used with all-cause death treated as a competing risk. Finally, we used alternative definitions of MVPA level according to guidelines-based threshold (MVPA = 150 min/week).

All the analyses were conducted using R software (version 4.2.2). A two-tailed P-value < 0.05 was deemed statistically significant.

Results

Baseline characteristics

Of the 85,196 participants included, the mean age was 61.09 (SD, 7.92) years, and 38,461 (45.14%) were male. All participants wore accelerometer for 7 days. During a median follow-up of 10.11 years, 5,017 participants developed knee or hip OA (Table 1). Compared with individuals without OA, those with a hip/knee OA showed significantly higher BMI (28.44 vs 26.51 kg/m²) and lower MVPA (265.67 vs 295.74 min/week).

Table 1
Baseline characteristics of participants by knee/hip OA.

Characteristics	Incident knee or hip OA			
	All participants	No	Yes	p value
N	85196	80179	5017	
Age, years, mean (SD)	61.09 (7.92)	60.88 (7.94)	64.45 (6.82)	< .001
Sex, male, n (%)	38461 (45.14)	36294 (45.27)	2167 (43.19)	0.004
Ethnicity, n (%)				0.003
Nonwhite	2926 (3.43)	2791 (3.48)	135 (2.69)	
White	82270 (96.57)	77388 (96.52)	4882 (97.31)	
Occupation, n (%)				0.003
Employed, student, or retired	80515 (94.51)	75727 (94.45)	4788 (95.44)	
Unemployed	4681 (5.49)	4452 (5.55)	229 (4.56)	
Household income, n (%)				< .001
Less than £31000	38897 (45.66)	36152 (45.09)	2745 (54.71)	
At least £31000	46299 (54.34)	44027 (54.91)	2272 (45.29)	
Education, college or university, n (%)	37428 (43.93)	35608 (44.41)	1820 (36.28)	< .001
Never smoking, n (%)	47491 (55.74)	44999 (56.12)	2492 (49.67)	< .001
Heavy alcohol consumption, n (%)	19443 (22.82)	18252 (22.76)	1191 (23.74)	0.11
Healthy diet, n (%)	56264 (66.04)	52860 (65.93)	3404 (67.85)	0.005
Cardiovascular disease, n (%)	5992 (7.03)	5495 (6.85)	497 (9.91)	< .001
Diabetes, n (%)	3145 (3.69)	2894 (3.61)	251 (5.00)	< .001
Hypertension, n (%)	33278 (39.06)	30955 (38.61)	2323 (46.30)	< .001
BMI, kg/m ² , mean (SD)	26.62 (4.47)	26.51 (4.41)	28.44 (5.02)	< .001
BMI category, n (%)				< .001
< 18.5	508 (0.60)	497 (0.62)	11 (0.22)	
18.5–24.9	33521 (39.35)	32236 (40.21)	1285 (25.61)	
25–29.9	35227 (41.35)	33067 (41.24)	2160 (43.05)	
≥ 30	15940 (18.71)	14379 (17.93)	1561 (31.11)	
Device-measured MVPA, min/week, mean (SD)	293.97 (244.20)	295.74 (243.90)	265.67 (247.29)	< .001
Device-measured LPA, min/week, mean (SD)	2116.48 (689.19)	2115.08 (689.74)	2138.89 (679.98)	0.018
Data are presented as mean (SD) or n (%).				
Abbreviations: SD, standard deviation; BMI, body mass index; OA, osteoarthritis; MVPA, moderate-to-vigorous physical activity; LPA, light physical activity.				

Association of MVPA with knee/hip OA

In overweight (BMI 25-29.9 kg/m²) and obese (BMI ≥ 30 kg/m²) participants, the dose–response associations of MVPA with knee/hip OA, knee OA, and hip OA were U-shaped (Fig. 1a-f). The risk of OA first decreases and then increases with rising MVPA. In normal-weight and underweight (BMI < 25 kg/m²) participants, the dose–response associations of MVPA with knee/hip OA, knee OA, and hip OA were J-shaped (Fig. 1g-i). As MVPA increases, OA risk gradually rises. The MVPA thresholds for knee/hip OA were 252 min/week (95% CI 151–445), 204 min/week (95% CI 167–326), and 667 min/week in obese, overweight, and normal/underweight individuals, respectively (Fig. 1a, d, **and g**).

After adjustment for covariates, moderate MVPA (151–445 min/week) was associated with lower risks for knee/hip OA compared with low or high MVPA in obese participants (HR 1.20, 95% CI 1.07 to 1.35, P = 0.001; HR 1.17, 95% CI 0.98 to 1.40, P = 0.06) (Table 2). By subtype of OA, moderate MVPA showed lowest risk for knee OA and hip OA. A similar result was observed in overweight participants for moderate MVPA (167–326 min/week). Among normal/underweight individuals, low MVPA (< 187 min/week) was associated with the lowest risk of OA and its subtypes, although the difference was not statistically significant. Supplementary Figure S2 showed Kaplan–Meier curves.

Table 2
Associations Between MVPA Level and Incident OA

BMI			No. of Cases/ 1000 Person-Years	Model 1		Model 2		Model 3	
	Exposures	Outcomes		HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
≥ 30 kg/m ²	MVPA (min/week)								
	151–445	Knee or Hip OA	500/8.65	Reference		Reference		Reference	
	< 151		893/12.44	1.26 (1.13, 1.42)	< 0.0001	1.27 (1.13, 1.42)	< 0.0001	1.20 (1.07, 1.35)	0.001
	> 445		168/9.09	1.15 (0.97, 1.38)	0.1	1.15 (0.96, 1.37)	0.11	1.17 (0.98, 1.40)	0.06
	141–500	Knee OA	402/5.88	Reference		Reference		Reference	
	< 141		581/8.49	1.29 (1.13, 1.47)	0.0001	1.22 (1.02, 1.46)	0.03	1.21 (1.00, 1.45)	0.04
	> 500		94/6.61	1.23 (0.98, 1.54)	0.07	1.24 (0.90, 1.72)	0.18	1.25 (0.90, 1.73)	0.17
	137–391	Hip OA	175/2.88	Reference		Reference		Reference	
	< 137		296/4.21	1.26 (1.04, 1.52)	0.01	1.25 (1.03, 1.51)	0.02	1.24 (1.02, 1.50)	0.04
	> 391		75/3.25	1.27 (0.97, 1.67)	0.07	1.26 (0.96, 1.66)	0.08	1.27 (0.97, 1.67)	0.08
25 ~ 29.9 kg/m ²	MVPA (min/week)								
	167–326	Knee or Hip OA	595/5.93	Reference		Reference		Reference	
	< 167		839/7.07	1.14 (1.03, 1.27)	0.01	1.15 (1.03, 1.29)	0.01	1.12 (1.01, 1.26)	0.03
	> 326		726/6.05	1.08 (0.97, 1.20)	0.12	1.08 (0.97, 1.19)	0.15	1.09 (0.98, 1.21)	0.08
	131–341	Knee OA	448/3.42	Reference		Reference		Reference	
	< 131		422/4.26	1.14 (0.99, 1.30)	0.05	1.14 (0.99, 1.30)	0.05	1.10 (0.96, 1.26)	0.13

Hazard ratios (95%CI) were calculated in Cox proportional hazards model: Model 1, adjusted for age, sex, ethnicity, household income, occupation, and education; Model 2, adjusted for age, sex, ethnicity, household income, occupation, education, smoking status, alcohol consumption, and diet; Model 3, adjusted for age, sex, ethnicity, household income, occupation, education, smoking status, alcohol consumption, diet, history of cardiovascular disease, history of diabetes, history of hypertension, and BMI.

Levels of significance: P < 0.05.

Abbreviation: HR, hazard ratio; CI, confidence interval; OA, osteoarthritis; MVPA, moderate-to-vigorous physical activity

BMI			No. of Cases/	Model 1		Model 2		Model 3	
	Exposures	Outcomes	1000 Person-Years	HR (95% CI)	P value	HR (95% CI)	P value	HR (95% CI)	P value
				1.30)		1.31)		1.26)	
	> 341		407/3.55	1.10 (0.96, 1.26)	0.16	1.09 (0.95, 1.25)	0.20	1.11 (0.97, 1.27)	0.12
	133–355	Hip OA	345/2.49	Reference		Reference		Reference	
	< 133		315/3.16	1.11 (0.95, 1.30)	0.16	1.12 (0.95, 1.31)	0.14	1.10 (0.95, 1.29)	0.19
	> 355		291/2.67	1.20 (1.03, 1.41)	0.01	1.19 (1.02, 1.40)	0.02	1.20 (1.03, 1.41)	0.02
<25 kg/m ²	MVPA (min/week)								
	< 187	Knee or Hip OA	425/4.11	Reference		Reference		Reference	
	187–389		390/4.63	1.03 (0.90, 1.19)	0.59	1.05 (0.91, 1.20)	0.47	1.08 (0.94, 1.23)	0.25
	> 389		481/4.89	1.04 (0.91, 1.19)	0.52	1.05 (0.90, 1.21)	0.53	1.09 (0.95, 1.26)	0.21
	< 187	Knee OA	197/1.88	Reference		Reference		Reference	
	187–389		189/1.74	1.03 (0.84, 1.27)	0.75	1.03 (0.84, 1.27)	0.73	1.08 (0.88, 1.33)	0.42
	> 389		233/1.86	1.07 (0.88, 1.30)	0.46	1.07 (0.89, 1.30)	0.42	1.10 (0.91, 1.34)	0.26
	< 187	Hip OA	212/1.96	Reference		Reference		Reference	
	187–389		257/2.06	1.01 (0.88, 1.17)	0.92	1.02 (0.87, 1.19)	0.76	1.01 (0.84, 1.21)	0.91
	> 389		246/2.36	1.02 (0.84, 1.24)	0.78	1.03 (0.85, 1.25)	0.71	1.08 (0.89, 1.30)	0.42
Hazard ratios (95%CI) were calculated in Cox proportional hazards model: Model 1, adjusted for age, sex, ethnicity, household income, occupation, and education; Model 2, adjusted for age, sex, ethnicity, household income, occupation, education, smoking status, alcohol consumption, and diet; Model 3, adjusted for age, sex, ethnicity, household income, occupation, education, smoking status, alcohol consumption, diet, history of cardiovascular disease, history of diabetes, history of hypertension, and BMI.									
Levels of significance: P < 0.05.									
Abbreviation: HR, hazard ratio; CI, confidence interval; OA, osteoarthritis; MVPA, moderate-to-vigorous physical activity									

Joint association of MVPA and LPA with OA

The risk matrix illustrating the joint associations of MVPA and LPA with OA was shown in Fig. 2. At the same MVPA level, moderate LPA showed lowest risk for knee/hip OA, knee OA, and hip OA in total populations. In obese populations, moderate

MVPA combined with moderate LPA yielded the lowest risk for knee/hip OA (HR 0.72, 95% CI 0.59 to 0.88), knee OA (HR 0.75, 95% CI 0.60 to 0.94), and hip OA (HR 0.60, 95% CI 0.42 to 0.86). Similar results were observed in overweight individuals. In underweight and normal-weight individuals, low MVPA combined with moderate LPA yielded the lowest risk for knee/hip OA, knee OA, and hip OA.

MVPA patterns with incident OA

Under the same MVPA pattern, the association between MVPA level and OA was consistent with previous findings (Fig. 3). At the same MVPA level, the WW pattern and the regular pattern showed comparable risks of knee/hip, knee, and hip OA in the overall population.

Stratified and sensitivity analysis

Stratified analyses showed that the results in all subgroups were consistent with previous findings (Supplementary Tables S1-3). Sensitivity analyses demonstrated that our findings were robust (Supplementary Tables S4).

Discussion

In this large prospective cohort study of 85,196 participants from the UK Biobank, we found that the association between accelerometer-measured MVPA and the risk of incident knee/hip OA is different in populations with different BMI. We then identified distinct MVPA thresholds for the prevention of knee/hip OA across different BMI populations. In addition, our joint association analyses revealed that incorporating moderate levels of LPA further reduced the risk of knee/hip OA across all populations. Furthermore, the pattern of MVPA (weekend warrior or regular) did not significantly alter OA risk. These findings offer novel, objective evidence for tailoring physical activity recommendations based on BMI status to mitigate knee and hip OA risk.

Partially consistent with our findings, numerous cohort studies have revealed an association between physical activity and hip/knee OA. A large-scale study enrolling 436,166 participants found that high-intensity job-related, travel-related, and leisure-time physical activity were associated with increased knee/hip OA risk. Moderate adherence to "strenuous sports" and "walking for pleasure" was protective against knee/hip OA [12]. Gu et al. [11] found that high PA levels increased total, knee, and hip OA risk, with BMI mediating the PA–OA relationship. These findings align with our observation in overweight and obese populations, where moderate MVPA was protective while high MVPA increased OA risk. However, in normal-weight and underweight participants, OA risk gradually increased with rising MVPA. As major lower-limb weight-bearing joints, hip and knee are particularly affected by BMI in overweight and obese populations [22]. We proposed that in these populations, moderate MVPA reduces OA risk by decreasing BMI, while excessive activity exacerbates joint loading and cartilage wear in all populations. Notably, previous studies failed to consider the influence of PA on OA across different BMI groups.

Existing studies on PA and OA have predominantly relied on questionnaire-based assessment [11, 12, 23], while studies using accelerometer-derived PA were scarce. Questionnaire-based assessments are prone to recall bias [24], limited in distinguishing PA types [6], and insensitive to light physical activity [7]. Furthermore, they cannot capture duration at specific intensity levels [25], providing only a rough estimate of optimal PA duration for OA prevention. Accelerometers provide objective assessments sensitive to all PA intensities, allow differentiation between PA types, and enable minute-level quantification of duration. In this study, all participants wore accelerometers for 7 consecutive days, following prior methodology [6, 26]. This approach samples PA on both weekdays and weekends, achieving over 80% intra-class correlations in most populations [27]. Based on accelerometer-measured PA, our study delivers specific exercise duration and intensity recommendations for different BMI groups, making guidance more practical and meaningful.

Another striking finding in this study is that we identified the optimal combinations of MVPA and LPA for preventing OA. Specifically, moderate levels of MVPA combined with moderate levels of LPA were associated with the lowest risk of knee/hip OA among overweight and obese populations. In contrast, low levels of MVPA combined with moderate levels of LPA conferred the lowest risk of knee/hip OA among normal-weight and underweight populations. Furthermore, weekend warriors and regularly active participants had similar OA risk at the same MVPA level, suggesting that distributing MVPA across more days or concentrating it into 1 to 2 days may not influence OA risk. This is consistent with previous studies reporting comparable risks

between weekend warrior and regular activity patterns across various chronic diseases [6, 24, 28]. To our knowledge, these findings have not been previously reported in the literature on the relationship between PA and osteoarthritis.

Guidelines recommend ≥ 150 minutes of MVPA per week for the prevention of cardiovascular disease. This threshold has been widely discussed in accelerometer-based MVPA studies across other chronic diseases. Min et al. [24] found that MVPA ≥ 150 minutes/week was associated with lower risks of dementia, stroke, Parkinson's disease, depressive disorders and anxiety. Another accelerometer-based study showed that the risk for all-cause mortality gradually decreased as the duration of MVPA increased to a higher level [7]. Similarly, Liu et al. [18] found that more MVPA was associated with a lower risk of incident liver outcomes. These studies suggest that more MVPA is better, yet they have not proposed a reasonable upper limit. In contrast, our study found that MVPA has an upper limit with respect to OA risk. To prevent knee/hip OA, the optimal MVPA range was 151–445 minutes/week in the obese group, 167–326 minutes/week in the overweight group, and no more than 677 minutes/week in the underweight and normal-weight groups. For overweight and obese populations, the above criteria align with the recommendation of ≥ 150 minutes/week. For underweight and normal-weight populations, the increase in OA risk was not significant when MVPA was below 677 minutes/week, suggesting that a range of 150–677 minutes/week may be more appropriate.

There are several limitations that need to be considered. First, there is currently a lack of robust evidence on whether a 7-day measurement is representative of habitual PA. Second, we identified MVPA thresholds across different BMI groups. However, these thresholds, which can be subject to variability due to device and demographic differences, may introduce a degree of subjectivity. Third, though the sample size of the UK Biobank was as large as 0.5 million, accelerometer-measured PA was only available for a subset of participants, who were generally healthier, more physically active, and had a lower mortality rate than the general UK population. The selection bias may limit the generalizability of the current findings. Fourth, as with any observational study, though we adjusted for a wide range of potential confounders, we cannot exclude the role of residual or unmeasured confounding, such as baseline cartilage damage grade and hip–knee–ankle angle.

