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Slower walking speed is associated with incident knee osteoarthritis-related outcomes

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Abstract

Objective—To determine whether slower walking speed was associated with increased risk of incident hip and knee osteoarthritis (OA)-related outcomes.

Methods—After providing informed consent, community-dwelling participants in the Johnston County Osteoarthritis Project completed two home-based interviews and an additional clinic visit for radiographic and physical evaluation. One thousand eight hundred fifty eight non-institutionalized residents age 45 years or older living for at least one year in one of six townships in Johnston County, North Carolina completed the study's questionnaires and clinical examinations at baseline and at follow-up testing. Walking time was assessed using a manual stopwatch in 2 trials over an 8 foot distance, and walking speed was calculated as the average of both trials. For the hip and knee, we examined 3 outcomes per joint site: radiographic OA (weight-bearing anteroposterior knee radiographs, supine anteroposterior pelvic radiographs of the hip); chronic joint symptoms; and symptomatic OA. Covariates included age, gender, race, education, marital status, body mass index, number of self-reported, health care provider-diagnosed chronic conditions, number of prescriptions, depressive symptoms, self-rated health, number of lower-body functional limitations, smoking, and physical activity.

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Results—Faster walking speed was consistently associated with lower incidence of radiographic (adjusted odds ratio [aOR]=0.88, 95% confidence interval [CI]=0.79–0.97) and symptomatic knee OA (aOR=0.84, 95% CI=0.75–0.95); slower walking speed was associated with greater incidence of these outcomes across a broad range of different clinical and radiographic OA outcomes.

Conclusion—Slower walking speed may be a marker for incident knee OA, but other studies must confirm this finding.

Keywords

Osteoarthritis; Gait; Epidemiology

Habitual walking speed is an excellent predictor of future hospitalization, disability, and death, with slower speeds increasing these risks across a spectrum of age groups, functional abilities, chronic conditions, and types of health outcomes [1–10]. The mechanisms by which walking speed are related to health are unknown. Speed of walking may be a marker of general health and physical functioning or could have specific biological and/or mechanical effects over time. Few studies have looked at walking speed's associations with incident morbidities occurring early in the disablement process. Examining these associations may improve our understanding of whether slower walking also may be associated with disabling disease over time.

Habitual walking speed may be a predictor or early marker of osteoarthritis (OA), a joint disease associated with pain and functional limitations with typical onset in mid-life. Increased joint stresses occur with faster walking speeds [11, 12], and repetitive high-level dynamic joint loading has been shown to contribute to chondrocyte death [13] and the development of OA in animal models [14]. Faster walking speed in combination with abnormal joint biomechanics may further amplify dynamic joint loading [11] and may accelerate joint degeneration. Decreasing walking speed has been suggested as a mechanism used by individuals with knee pathologies to reduce loading and pain in the medial compartment of the knee [15]. In cross-sectional analyses, individuals with knee or hip OA walk more slowly with smaller stride lengths and greater stance duration than those with healthy joints [16–19].

Before OA is evident on clinical examination or with diagnostic images, individuals may exhibit signs of early disease, particularly poorer functional abilities, including slower walking speed. OA can be defined in a variety of ways, and its definition is evolving because radiographic findings and symptoms do not always correlate. Here, we defined OA-related outcomes in 3 ways: radiographic OA (rOA), a standard in the field [20–23]; chronic joint symptoms; and symptomatic OA--the presence of chronic joint symptoms and rOA in the same joint [23, 24].

The purpose of this study was to determine whether habitual walking speed is associated with the risk of incident hip and knee OA-related outcomes over an average 6 year follow-up period. Faster walking speeds may contribute to greater aberrant mechanical effects at the knee and hip over time and, in turn, be associated with incident hip and knee OA-related outcomes. Alternatively, based on the complexities of defining OA and a short mean follow-up time (which may not be adequate for a healthy joint to develop OA), slower walking speed may be a marker of pre-clinical disease and would be associated with incident hip and knee-OA related outcomes.

METHODS

Data

Briefly, the Johnson County Osteoarthritis Project is a community-based cohort study of hip and knee OA among community residents aged 45 and older, recruited by probability sampling of Caucasian and African-Americans in 6 townships of Johnston County, North Carolina [24, 25]. After giving informed consent, participants completed home interviews and a clinic visit for radiographic and physical evaluation. The baseline cohort of 3,187 residents was assembled from 1991–1997 (T0), with follow-up of 1858 participants from 1999–2004 (T1). The 1,329 lost to follow-up included: emigration from study area (N=161), refusals (N=435), physically or mentally unable to participate (N=234), death (N=411), and inability to locate, following search of local death indices and the National Death Index (N=88). The mean time from baseline to follow-up was 6.1 years (standard deviation=1.4 years, range=3.6–13.3 years). Compared to participants who returned for the follow-up visit, those who did not return were more likely to be men (42.2% vs. 34.8%, Chi-square $p<0.01$), African American (36.2% vs. 29.8%, Chi-square $p<0.01$), and older at baseline (mean age 63.7 years vs. 60.2 years, t-test $p<0.01$).

Measures

Primary Outcome (Dependent) Variables—Radiographic and joint symptom data were used to define the 5 primary outcome variables. Bilateral weight-bearing anteroposterior radiography of the knee with foot mat placement was performed, as previously described [24]. Women age 50 or older and all men completed supine anteroposterior pelvic radiography; women under age 50 did not complete baseline pelvic radiographs to limit radiation exposure to their reproductive tissues, and thus, data for women under 50 were not available for radiographic and symptomatic hip OA analyses (n=216 from the 1858 with baseline and follow-up data). Radiographs were rated by a bone and joint radiologist (JBR) using the Kellgren-Lawrence (K-L) radiographic atlas for knee and hip radiographic grades [21, 22]. Inter-rater and intra-rater reliability for the radiologist were high (weighted kappa 0.86 and 0.89, respectively) [25]. K-L grades range from 0 to 4 (none, questionable, mild, moderate or severe OA); *rOA* was defined by K-L grades ≥ 2. *Chronic joint symptoms* were defined as a participant's "Yes" response to the question: "On most days do you have pain, aching or stiffness in your [left/right] [knee/hip]?" *Symptomatic OA* of a hip or knee was defined by presence of rOA and self-reported chronic joint symptoms in the same joint. *Isolated rOA* was defined as rOA without presence of chronic joint symptoms, and *isolated chronic joint symptoms* as incident chronic joint symptoms without presence of rOA.

Three non-mutually exclusive analytic cohorts (sub-samples) were created to assess different incident outcomes (Figure 1). First, we identified the 860 participants free of any *rOA* at baseline (Sub-sample I), which allowed us subsequently to estimate incident rOA, regardless of symptoms. Second, we identified the 1,195 participants who were free of symptomatic OA at baseline (Sub-sample II), that is, they may have had chronic joint symptoms without rOA, rOA without chronic joint symptoms, or neither. This cohort allowed us to estimate incident *symptomatic OA* among those with none or just one component of the definition. