American College of Rheumatology
Empowering Rheumatology Professionals

Arthritis Care & Research
Vol. 76, No. 2, February 2024, pp 200–207
DOI 10.1002/acr.25209

Does Physical Activity Confound Race Differences in Osteoarthritis-Related Functional Limitation?

Ernest R. Vina,[1] Puja Patel,[2] Carolina Villamil Grest,[2] C. Kent Kwoh,[3] Jason T. Jakiela,[4] Thomas Bye,[4] and Daniel K. White[4]

Objective. This study sought to determine the extent to which physical activity confounds the relation between race and the incidence of osteoarthritis (OA)-related functional limitation.

Methods. OA Initiative study participants with or at increased risk of knee OA who wore an accelerometer were included. Race was self-reported. Average time spent in moderate to vigorous physical activity (minutes per day) based on ActiGraph uniaxial accelerometer data was assessed. Functional limitation was based on the following: (1) inability to achieve a community walking speed (1.2 m/s) standard, (2) slow walking speed (<1.0 m/s), and (3) low physical functioning based on a Western Ontario and McMaster Universities OA Index (WOMAC) physical function score greater than 28 of 68.

Results. African American (AA) participants (n = 226), compared with White participants (n = 1348), had a higher likelihood of developing functional limitation based on various measures. When adjusted for time in moderate to vigorous physical activity, the association between AA race and inability to walk a community walking speed slightly decreased (from relative risk [RR] 2.15, 95% confidence interval [95% CI] 1.64–2.81, to RR 1.99, 95% CI 1.51–2.61). Association between AA race and other measures of functional limitation mildly decreased (slow walking speed: from RR 2.06, 95% CI 1.40–3.01, to RR 1.82, 95% CI 1.25–2.63; low physical functioning: from RR 3.44, 95% CI 1.96–6.03, to RR 3.10, 95% CI 1.79–5.39). When further adjusted for demographic and other clinical variables, only the association between race and low physical functioning (WOMAC) significantly decreased and no longer met statistical significance.

Conclusion. Greater physical activity is unlikely to completely make up for race differences in OA-related functional limitation, and other barriers to health equity need to be addressed.

INTRODUCTION

Osteoarthritis (OA) is a leading cause of disability in adults.[1] However, the burden of disease is not equally distributed. African American (AA) participants report worse OA-related functional limitation and pain compared with White (WH) participants.[2–6] Fortunately, exercise, which is known to reduce OA-related pain and improve physical function, may help reduce health disparities in adults with OA. AA participants, compared with WH participants, had worse walking endurance and health-related quality of life (HRQoL) at the start of an 18-month exercise intervention that targeted those with knee OA, and race differences were absent by the conclusion of the intervention.[7] Walking programs have also decreased pain, fatigue, and stiffness when tested among AA participants with arthritis.[8,9]

Although exercise can benefit those with OA,[10] there is also evidence that AA participants are less likely to be physically active than WH participants. Several national surveys have consistently found that AA participants report lower rates of leisure time physical activity compared with WH participants.[11–13] Aerobic physical activity participation, in particular, among AA adults has remained lower compared with WH adults in the last two decades.[14] These race differences persisted even after controlling for income, employment, marital status, and other socioeconomic factors.[13,14] AA participants compared with WH participants with OA and other forms of arthritis are also less likely to meet physical

[1]Ernest R. Vina, MD, MS: Temple University, Philadelphia, Pennsylvania, and University of Arizona, Tucson; [2]Puja Patel, DO, Carolina Villamil Grest, PhD, MSW: Temple University, Philadelphia, Pennsylvania; [3]C. Kent Kwoh, MD: University of Arizona College of Medicine, Tucson; [4]Jason T. Jakiela, PhD, Thomas Bye, MS, Daniel K. White, PT, ScD, MSc: University of Delaware, Newark.

Additional supplementary information cited in this article can be found online in the Supporting Information section (https://onlinelibrary.wiley.com/doi/10.1002/acr.25209).

Author disclosures are available at https://onlinelibrary.wiley.com/doi/10.1002/acr.25209.

Address correspondence via email to Ernest R. Vina, MD, at evina@arizona.edu.

Submitted for publication April 11, 2023; accepted in revised form July 19, 2023.

SIGNIFICANCE & INNOVATIONS

- Using both patient-reported and performance-based measures of physical function, we found that African American race was associated with higher incidence of osteoarthritis (OA)-related functional limitations over 4 years.
- Our study evaluated the confounding effects of physical activity in the relationship between race and OA-related functional limitation; we found slight to mild confounding effects.

activity guidelines based on patient-reported and accelerometer data.[15–20]

It is possible that observed race disparities in pain and functional limitation may be partially caused by race differences in physical activity. Low physical activity is a risk factor for pain, functional limitation, and low HRQoL in adults with knee OA,[21,22] and AA participants report less physical activity than WH participants.[11–13] Yet, physical activity is not necessarily an intermediate variable between race and OA-related functional limitation (Figure 1). The extent to which physical activity confounds the relation of AA participants with OA with worse pain and functional limitation compared with WH participants with OA is unclear. This is important to clarify given the need to address and identify underlying reasons for health disparities in adults with knee OA. As well, this is highly relevant to physical therapists, rheumatologists, and other clinicians who play an important role in the management of OA through the prescription or administration of exercise and physical activity intervention to adults with knee OA. The main objective of this study is to examine race differences in functional limitation, pain, and HRQoL and to determine the extent physical activity may confound these relationships in adults with knee OA.

PATIENTS AND METHODS

Study design, setting, and participants. We used data from the OA Initiative (OAI), a large multicenter prospective cohort study of individuals with or at risk for knee OA in the United States. Study overview, objectives, and sample selection have been previously described (https://nda.nih.gov/oai/). Briefly, the OAI is a prospective longitudinal cohort study of people 45 to 79 years of age. Individuals with symptomatic knee OA and those at high risk of developing symptomatic knee OA were included in one of two cohorts. In particular, the progression cohort included participants who had symptomatic knee OA in at least one knee at recruitment. The incidence cohort included those at risk for knee OA with substantial risk factors including frequent knee symptoms, overweight/obesity, history of knee injury or surgery, family history of total knee replacement, Heberden's nodes, and repetitive knee bending but without symptomatic knee OA in either knee. OAI participants without symptoms or risk factors were excluded.

Study participants were recruited between 2004 and 2006 from the University of Maryland School of Medicine and Johns Hopkins University, Ohio State University, University of Pittsburgh, and Memorial Hospital of Rhode Island. Participants were then assessed annually through 9 years of follow-up. The study was approved by the Institutional Review Board (IRB) of the OAI Coordinating Center at the University of California, San Francisco, and by the IRBs of each site.

The present study includes OAI participants in either the progression or incidence cohort. We restricted our sample to include only those who wore the accelerometer at the 48-month OAI clinic visit and completed outcome measures at the 96-month OAI clinic visit. Because there were very few Asian/Asian American study participants in the study cohort (n = 45), they were excluded. For the purposes of this analysis, the 48-month clinic visit represents our analytic baseline.

Study variables. *Exposure and outcomes.* Race (WH or AA) was patient reported at the enrollment visit. We employed walking speed calculated from a 20-m walk test to define our walking outcomes. The 20-m walk test required participants to walk at their usual speed over a marked 20-m course in an unobstructed and dedicated corridor while being timed with a digital stopwatch. The 20-m walk test has high test–retest reliability (intraclass correlation coefficients were greater than 0.9) for measuring walking speed in older adults.[23,24] In particular, we defined a substandard community walking speed as inability to walk 1.2 m/s or faster because this is the minimum speed necessary to cross streets at timed crosswalks.[25] Slow walking speed was

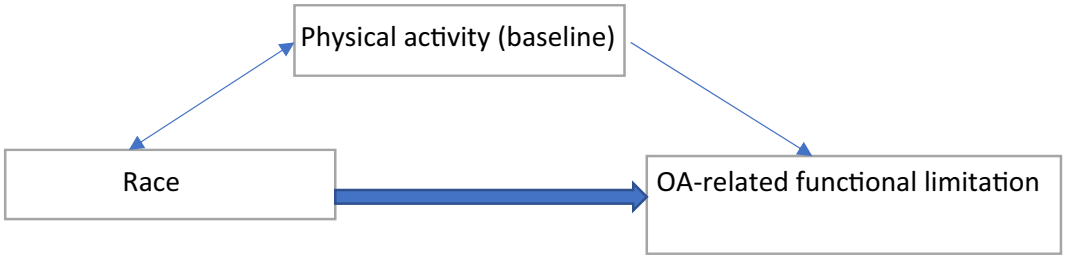

Figure 1. Theoretical model. OA = osteoarthritis.

defined as walking slower than 1.0 m/s, a risk factor for persistent functional limitation and death among older adults.[26]

Knee OA-related low physical functioning and pain were assessed using the 24-item Western Ontario and McMaster Universities OA Index (WOMAC), with the physical function (range: 0–68) and pain (range: 0–20) subscales, respectively.[27] In these patient-reported subscale measures, higher scores indicate more knee OA-related symptoms. Low physical functioning was based on attaining a score 28 or higher of 68 on the WOMAC physical function scale.[27] This cut point is consistent with a previous definition of poor functional outcome for persons with knee OA[28] and is within a range of scores reported for persons awaiting total knee replacement.[29] Persons reaching a score of 28 or higher of 68 report having at least slight to moderate difficulty in all 17 tasks from the WOMAC physical function scale or severe to extreme difficulty in seven to nine tasks. Incident knee pain was based on the WOMAC pain score exceeding a Patient Acceptable Symptom State (greater than 5 of 20).[30]

Physical HRQoL was assessed using the 12-Item Short Form Health Survey (SF-12) physical health component score.[31] Also a patient-reported measure, scores for the SF-12 range from 0 to 100, with higher scores indicating better physical health functioning. Incident-low physical HRQoL was defined as having an SF-12 score of less than 40, which is 1 SD below normative values from the general population.[31]

Physical activity. Baseline physical activity was objectively measured with an ActiGraph accelerometer at the 48-month clinic visit. An accelerometer provides a valid and reliable measure of physical activity frequency, intensity, and duration, providing a more precise measure of physical activity compared with a self-reported measure.[32,33] OAI participants were instructed to wear the ActiGraph (GT1M) uniaxial accelerometer at the right hip during waking hours for 7 consecutive days. An SAS macro provided by the National Cancer Institute (available at http://riskfactor.cancer.gov/tools/nhanes_pam) was used to determine ActiGraph wear time. Nonwear time was defined as 60 minutes or longer of zero activity, with allowance for up to 2 minutes of activity counts 0 to 100, and this was subtracted from 24 hours to determine wear time.[34] A valid wear day was defined as a day with 10 hours or longer of wear time. Participants were included if 4 to 7 valid wear days were available, regardless of the day of the week.

Moderate to vigorous physical activity was analytically identified by activity counts 2,020 per minute or greater.[34] The definition was based on the US physical activity guideline that was available and published during study recruitment.[35] The mean minutes per day spent in moderate-vigorous physical activity was determined. The study's method of processing accelerometer data has been used in previous studies.[36]

Sociodemographic and clinical variables. Educational attainment (with vs without college degree or more) were self-reported at baseline. Body mass index (BMI) was calculated. Baseline radiographs were centrally read for all participants who had at least one follow-up visit knee x-ray.[37] Having radiographic knee OA was defined by the presence of definite osteophytes. Depression was ascertained using the validated Center for Epidemiologic Studies Depression Scale (CES-D).[38] Scores range from 0 to 60, with scores 16 or greater suggesting depression.[39] Knee pain severity in the past 30 days based on a visual analog scale (VAS; range: 0–10) was also assessed.

Statistical analysis. Baseline demographic and clinical characteristics of the primary study cohort overall were summarized. They were also compared by race. Continuous variables were compared using two-sample *t*-test. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test. Race differences (WH vs AA) in primary outcome (substandard community walking speed) and secondary outcome (slow walking speed, low physical functioning, incident knee pain, and incident-low physical HRQoL) measures were assessed using generalized linear models. WH race served as the reference group, as WH participants comprised the largest race group in the OAI. Risk ratios (RRs) and 95% confidence intervals (95% CIs) were used to evaluate the association between race and the incidence of functional limitation, pain, and walking over 4 years, unadjusted and adjusted for physical activity, sociodemographic, and clinical variables. Covariates were chosen based on sociodemographic (age, sex, and education [college]) and clinical (BMI, radiographic OA, CES-D, and VAS pain) variables known to potentially confound race differences in OA-related functional outcomes.[3] We repeated the analyses stratified by the presence/absence of radiographic OA. Statistical analyses were conducted using SAS Version 9.4 (SAS Institute).

RESULTS

Sample characteristics. Of the 4,796 OAI participants at baseline, 45 were Asian, and 2,717 had ActiGraph accelerometer data at the 48-month clinic visit, of which 84 did not wear the monitor for at least 4 valid days (Figure 2). Of the participants, 349 did not attend the follow-up visit.

Among the remaining 1,574 OAI study participants in this sample, the mean age was 60.5 years, and more than half were women (Table 1). Most had at least a college degree (68.0%), and the mean BMI was 28.3. The majority had radiographic signs of knee OA, and the mean knee pain severity and CES-D scores were 3.0 (of 10) and 6.6, respectively. A total of 1,348 WH and 226 AA participants were included in the study. The patient characteristics of subsamples for each study outcome were additionally reported (Supplementary Table 1).

