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Association Between Walking for Exercise and Symptomatic and Structural Progression in Individuals With Knee Osteoarthritis: Data From the Osteoarthritis Initiative Cohort

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Objective. To assess the relationship between walking for exercise and symptomatic and structural disease progression in individuals with knee osteoarthritis (OA).

Methods. We assessed a nested cohort of participants age 50 years or older within the Osteoarthritis Initiative, a community-based observational study in which subjects were enrolled between 2004 and 2006. We focused on 4 dichotomous outcomes from baseline to the 48-month visit, involving determination of the frequency of knee pain and radiographic severity of knee OA on posteroanterior semiflexed knee radiographs. The outcomes assessed included 1) new frequent knee pain, 2) worsening of radiographic severity of knee OA based on the Kellgren/Lawrence grade, 3) progression of medial joint space narrowing, and 4) improved frequent knee pain. We used a modified version of the Historical Physical Activity Survey Instrument to ascertain those subjects who reported walking for exercise after age 50 years. The survey was administered at the 96-month visit (2012–2014).

Results. Of 1,212 participants with knee OA, 45% were male and 73% reported walking for exercise. The mean ± SD age was 63.2 ± 7.9 years, and the mean ± SD body mass index was 29.4 ± 4.6 kg/m^2. The likelihood of new frequent knee pain was reduced in participants with knee OA who walked for exercise as compared to those who were non-walkers (odds ratio [OR] 0.6, 95% confidence interval [95% CI] 0.4–0.8), and progression of medial joint space narrowing was less common in walkers compared to non-walkers (OR 0.8, 95% CI 0.6–1.0).

Conclusion. In individuals with knee OA who were age 50 years or older, walking for exercise was associated with less frequent development of knee pain. These findings support the notion that walking for exercise should be encouraged for people with knee OA. Furthermore, we offer a proof of concept that walking for exercise could be disease modifying, which warrants further study.

INTRODUCTION

Osteoarthritis (OA) is the most common type of arthritis in the US and is a leading cause of pain for those affected (1). Current pharmacologic therapies are limited to topical and oral nonsteroidal antiinflammatory drugs, intraarticular glucocorticoids, and analgesics such as tramadol, which only treat pain and do not modify structure (2). Professional societies, including the

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American College of Rheumatology (ACR) and the Osteoarthritis Research Society International (OARSI), have endorsed treatment recommendations under a comprehensive care strategy incorporating educational, behavioral, and physical interventions (2,3).

Exercise is a physical intervention often touted as a treatment for OA (2–4). The ACR guidelines specifically mention walking as a reasonable means of obtaining such exercise (2). Two clinical trials of land-based exercises that included walking as a treatment for knee OA (5,6) and 1 trial of walking alone as an intervention (n = 92) (7) support these recommendations. However, these trials were relatively short in duration. To address whether walking for exercise over time is beneficial in terms of alleviating long-term symptoms and structural progression, ascertainment of the effectiveness of walking for exercise over many years and longer follow-up periods is required.

To our knowledge, the Osteoarthritis Initiative is the only cohort study in which walking for exercise over several years has been assessed, and in which outcomes of knee OA, including symptoms and structural changes, have been carefully characterized. Thus, we used data from the Osteoarthritis Initiative cohort to address whether this exposure to walking is beneficial or detrimental in terms of modifying the course of symptoms or radiographic disease severity in individuals who have knee OA.

PATIENTS AND METHODS

Study design. The study was designed as a nested cohort study within the Osteoarthritis Initiative, a multicenter, prospective, longitudinal observational study involving individuals with or without symptomatic knee OA enrolled between 2004 and 2006. Staff at the following 4 clinic sites recruited participants: Memorial Hospital of Rhode Island, Ohio State University, the University of Pittsburgh, and the University of Maryland/Johns Hopkins. Participants attended annual evaluations from baseline to month 48, and thereafter every 2 years to month 96. Institutional review board approval was obtained at each clinic site, coordinating center, and the Baylor College of Medicine. Each participant provided written informed consent.

All publicly available data can be accessed through the Osteoarthritis Initiative website at https://nda.nih.gov/oai/.

Study timeline. The Historical Physical Activity Survey Instrument was administered to the included participants from the Osteoarthritis Initiative cohort at the 96-month visit, as part of an ancillary study to the parent Osteoarthritis Initiative. The radiographs and knee pain questions were planned as part of the parent study and ascertained at the Osteoarthritis Initiative baseline and 48-month visits, representing the 2 time points with the largest number of outcomes available in this cohort. The timing of the exposure was not optimal, since it was ascertained after the outcomes of interest; however, this was an unprecedented opportunity to capture information on physical activity over a lifetime in a cohort with highly characterized knee OA outcomes, not available in any other cohort.

Inclusion criteria. To be eligible, participants had to be age ≥50 years at baseline, to have complete data on knee-specific pain and knee radiographs at the 36-month or 48-month visits, and to have completed a modified version of the Historical Physical Activity Survey Instrument (8) at the 96-month visit. Participants were required to have radiographic evidence of knee OA (see below for further details) in at least one native knee at the time of enrollment.

Knee radiographs. The largest number of funded radiographic readings within the Osteoarthritis Initiative occurred at the baseline and 48-month visits, and therefore we chose these as the time points of interest for our study. If radiographs from the 48-month visit were missing, we used films from the 36-month visit instead. Bilateral, fixed-flexion, weight-bearing posteroanterior radiographs of the knees were obtained at these visits.

Kellgren/Lawrence (K/L) grades of radiographic knee OA severity (scale 0–4) (9) and the extent of medial joint space narrowing (JSN) were scored centrally based on the OARSI atlas of individual radiographic features (10). The reliability of these readings (read–reread) was good (weighted kappa for intrarater reliability 0.71, 95% confidence interval [95% CI] 0.55–0.87) (11). Radiographic OA was defined as a K/L grade ≥2.

Pain assessment. Participants were assessed for symptoms using a general screening assessment of frequent knee pain. Participants were asked the following question: "During the last 12 months, have you had pain, aching, or stiffness in or around your right/left knee on most days for at least one month? By most days, we mean more than half the days of a month" (12).

Knee arthroplasty. Knee replacement (partial or total) was reported or observed on radiographs at or before the 4-year visit of the Osteoarthritis Initiative study (>96% of participants adjudicated). A knee replacement was recorded if 1 of 3 criteria for a partial or total knee replacement were met, as follows: 1) the knee

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replacement was centrally adjudicated (medical records reviewed by 2 adjudicators and also by a physician adjudicator if there was disagreement between the first 2 adjudicators), 2) the knee replacement was observed on a study radiograph, or 3) the knee replacement was self-reported (even if the self-reported replacement had not gone through the adjudication process).

Static alignment. We defined static alignment using hip–knee–ankle angles measured on long-limb films. Long-limb films were acquired between months 12 and 48, based on participant availability. Staff obtained bilateral films with participants standing with the tibial tubercle forward. Hip–knee–ankle angles were calculated at the intersection of 2 lines: 1) from the ankle talar surface center to the tibial interspinous sulcus base, and 2) from the femoral head and intercondylar notch centers (13,14). Alignment was classified as varus if the angle was less than or equal to −2°, valgus if the angle was greater than or equal to 2°, and neutral if the angle was any value in between (15). These radiographs were obtained as part of a separate ancillary grant to the Osteoarthritis Initiative. As a result, these radiographs were not obtained at the baseline visit; they were collected at month 12 (40%), month 24 (41%), month 36 (18%), and month 48 (2%). In total, 985 (81%) of the 1,212 participants had long-limb films available, and 1,484 (82%) of the 1,808 knees assessed by radiography were included.

Historical Physical Activity Survey Instrument. To ascertain the exposure of walking for exercise, we administered a modified version of the Historical Physical Activity Survey Instrument (8). This survey questionnaire was mailed to participants. We altered the survey so that a participant could complete it as a take-home survey, similar to the self-administered questionnaire previously described by Chasan-Taber et al (16). If the survey was incomplete at the time of the closest in-person follow-up clinic visit (the 96-month visit), clinic staff asked participants to complete it at the clinic visit; clinic staff assistance was available if requested. These data were acquired between September 12, 2012 and October 31, 2014.

The walking for exercise exposure was assessed using the following question: "When you were 50 and older, did you walk for exercise at least 10 times? Please include walking outdoors and walking on a treadmill or track." Those who answered "yes" were considered walkers. Those who answered "no" or "don't know" (n = 25) were considered non-walkers. For those who responded to the questionnaire overall but had missing data on walking (n = 17), we coded them as non-walkers as well.

Those who answered "yes" were then asked further questions about the amount they walked for exercise. First, they were asked the question: "While you were 50 and older, did you walk for exercise at least 20 minutes within a given day (these do not have to be consecutive minutes)." If the answer was affirmative, then they were asked the question: "How many years did you walk for exercise? These do not have to be consecutive years." The response choices they were given were 1–5 years, 6–10 years, 11–20 years, >20 years, or "don't know." Thereafter, they were asked: "How many months per year did you walk for exercise? Again, these do not have to be consecutive months." The response choices they were given were 1–4 months per year, 5–8 months per year, 9–12 months per year, or "don't know." Finally, they were asked: "How many times per month did you walk for exercise?" The response choices they were given were 1–3 times per month, 4–8 times per month, 9 or more times per month, or "don't know." Using the median value for the answers given to each of these questions, an estimate was made regarding the number of times that the participant had walked for exercise since turning age 50 years.

Covariates. Date of birth and date of the baseline visit were used to calculate each participant's age. Body mass index was calculated as weight divided by height squared (kg/m^2), measured at the baseline visit.

Outcome measures. ***New frequent knee pain.*** Using the frequent knee pain question as defined under the "Pain Assessment" section of the questionnaire, the outcome of new frequent knee pain was defined as a knee without frequent knee pain at baseline but with frequent knee pain at the 48-month visit. To be explicit, the question focused on frequent knee pain, not any knee pain.

Improved frequent knee pain. The outcome of improved frequent knee pain was similarly defined using the frequent knee pain question. Specifically, improvement was defined as a knee having frequent knee pain at baseline but not at the 48-month visit.

Medial JSN worsening. The outcome of medial JSN worsening was defined as an increase in medial JSN score from baseline to the 48-month visit, including within-grade worsening (17). We chose to evaluate JSN worsening in the medial compartment, as most of the loading within a knee passes through the medial tibiofemoral compartment.

K/L grade worsening. The outcome of K/L grade worsening was defined as an increase in the K/L radiographic severity grade over the same time period. For all outcomes, if data from the 48-month visit were not available, data from the 36-month visit were carried forward, which occurred for 8% of the participants.

Statistical analysis. We performed unadjusted and adjusted knee-based logistic regression analyses, using generalized estimating equations to account for correlation within person (18), in which the predictor was walking for exercise. Walking for exercise was defined dichotomously (walkers versus non-walkers).

For the 4 outcome measures (new frequent knee pain, improved frequent knee pain, medial JSN worsening, and K/L grade worsening), adjusted analyses included age, sex, and baseline K/L grade as covariates. For the pain analyses, we excluded knees that already had the outcomes of interest from those respective analyses (e.g., those with baseline frequent knee pain were excluded from new frequent knee pain analyses). We included knees with K/L grade 4 and medial JSN grade 3 in the structural analyses, since, for these knees, they still had the potential of requiring an interval knee replacement, which would have allowed for the outcomes of K/L grade worsening and medial JSN worsening, respectively. We also performed analyses stratified by baseline age (age 50–59 years, age 60–69 years, and age 70–79 years) to address the possibility of reverse causation. Finally, we examined the frequency of each outcome among walkers and non-walkers stratified by knee static alignment (varus, neutral, or valgus). No statistical analyses stratified by alignment were performed, because of a limited sample size in some strata. The prospective protocol describing the statistical analysis plan for this study is provided in the Supplementary Statistical Analysis (available on the *Arthritis & Rheumatology* website at https://onlinelibrary.wiley.com/doi/10.1002/art.42241).

Because data on walking were missing for some participants, we performed a simplistic nonresponder imputation sensitivity analysis. We used a best case imputation and worst case imputation to provide a manual "extreme case," in which all those who had missing data on walking status were assumed to be walkers in one imputation and assumed to be non-walkers in another imputation.

RESULTS

Of the original 4,796 participants enrolled in the Osteoarthritis Initiative, 549 were younger than age 50 years at the time of the baseline visit, leaving 4,247 participants. Of these, 267 had missing baseline radiographs, leaving 3,980 participants who were evaluated for evidence of radiographic knee OA at the baseline visit. Of these, 1,624 did not have evidence of radiographic knee OA, leaving 2,356 participants considered eligible to have been surveyed at the 96-month visit, which we refer to as the "intent-to-survey" group. Of the 2,356 in the "intent-to-survey" group, 417 participants attended the 96-month visit prior to the date at which the Historical Physical Activity Survey Instrument was first administered within the Osteoarthritis Initiative, leaving 1,939 participants; 346 participants did not attend the 96-month visit at all, leaving 1,593 participants. Of these, 337 people attended the 96-month visit when the survey was being administered but chose not to complete the questionnaire, leaving 1,256 participants for whom we had exposure data and who were considered eligible to participate in this study. Of these, 44 did not have follow-up radiographs, leaving a total of 1,212 participants. Figure 1 illustrates how we arrived at the sample that was included in our study.

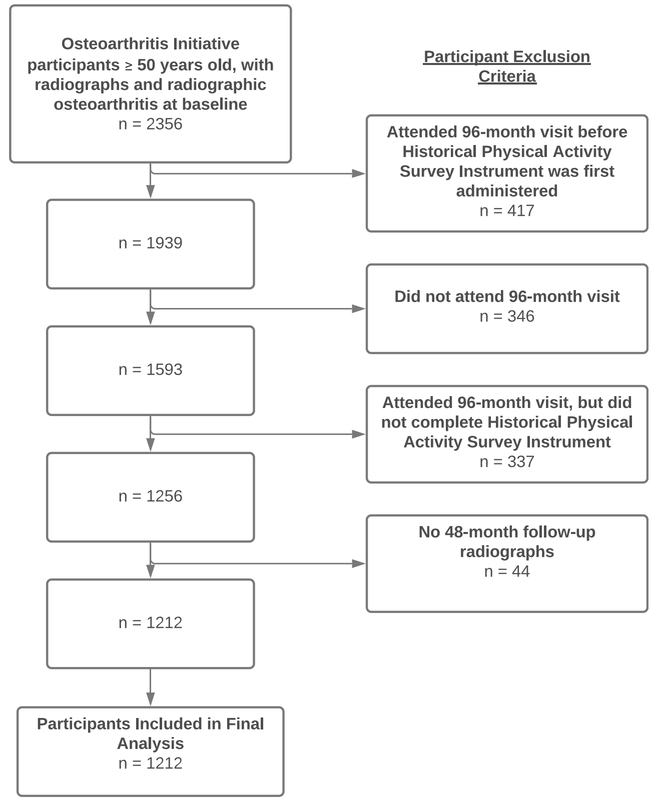

Figure 1. Flow diagram showing the eligibility criteria applied to the cohort and the sample size identified for final analysis of the effects of walking for exercise among a subset of individuals with knee osteoarthritis from the Osteoarthritis Initiative cohort.

Among the 1,212 participants (who contributed 1,808 knees for assessment), 887 (73%) reported walking for exercise. In total, 45% of participants were male, the mean ± SD age was 63.2 ± 7.9 years, and the mean ± SD body mass index was 29.5 ± 4.6 kg/m^2 (Table 1).

Knee-based descriptors at baseline were assessed in this Osteoarthritis Initiative sample. We observed that 64%, 29%, and 7% of participants had K/L radiographic knee OA severity grades of 2, 3, and 4, respectively, 65% of participants had some medial JSN, and 37% of participants reported having frequent knee symptoms. Rates of total knee replacement over the 48-month follow-up period were similar between those who walked for exercise and those who did not walk for exercise (Table 1). For 151 participants (12.6%), 36-month follow-up data instead of 48-month data were used. The characteristics of the participants who were not included in the study were similar to those who were included (see Supplementary Table 1, available on the *Arthritis & Rheumatology* website at https://onlinelibrary.wiley.com/doi/10.1002/art.42241).

Participants with knee OA who walked for exercise had a 40% decreased odds of new frequent knee pain compared to

Table 1. Characteristics of the included participants with knee OA from the Osteoarthritis Initiative cohort at baseline and 48 months, among non-walkers, walkers, and in total*

Time point, characteristic	Non-walkers	Walkers	All participants
Baseline			
Person-based characteristics			
No. of participants	325	887	1,212
Age, mean ± SD years	64.5 ± 8.3	62.7 ± 7.7	63.2 ± 7.9
Male sex	167/325 (51)	381/887 (43)	548/1,212 (45)
Body mass index, mean ± SD kg/m^2	30.2 ± 4.6	29.2 ± 4.6	29.4 ± 4.6
Estimated total no. of days of walking for exercise after age 50 years			
Minimum	0	13	–
25th percentile	0	337	–
Median	0	845	–
75th percentile	0	1,417	–
Maximum	0	2,100	–
Knee-based characteristics			
No. of participants	503	1,305	1,808
OA severity by K/L grade			
Grade 2	284/503 (56)	869/1,305 (67)	1,153/1,808 (64)
Grade 3	175/503 (35)	354/1,305 (27)	529/1,808 (29)
Grade 4	44/503 (9)	82/1,305 (6)	126/1,808 (7)
Medial JSN grade			
Grade 0	151/503 (30)	487/1,305 (37)	638/1,808 (35)
Grade 1	173/503 (34)	475/1,305 (36)	648/1,808 (36)
Grade 2	144/503 (29)	293/1,305 (22)	437/1,808 (24)
Grade 3	35/503 (7)	50/1,305 (4)	85/1,808 (5)
Frequent knee symptoms	223/503 (44)	453/1,305 (35)	676/1,808 (37)
Static alignment			
No. of participants	418	1,066	1,484
Varus	227/418 (54)	480/1,066 (45)	707/1,484 (48)
Neutral	129/418 (31)	407/1,066 (38)	536/1,484 (36)
Valgus	62/418 (15)	179/1,066 (17)	241/1,484 (16)
48 months, knee-based characteristics			
Frequent knee symptoms	233/503 (46)	496/1,305 (38)	729/1,808 (40)
Knee replacement	27/503 (5)	50/1,305 (4)	77/1,808 (4)

* Except where indicated otherwise, values are the number/total number (%) of participants. OA = osteoarthritis; K/L = Kellgren/Lawrence; JSN = joint space narrowing.

Table 2. Prevalence and odds of outcomes according to worsened or improved status among walkers versus non-walkers with knee OA*

	Prevalence of outcome, no./total (%)	Unadjusted odds ratio (95% CI)	Adjusted odds ratio (95% CI)†
Worsened outcome			
New frequent knee pain			
Non-walkers	103/280 (37)	Referent	Referent
Walkers	223/852 (26)	0.6 (0.4–0.8)‡	0.6 (0.4–0.8)‡
Worsening of K/L OA severity grade			
Non-walkers	105/503 (21)	Referent	Referent
Walkers	234/1,305 (18)	0.8 (0.6–1.1)	0.8 (0.6–1.1)
Worsening of medial JSN grade			
Non-walkers	137/503 (27)	Referent	Referent
Walkers	281/1,305 (22)	0.7 (0.6–1.0)‡	0.8 (0.6–1.0)‡
Improved outcome			
Improved frequent knee pain			
Non-walkers	93/223 (42)	Referent	Referent
Walkers	180/453 (40)	0.9 (0.7–1.3)	0.8 (0.6–1.2)

* Each outcome was assessed for its presence versus absence (yes/no) in walkers relative to non-walkers. OA = osteoarthritis; 95% CI = 95% confidence interval; JSN = joint space narrowing.
† Adjusted for age, sex, and baseline Kellgren/Lawrence (K/L) grade.
‡ Statistically significant at $P < 0.05$.