Conclusion

The risk of knee/hip OA first decreases and then increases with rising MVPA in overweight and obese participants, while the risk gradually increased with higher MVPA levels among underweight and normal-weight individuals. To prevent knee/hip OA, overweight and obese individuals are advised to engage in moderate levels of MVPA (151–445 min/week and 167–326 min/week, respectively), and underweight and normal-weight individuals should keep MVPA below 677 min/week. Additionally, incorporating moderate levels of LPA (1785–2461 min/week) further reduces OA risk, and both weekend warrior and regular activity patterns are acceptable.

Abbreviations

- MVPA
moderate-to-vigorous physical activity
- OA
osteoarthritis
- RCS
restricted cubic spline
- LPA
light physical activity
- WW
weekend warriors
- SD
standard deviation
- CI
confidence interval
- PSM
propensity-score matched

IPTW
inverse probability of treatment weighting
HR
hazard ratio

Declarations

Author Contribution

JZ, QT, and DD designed the study reviewed and revised the manuscript. CZ and KL were responsible for analyzing and interpreting data. PL and JC contributed to data collection and literature research. CZ and MX analyzed and wrote the manuscript. All authors read and approved the final manuscript.

Acknowledgement

The authors thank the investigators and participants in UK Biobank for their contributions to this study.

Data Availability

The data that support the findings of this study are available from UK biobank, but restrictions apply to the availability of these data, which were used under licence for the current study and so are not publicly available. The data are, however, available upon request and with the permission of UK biobank.

References

1. Chen T, Chen W, Xu T, Wang H, Zhang Y, Wang L, et al. Osteoarthritis: Epidemiology, Pathogenesis, and Treatment. *MedComm* (2020). 2026;7(e70727).
2. Katz JN, Arant KR, Loeser RF. Diagnosis and Treatment of Hip and Knee Osteoarthritis: A Review. *JAMA*. 2021;325(6):568–578.
3. . Global, regional, and national disability-adjusted life-years (DALYs) for 315 diseases and injuries and healthy life expectancy (HALE), 1990–2015: a systematic analysis for the Global Burden of Disease Study 2015. *Lancet*. 2016;388(10053):1603–1658.
4. Hunter DJ, Bierma-Zeinstra S. Osteoarthritis. *Lancet*. 2019;393(10182):1745–1759.
5. Barnett R. Osteoarthritis. *Lancet*. 2018;391(10134):1985.
6. Khurshid S, Al-Alusi MA, Churchill TW, Guseh JS, Ellinor PT. Accelerometer-Derived "Weekend Warrior" Physical Activity and Incident Cardiovascular Disease. *JAMA*. 2023;330(3):247–252.
7. Cao Z, Min J, Chen H, Hou Y, Yang H, Si K, et al. Accelerometer-derived physical activity and mortality in individuals with type 2 diabetes. *Nat Commun*. 2024;15(1):5164.
8. Chen T, Chen S, Honda T, Kishimoto H, Nofuji Y, Narazaki K. Associations of objectively measured physical activity and sedentary time with all-cause mortality in Japanese older adults: a 10-year prospective study. *Br J Sports Med*. 2025;59(14):992–1000.
9. Hu B, Han D, Nevitt MC, Wise BL, Segal NA. Longitudinal Relationship Between Physical Activity and Joint Space Narrowing: Forty-Eight-Month Follow-Up Data From the Osteoarthritis Initiative. *Arthritis Care Res (Hoboken)*. 2022;74(7):1163–1171.
10. Racunica TL, Teichtahl AJ, Wang Y, Wluka AE, English DR, Giles GG, et al. Effect of physical activity on articular knee joint structures in community-based adults. *Arthritis Rheum*. 2007;57(7):1261–1268.
11. Gu H, Chen R, Fang T, Xu J, Zhang Y, Bian C, et al. Associations of physical activity with the risks of osteoarthritis and subtypes: a population-based cohort study of UK Biobank data. *Bone Joint Res*. 2025;14(7):656–665.