In this cohort, AA participants, compared with WH participants, were younger and less likely to have a college degree (Table 2). They also had higher BMI and CES-D scores, were more likely to have radiographic knee OA, and had higher knee pain severity scores. AA participants were less likely than WH participants to spend time in moderate to vigorous physical activity

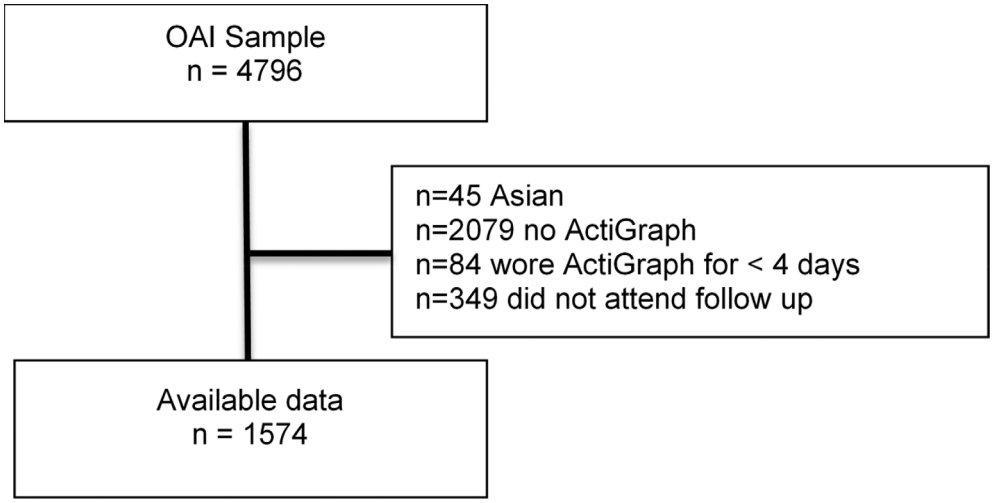

Figure 2. Study participant flow diagram. OAI = Osteoarthritis Initiative.

(mean ± SD daily minutes: 14.4 ± 15.4 vs 19.8 ± 20.1, respectively) as well.

OA-related clinical outcomes by race. AA participants, compared with WH participants, had a higher likelihood of developing the inability to walk a community walking speed standard (35.7% vs 16.7%, $P < 0.0001$), a slow walking speed (15.3% vs 7.4%, $P < 0.0002$), and low physical functioning based on the WOMAC physical function score (9.0% vs 2.6%, $P < 0.0001$) at the 96-month clinic visit. They were also more likely to develop an incident knee OA-related pain based on the WOMAC pain score (18.5% vs 11.5%, $P < 0.05$). Incident-low physical HRQoL based on the SF-12 score at the 96-month clinic visit did not differ between the two races (Table 3). The observed race differences were similar for those with and without radiographic OA (Supplementary Tables 2 and 3).

Effects of physical activity, sociodemographic, and clinical variables. When adjusted for time in moderate to vigorous physical activity, the association between race and inability to walk a community walking speed slightly decreased (from RR 2.15, 95% CI 1.64–2.81, to RR 1.99, 95% CI 1.51–2.61). When additionally adjusted for sociodemographic and clinical variables, the association remained minimally changed and remained statistically significant (Table 3).

When adjusted for time in moderate to vigorous physical activity, the association between race and incident slow walking speed mildly decreased (from RR 2.06, 95% CI 1.40–3.01, to RR 1.82, 95% CI 1.25–2.63). When further adjusted for sociodemographic and clinical variables, the association minimally changed and remained statistically significant (Table 3).

In comparison, after controlling for time in moderate to vigorous physical activity, the association between race and low physical function based on the WOMAC score mildly decreased (from RR 3.44, 95% CI 1.96–6.03 to RR 3.10, 95% CI 1.79–5.39). However, with further adjustment for sociodemographic and clinical variables, the association significantly decreased to an RR 1.63, 95% CI 0.86–3.09, and was no longer statistically significant (Table 3).

Similarly, the association between race and incident knee pain based on the WOMAC pain score minimally changed after controlling for time in moderate to vigorous physical activity (from RR 1.62, 95% CI 1.10–2.38, to RR 1.57, 95% CI 1.07–2.31). Further adjustment for demographic and clinical variables, however, significantly decreased any association between race and incident knee pain or low physical HRQoL (Table 3). These associations were similar for those with and without radiographic OA (Supplementary Tables 2 and 3).

Table 1. Patient characteristics of the entire analytic sample (n = 1,574)*

Patient characteristic	
Race, n (%)	
White	1,348 (85.64)
African American	226 (14.36)
Age, y, mean (SD)	60.53 (8.89)
Female, n (%)	842 (53.49)
Education, with college degree or more, n (%)	1,067 (68.01)
BMI, mean (SD)	28.32 (4.61)
With radiographic knee OA, n (%)	865 (54.99)
CES-D, mean (SD)	6.56 (7.44)
Pain severity (VAS), mean (SD)	2.96 (2.57)

* The Center for Epidemiologic Studies Depression Scale (CES-D) ranged 0–45. The visual analog scale (VAS) for worse knee ranged 0–10. BMI = body mass index; OA = osteoarthritis.

DISCUSSION

In this study comparing AA and WH adults with or at high risk of having knee OA, AA adults were more likely to develop

Table 2. Participant characteristics by race*

Characteristic	White (n = 1348)	African American (n = 226)	*P* value[a]
Age, y, mean (SD)	60.89 (9.04)	58.39 (7.64)	<0.0001
Female, n (%)	687 (50.96)	155 (68.58)	<0.0001
Education, n (%) with college degree or more	983 (72.98)	84 (37.84)	<0.0001
BMI, mean (SD)	27.97 (4.51)	30.44 (4.67)	<0.0001
With radiographic OA, n (%)[b]	713 (52.93)	152 (67.26)	<0.0001
CES-D, mean (SD)	6.30 (7.19)	8.17 (8.65)	0.0001
Pain severity (VAS), mean (SD)	2.68 (2.42)	4.62 (2.84)	<0.0001
Moderate to vigorous intensity physical activity, min/d, mean (SD)	19.84 (20.09)	14.39 (15.35)	0.0001

* The Center for Epidemiologic Studies Depression Scale (CES-D) ranged 0–45. The visual analog scale (VAS) for worse knee ranged 0–10. BMI = body mass index; OA = osteoarthritis.
[a] For continuous variables, *t*-test was used. Fisher's exact test was used for categorical variables.
[b] Presence of definite osteophytes on x-ray of the knee.

OA-related pain and functional limitations such as substandard community walking speed, slow walking speed, and low physical functioning. The incidence of low physical HRQoL was similar between AA participants and WH participants. Physical activity level had minimal to mild confounding effects on the observed differences in OA-related outcome variables. Adjusting for demographic and clinical variables eliminated observed race differences in only the patient-reported measures of physical function and pain but not the performance measures of physical function. AA participants in our cohort compared with WH participants were also predominantly women with higher BMI, had poorer educational attainment, and were more likely to have radiographic signs of knee OA, high knee pain severity, and high levels of depression.

In our study, identifying as AA race was associated with two to three times the incidence of functional limitation over 4 years among those with or at high risk of having knee OA. AA race was also associated with greater incidence of OA-related knee pain. Racial differences in OA-related disability and pain are well established in the literature.[3,4,40,41] Studies of patients with knee and/or hip OA living in North Carolina demonstrated that AA participants, compared with WH participants, had worse OA-related function and pain based on the WOMAC and other arthritis measurement scores.[3,4] In a study of patients with knee OA living in the southeastern United States, AA participants reported poorer function and greater clinical pain than non-Hispanic WH participants.[40] Upon quantitative sensory testing, they also had increased pain sensitivity and reduced pain inhibition. In evidence from a cross-sectional study conducted by Flowers et al[41] comparing performance-based function assessments in AA participants and WH participants with knee OA, AA participants had at least twice the odds of having poorer outcomes on several functional tests performed (eg, 2-minute step test, 30-second chair stand). Moreover, a recent meta-analysis concluded that AA participants with OA, compared with WH participants with OA, had a propensity for higher self-reported disability, clinical pain severity, and poorer performance testing.[42]

As expected, AA participants in this cohort were less likely to participate in moderate to vigorous physical activity than WH participants. Self-reported physical activity data from the Behavioral Risk Factor Surveillance System database had been applied to the 2003 physical activity guidelines in arthritis populations in

Table 3. Association of race with study outcomes*

Characteristic	White, n/N (%)	African American, n/N (%)	Model 1 RR (95% CI)	Model 2 RR (95% CI)	Model 3 RR (95% CI)	Model 4 RR (95% CI)
Inability to walk a community walking speed	173/1,039 (16.65)	45/126 (35.71)	2.15 (1.64–2.81)[a]	1.99 (1.51–2.61)[a]	2.02 (1.47–2.77)[a]	1.98 (1.45–2.72)[a]
Slow walking speed	95/1,277 (7.44)	30/196 (15.31)	2.06 (1.40–3.01)[b]	1.82 (1.25–2.63)[b]	1.77 (1.19–2.62)[b]	1.80 (1.22–2.65)[b]
Low physical functioning (WOMAC function ≥28)	34/1,306 (2.60)	17/190 (8.95)	3.44 (1.96–6.03)[a]	3.10 (1.79–5.39)[a]	1.67 (0.88–3.18)	1.63 (0.86–3.09)
Incident knee pain[c]	136/1,187 (11.46)	25/135 (18.52)	1.62 (1.10–2.38)[d]	1.57 (1.07–2.31)[d]	1.15 (0.76–1.74)	1.15 (0.76–1.73)
Incident-low physical HRQoL (SF-12 <50)	112/1,065 (10.52)	17/113 (15.04)	1.17 (0.78–1.73)	1.09 (0.73–1.63)	0.87 (0.57–1.32)	0.87 (0.57–1.32)