Table 3. Frequency of outcomes among walkers versus non-walkers with knee OA stratified by static alignment*

	Varus knees	Neutral knees	Valgus knees
New frequent knee pain			
Non-walkers	47/120 (39)	28/77 (36)	9/31 (29)
Walkers	82/290 (28)	60/266 (23)	40/122 (33)
Worsening of K/L OA severity grade			
Non-walkers	59/227 (26)	13/129 (10)	9/62 (15)
Walkers	97/480 (20)	58/407 (14)	35/179 (20)
Worsening of medial JSN grade			
Non-walkers	88/227 (39)	14/129 (11)	3/62 (5)
Walkers	149/480 (31)	69/407 (17)	16/179 (9)
Improved frequent knee pain			
Non-walkers	43/107 (40)	20/52 (38)	15/31 (48)
Walkers	74/190 (39)	66/141 (47)	20/57 (35)

* Values are the number/total number (%) of participants. Each outcome was assessed for its presence versus absence (yes/no) in walkers relative to non-walkers. OA = osteoarthritis; K/L = Kellgren/Lawrence; JSN = joint space narrowing.

non-walkers, with an adjusted odds ratio (OR) of 0.6 (95% CI 0.4–0.8) (Table 2). The adjusted OR for the outcome of medial JSN progression in walkers compared to non-walkers was 0.8 (95% CI 0.6–1.0) (Table 2). The other 2 outcomes, worsening of K/L grade and improved frequent knee pain, did not show statistically significant increased odds of occurring in walkers compared to non-walkers.

Results of stratified analyses based on age groups were similar to those observed in the whole group for all ages, and did not provide any suggestion of reverse causation (data not shown). In sensitivity analyses based on the assumption that all participants who had missing data on walking were non-walkers, the results were similar to those in the primary analysis (see Supplementary Table 2, available on the *Arthritis & Rheumatology* website at https://onlinelibrary.wiley.com/doi/10.1002/art.42241). In analyses based on the assumption that all participants who had missing data on walking were walkers, the results were also similar, though the point estimates for medial JSN grade worsening were closer to 1 and no longer statistically significant (see Supplementary Table 3, available on the *Arthritis & Rheumatology* website at https://onlinelibrary.wiley.com/doi/10.1002/art.42241). Importantly for the outcome of new frequent knee pain, the finding was robust in both imputation models.

In stratified analyses based on static knee alignment (Table 3), walkers with varus alignment less frequently developed new frequent knee pain compared to non-walkers in this group (28% versus 39%), and fewer walkers with varus alignment experienced K/L grade worsening (20% versus 26%) and medial JSN grade worsening (31% versus 39%) compared to non-walkers with varus alignment. In the group of participants with neutral static alignment, walkers less frequently developed new frequent knee pain (23% versus 36%) and more frequently experienced improved frequent knee pain (47% versus 38%) compared to non-walkers. However, among those with neutral alignment, walkers more frequently experienced medial JSN worsening (17% versus 11% of non-walkers). Interestingly, walkers with valgus alignment more frequently had K/L grade worsening (20% versus 15%) and less frequently had improved frequent knee pain (35% versus 48%) than non-walkers with valgus alignment. Thus, there did appear to be a potentially differential effect of walking for exercise based on knee static alignment.

DISCUSSION

Findings from our study support the idea that walking is beneficial in patients with knee OA, in terms of both structural modifications and symptom improvements. Specifically, we found that those who walked for exercise were less likely to develop new frequent knee pain; however, we found no relationship between walking and improvement in frequent knee pain. Hence, it may be especially beneficial to advise people to walk for exercise to help prevent the onset of frequent knee pain. These findings also offer the first reported evidence that walking may be an effective treatment to slow the structural progression of knee OA. Our findings highlight the possibility that biomechanical interventions may hold the key to the elusive treatments in this disease and might provide benefit in alleviating the structural progression and symptoms of OA. This is potentially an important paradigm shift in the field of OA research.

To our knowledge, this is the first study to explore the effects of walking stratified by knee static alignment. Specifically, we observed that walking might be related to less symptomatic and structural progression among knees with varus alignment (48% of cohort), less symptomatic progression among knees with neutral alignment (36% of cohort), and possibly little benefit among knees with valgus alignment (16% of cohort). Previous studies have yielded a wealth of data indicating that knee OA is largely biomechanically driven (15,19–27), and therefore it is not surprising that we found that static alignment could be an important effect measure modifier in evaluating the association between walking and knee OA progression. It will be important to replicate these analyses in other epidemiologic studies with larger groups of subjects with knee OA stratified according to neutral alignment versus valgus alignment to confirm these findings.

As supported by our study, the current guidelines advocate that walking is beneficial for knee OA. Investigators who conducted a systematic review to inform the 2018 Physical Activity Guidelines for Americans (28) reported that, while there is moderate evidence of the safety of walking for exercise involving up to 10,000 steps/day, there is limited evidence to indicate that walking more than 10,000 steps/day may adversely affect knee OA progression (29). It is unclear if our findings address those concerns, since we focused on walking for exercise, and fewer than 14% of participants in a US-based cohort, similar to the Osteoarthritis Initiative, exceeded 10,000 steps/day (30). There are 2 moderate to large-sized epidemiologic studies, including those with and those without knee OA, suggesting harmful outcomes related to walking (31,32). These studies used step counts from activity monitors over 7 days to quantify daily step counts. This is the standard method of using physical activity monitoring data; however, this is potentially problematic as the exposure ascertainment time frame is very short and not specific to walking for exercise, and people are known to modify their activity when they know they are being monitored. Thus, these measures may not be a true reflection of the amount people walk for exercise over an extended time. In our study, we used a retrospective, self-reported measure of walking. While our measurement method has limitations due to recall bias, a benefit to our method of ascertaining walking is that it provides an average amount of data on walking for exercise over a much longer time period.

There are some limitations to our study. This is an observational study wherein the walkers were self-selected. There is the possibility that the association observed may result from reverse causation; people might walk more because they have less severe knee OA, as opposed to the possibility that walking is protective against progression of OA. We performed age-stratified analyses in which the findings were similar to those obtained in the whole group, making this possibility of reverse causation less likely, based on the idea that people self-selected walking for exercise; if the situation of reverse causation existed, then those who had knee pain at a younger age when they did walk would presumably stop over time because they had pain, which was not observed in our study.

Another limitation is that, as mentioned previously, the walking exposure was ascertained retrospectively, which raises concerns about recall bias. Beyond the idea that people had to think back over their life to estimate their walking exposure, the addition of the Historical Physical Activity Survey Instrument was part of an ancillary study to the main Osteoarthritis Initiative study, and therefore the ascertainment of the exposure of physical activity was performed after the outcomes of interest. Admittedly, this is not ideal; however, since the participants were reviewing their lifetime of physical activity, which was already a retrospective activity, it is less likely that the timing of the administration of the instrument detracts from the observed findings. Of important note, participants were unaware of our specific study questions when they completed the surveys, making the retrospective aspects of the ascertainment less likely to impact our results.

Another limitation of our study is that it used participants who had radiographic knee OA and who were ages 50 years and older. Therefore, it is not clear if these results would apply to those without OA and those in younger age groups.

Finally, because of the nature of the cohort, static knee alignment was not ascertained at the same time for all participants. However, static alignment is unlikely to change rapidly over time. Future studies should make a particular effort to assess static alignment at the baseline evaluations.

This study only addresses walking for exercise. It does not address the situation of compulsory walking, such as occupational walking (e.g., mail carriers) or walking for transportation. Although the study assesses walking for exercise over several years, it was based on self-report, not step counts from an activity monitor; thus, specific statements about extremely high exposures to walking cannot be made.

In conclusion, the findings from our study provide a glimmer of hope that there may be an inexpensive intervention that modifies the structure and symptoms related to knee OA, the most common type of arthritis and a source of substantial disability. Clinicians should encourage patients to walk and consider in-person or web-based walking programs, such as "Walk with Ease," which has demonstrated durable benefits over 1 year (33,34). Our findings support recommendations by professional societies that walking for exercise should be encouraged. Beyond a benefit in terms of alleviating the symptoms of knee OA, the findings from our study also suggest that walking may also provide a structural benefit for a large portion of the community with OA. A randomized controlled trial of walking in those with knee OA stratified by alignment is warranted.

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. Mr. Richard 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.

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