12. Zhu J, Chen W, Hu Y, Qu Y, Yang H, Zeng Y, et al. Physical activity patterns, genetic susceptibility, and risk of hip/knee osteoarthritis: a prospective cohort study based on the UK Biobank. *Osteoarthritis Cartilage*. 2022;30(8):1079–1090.
13. Reyes C, Leyland KM, Peat G, Cooper C, Arden NK, Prieto-Alhambra D. Association Between Overweight and Obesity and Risk of Clinically Diagnosed Knee, Hip, and Hand Osteoarthritis: A Population-Based Cohort Study. *Arthritis Rheumatol*. 2016;68(8):1869–1875.
14. Alrushud AS, Rushton AB, Kanavaki AM, Greig CA. Effect of physical activity and dietary restriction interventions on weight loss and the musculoskeletal function of overweight and obese older adults with knee osteoarthritis: a systematic review and mixed method data synthesis. *BMJ Open*. 2017;7(6):e014537.
15. Skou ST, Roos EM. Physical therapy for patients with knee and hip osteoarthritis: supervised, active treatment is current best practice. *Clin Exp Rheumatol*. 2019 Sep-Oct;37 Suppl 120(5):112–117.
16. Hall M, Castelein B, Wittoek R, Calders P, Van Ginckel A. Diet-induced weight loss alone or combined with exercise in overweight or obese people with knee osteoarthritis: A systematic review and meta-analysis. *Semin Arthritis Rheum*. 2019;48(5):765–777.
17. Allen NE, Lacey B, Lawlor DA, Pell JP, Gallacher J, Smeeth L, et al. Prospective study design and data analysis in UK Biobank. *Sci Transl Med*. 2024;16(729):eadf4428.
18. Liu M, Ye Z, Zhang Y, He P, Zhou C, Yang S, et al. Accelerometer-derived moderate-to-vigorous physical activity and incident nonalcoholic fatty liver disease. *BMC Med*. 2024;22(1):398.
19. Burns EM, Rigby E, Mamidanna R, Bottle A, Aylin P, Ziprin P, et al. Systematic review of discharge coding accuracy. *J Public Health (Oxf)*. 2012;34(1):138–148.
20. Salazar MC, Rosen JE, Wang Z, Arnold BN, Thomas DC, Herbst RS, et al. Association of Delayed Adjuvant Chemotherapy With Survival After Lung Cancer Surgery. *JAMA Oncol*. 2017;3(5):610–619.
21. Shi Y, Lin F, Li Y, Wang Y, Chen X, Meng F, et al. Association of pro-inflammatory diet with increased risk of all-cause dementia and Alzheimer's dementia: a prospective study of 166,377 UK Biobank participants. *BMC Med*. 2023;21(1):266.
22. Hall M, van der Esch M, Hinman RS, Peat G, de Zwart A, Quicke JG, et al. How does hip osteoarthritis differ from knee osteoarthritis? *Osteoarthritis Cartilage*. 2022;30(1):32–41.
23. Wu Y, Boer CG, Hofman A, Schiphof D, van Middelkoop M, Szilagyi IA, et al. Weight-Bearing Physical Activity, Lower-Limb Muscle Mass, and Risk of Knee Osteoarthritis. *JAMA Netw Open*. 2024;7(4):e248968.
24. Min J, Cao Z, Duan T, Wang Y, Xu C. Accelerometer-derived 'weekend warrior' physical activity pattern and brain health. *Nat Aging*. 2024;4(10):1394–1402.
25. Raichlen DA, Aslan DH, Sayre MK, Bharadwaj PK, Ally M, Maltagliati S, et al. Sedentary Behavior and Incident Dementia Among Older Adults. *JAMA*. 2023;330(10):934–940.
26. . Association Between Change in Accelerometer-Measured and Self-Reported Physical Activity and Cardiovascular Disease in the Look AHEAD Trial. *Diabetes Care*. 2022;45(3):742–749.
27. Matthews CE, Hagströmer M, Pober DM, Bowles HR. Best practices for using physical activity monitors in population-based research. *Med Sci Sports Exerc*. 2012;44(1 Suppl 1):S68-76.
28. Kany S, Al-Alusi MA, Rämö JT, Pirruccello JP, Churchill TW, Lubitz SA, et al. Associations of "Weekend Warrior" Physical Activity With Incident Disease and Cardiometabolic Health. *Circulation*. 2024;150(16):1236–1247.