* Model 1 was unadjusted. Model 2 was adjusted for physical activity (time in moderate to vigorous intensity physical activity). Model 3 was adjusted for age, sex, body mass index, radiographic osteoarthritis, depression (Center for Epidemiologic Studies Depression Scale), education (college), and pain (visual analog scale). Model 4 was based off of Model 3 but was additionally adjusted for physical activity (time in moderate activity). 95% CI = 95% confidence interval; HRQoL = health-related quality of life; RR = relative risk; SF = 12-Item Short Form Health Survey; WOMAC = Western Ontario and McMaster Universities Arthritis Index.
[a] $P < 0.0001$.
[b] $P < 0.005$.
[c] Exceeding a Patient Acceptable Symptom State score on the WOMAC pain score (greater than 5 of 20).
[d] $P < 0.05$.

multiple studies.[15–17] All studies demonstrated that AA participants were less likely than WH participants to meet the 2003 guidelines. Upon applying physical activity data from the National Health Interview Survey database to the 2008 physical activity guidelines, other investigators found similar findings.[18,19] Self-reported data may not be the most accurate measure of physical activity, however. In a study of US adults with OA, the observed correlations between self-reported and objective measures of physical activity were mostly weak to moderate.[43] Applying an accelerometer to assess racial differences in physical activity guideline attainment among those with or at risk for knee OA, Song et al[20] found that AA participants were 72% to 76% less likely than WH participants to meet physical activity guidelines. Although these previous studies were insightful, none of the studies evaluated the confounding effects of physical activity in the relationship between race and OA-related functional limitation. We found that, although time spent in moderate to vigorous physical activity confounded the association between race and multiple measures of functional limitation, the observed magnitude of confounding effects was small.

Racial disparities in OA-related outcomes could be related to differences in sociodemographic and clinical characteristics based on previous studies. Poorer socioeconomic status (including lower income) and lower social support have been associated with worse patient-reported OA-related outcomes.[4,44,45] Higher BMI has also been associated with poorer daily functions in other studies.[46] Differences in radiographic disease severity may also affect racial differences in OA-related functional limitations. In one study, racial differences in knee OA symptoms persisted despite adjustment for sociodemographic and radiographic OA severity, but the differences were no longer significant when further controlled for depressive symptoms and BMI.[3] The study suggests that depressive symptoms and BMI may play a more significant factor than the other variables in explaining race differences in OA-related symptoms. In our study, further adjustment for demographic and other clinical variables significantly reduced the association between race and OA-related pain and dysfunction based on the WOMAC but not the walking speed performance measures. The differential effects could be caused by the fact the WOMAC is a patient-reported measure and the walking speed measures are not. Patient-reported outcome measures may be more susceptible to the effects of sociodemographic and clinical variables.

Strengths of our study include using data from a prospective longitudinal cohort with substantial number of study participants. We also used objective measurements of functional limitation physical activity using an accelerometer and both patient-reported and performance-based measures of physical function. Clinicians should be aware that moderate to vigorous physical activity may reduce race differences in OA-related functional outcomes but only to a certain extent. Regular moderate to vigorous physical activity, however, may have other beneficial health effects among racial and ethnic minorities besides relieving arthritis symptoms (eg, improved general physical fitness, greater bone mineral density).[47] Clinicians should also acknowledge that certain demographic and clinical factors may also reduce race differences in patient-reported physical dysfunction. Future studies should evaluate other factors that may play a role in understanding racial differences in OA-related functional limitations. These variables should include a more detailed account of socioeconomic status (eg, occupation), presence of other clinical comorbidities, pain-coping patterns, and psychological resilience.[48] Novel programs that may increase regular physical activity among racial/ethnic minorities with OA should also continue to be developed and studied. Such programs should be culturally appropriate, address barriers to physical activity among racial/ethnic minorities and be responsive to their identified needs.

There are also some limitations to consider in this study. First, Asians/Asian Americans were excluded from analysis because of the small number of study participants. Additionally, Hispanic people/Latinos can have significantly higher arthritis-related pain and are less likely to be physically active than non-Hispanic WH participants.[19] However, there were a small number of Hispanic people recruited in the OAI (n = 60). Although Hispanic people/Latinos were included in our investigation, a study analyzing ethnic differences (ie, Hispanic people vs non-Hispanic people) in OA-related symptoms and physical activity using OAI data would not be adequately powered. In addition, common social and environmental factors such as lack of childcare, lack of parks, family responsibilities, neighborhood safety, and inflexible work environment have been recognized as barriers to physical activity in AA participants.[49] However, these factors were not assessed in our study and, thus, were not available to include in our analysis. Future investigations should analyze the roles of these variables in racial disparities in OA-related outcomes.

In conclusion, greater physical activity is unlikely to completely make up for race differences in OA-related functional limitation. Other barriers to health equity need to be addressed, so appropriate interventions can be implemented earlier to help reduce health disparities in OA, especially among AA people.

AUTHOR CONTRIBUTIONS

All authors were involved in drafting the article or revising it critically for important intellectual content, and all authors approved the final version to be published. Dr. Vina had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Study conception and design. Vina, White.

Acquisition of data. Kwoh.

Analysis and interpretation of data. Vina, Patel, Villamil Grest, Kwoh, Jakiela, Bye, White.

REFERENCES

1. Cross M, Smith E, Hoy D, et al. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. Ann Rheum Dis 2014;73:1323–30.

2. Golightly YM, Dominick KL. Racial variations in self-reported osteoarthritis symptom severity among veterans. Aging Clin Exp Res 2005; 17:264–9.
3. Allen KD, Helmick CG, Schwartz TA, et al. Racial differences in self-reported pain and function among individuals with radiographic hip and knee osteoarthritis: the Johnston County Osteoarthritis Project. Osteoarthritis Cartilage 2009;17:1132–6.
4. Allen KD, Oddone EZ, Coffman CJ, et al. Racial differences in osteoarthritis pain and function: potential explanatory factors. Osteoarthritis Cartilage 2010;18:160–7.
5. Groeneveld PW, Kwoh CK, Mor MK, et al. Racial differences in expectations of joint replacement surgery outcomes. Arthritis Rheum 2008; 59:730–7.
6. Vina ER, Ran D, Ashbeck EL, et al. Natural history of pain and disability among African-Americans and Whites with or at risk for knee osteoarthritis: a longitudinal study. Osteoarthritis Cartilage 2018;26:471–9.
7. Foy CG, Penninx BW, Shumaker SA, et al. Long-term exercise therapy resolves ethnic differences in baseline health status in older adults with knee osteoarthritis. J Am Geriatr Soc 2005;53:1469–75.
8. Wyatt B, Mingo CA, Waterman MB, et al. Impact of the Arthritis Foundation's Walk With Ease Program on arthritis symptoms in African Americans. Prev Chronic Dis 2014;11:E199.
9. Jones LC, Watkins Y, Alva D. Operation change: a new paradigm addressing behavior change and musculoskeletal health disparities. J Racial Ethn Health Disparities 2018;5:1264–72.
10. Kolasinski SL, Neogi T, Hochberg MC, et al. 2019 American College of Rheumatology/Arthritis Foundation guideline for the management of osteoarthritis of the hand, hip, and knee [review]. Arthritis Care Res (Hoboken) 2020;72:149–62.
11. He XZ, Baker DW. Differences in leisure-time, household, and work-related physical activity by race, ethnicity, and education. J Gen Intern Med 2005;20:259–66.
12. Crespo CJ, Smit E, Andersen RE, et al. Race/ethnicity, social class and their relation to physical inactivity during leisure time: results from the Third National Health and Nutrition Examination Survey, 1988-1994. Am J Prev Med 2000;18:46–53.
13. Saffer H, Dave D, Grossman M, et al. Racial, ethnic, and gender differences in physical activity. J Hum Cap 2013;7:378–410.
14. Watson KB, Whitfield G, Chen TJ, et al. Trends in aerobic and muscle-strengthening physical activity by race/ethnicity across income levels among US adults, 1998-2018. J Phys Act Health 2021;18(S1): S45–S52.
15. Hootman JM, Macera CA, Ham SA, et al. Physical activity levels among the general US adult population and in adults with and without arthritis. Arthritis Rheum 2003;49:129–35.
16. Fontaine KR, Heo M, Bathon J. Are US adults with arthritis meeting public health recommendations for physical activity? Arthritis Rheum 2004;50:624–8.
17. Fontaine KR, Heo M. Changes in the prevalence of US adults with arthritis who meet physical activity recommendations, 2001-2003. J Clin Rheumatol 2005;11:13–6.
18. Murphy LB, Hootman JM, Boring MA, et al. Leisure time physical activity among U.S. adults with arthritis, 2008-2015. Am J Prev Med 2017;53:345–54.
19. Huckleby J, Williams F, Ramos R, et al. The effects of race/ethnicity and physician recommendation for physical activity on physical activity levels and arthritis symptoms among adults with arthritis. BMC Public Health 2021;21:1564.
20. Song J, Hochberg MC, Chang RW, et al. Racial and ethnic differences in physical activity guidelines attainment among people at high risk of or having knee osteoarthritis. Arthritis Care Res (Hoboken) 2013;65: 195–202.
21. Losina E, Silva GS, Smith KC, et al. Quality-adjusted life-years lost due to physical inactivity in a US population with osteoarthritis. Arthritis Care Res (Hoboken) 2020;72:1349–57.
22. Esser S, Bailey A. Effects of exercise and physical activity on knee osteoarthritis [review]. Curr Pain Headache Rep 2011;15:423–30.
23. Fransen M, Crosbie J, Edmonds J. Reliability of gait measurements in people with osteoarthritis of the knee. Phys Ther 1997;77:944–53.
24. Guralnik JM, Ferrucci L, Pieper CF, et al. Lower extremity function and subsequent disability: consistency across studies, predictive models, and value of gait speed alone compared with the short physical performance battery. J Gerontol A Biol Sci Med Sci 2000;55:M221–31.
25. Langlois JA, Keyl PM, Guralnik JM, et al. Characteristics of older pedestrians who have difficulty crossing the street. Am J Public Health 1997;87:393–7.
26. Cesari M, Kritchevsky SB, Penninx BW, et al. Prognostic value of usual gait speed in well-functioning older people–results from the Health, Aging and Body Composition Study. J Am Geriatr Soc 2005; 53:1675–80.
27. Bellamy N, Buchanan WW, Goldsmith CH, et al. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15:1833–40.
28. Sharma L, Cahue S, Song J, et al. Physical functioning over three years in knee osteoarthritis: role of psychosocial, local mechanical, and neuromuscular factors. Arthritis Rheum 2003;48:3359–70.
29. McHugh GA, Luker KA, Campbell M, et al. Pain, physical functioning and quality of life of individuals awaiting total joint replacement: a longitudinal study. J Eval Clin Pract 2008;14:19–26.
30. Escobar A, Gonzalez M, Quintana JM, et al. Patient acceptable symptom state and OMERACT-OARSI set of responder criteria in joint replacement. Identification of cut-off values. Osteoarthritis Cartilage 2012;20:87–92.
31. Ware J Jr, Kosinski M, Keller SD. A 12-Item Short-Form Health Survey: construction of scales and preliminary tests of reliability and validity. Med Care 1996;34:220–33.
32. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. Med Sci Sports Exerc 1998;30:777–81.
33. Tucker JM, Welk GJ, Beyler NK. Physical activity in U.S.: adults compliance with the Physical Activity Guidelines for Americans. Am J Prev Med 2011;40:454–61.
34. Troiano RP, Berrigan D, Dodd KW, et al. Physical activity in the United States measured by accelerometer. Med Sci Sports Exerc 2008;40:181–8.
35. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine [review]. JAMA 1995;273:402–7.
36. Thoma LM, Dunlop D, Song J, et al. Are older adults with symptomatic knee osteoarthritis less active than the general population? Analysis from the Osteoarthritis Initiative and the National Health and Nutrition Examination Survey. Arthritis Care Res (Hoboken) 2018;70: 1448–54.
37. Riddle DL, Jiranek WA, Hull JR. Validity and reliability of radiographic knee osteoarthritis measures by arthroplasty surgeons. Orthopedics 2013;36:e25–32.
38. Radloff LS. The CES-D scale: a self-report depression scale for research in the general population. Appl Psychol Meas 1977;1: 385–401.
39. Lewinsohn PM, Seeley JR, Roberts RE, et al. Center for Epidemiologic Studies Depression Scale (CES-D) as a screening instrument for depression among community-residing older adults. Psychol Aging 1997;12:277–87.

40. Cruz-Almeida Y, Sibille KT, Goodin BR, et al. Racial and ethnic differences in older adults with knee osteoarthritis. Arthritis Rheumatol 2014;66:1800–10.

41. Flowers PP, Schwartz TA, Arbeeva L, et al. Racial differences in performance-based function and potential explanatory factors among individuals with knee osteoarthritis. Arthritis Care Res (Hoboken) 2020;72:1196–204.

42. Vaughn IA, Terry EL, Bartley EJ, et al. Racial-ethnic differences in osteoarthritis pain and disability: a meta-analysis. J Pain 2019;20: 629–44.

43. Liu SH, Eaton CB, Driban JB, et al. Comparison of self-report and objective measures of physical activity in US adults with osteoarthritis. Rheumatol Int 2016;36:1355–64.

44. Adler NE, Ostrove JM. Socioeconomic status and health: what we know and what we don't [review]. Ann N Y Acad Sci 1999;896:3–15.

45. Ethgen O, Vanparijs P, Delhalle S, et al. Social support and health-related quality of life in hip and knee osteoarthritis. Qual Life Res 2004;13:321–30.

46. Ang DC, Ibrahim SA, Burant CJ, et al. Is there a difference in the perception of symptoms between African Americans and whites with osteoarthritis? J Rheumatol 2003;30:1305–10.

47. Buchner DM, Beresford SA, Larson EB, et al. Effects of physical activity on health status in older adults. II. Intervention studies [review]. Annu Rev Public Health 1992;13:469–88.

48. Bartley EJ, Hossain NI, Gravlee CC, et al. Race/ethnicity moderates the association between psychosocial resilience and movement-evoked pain in knee osteoarthritis. ACR Open Rheumatol 2019;1:16–25.

49. Siddiqi Z, Tiro JA, Shuval K. Understanding impediments and enablers to physical activity among African American adults: a systematic review of qualitative studies [review]. Health Educ Res 2011; 26:1010–24.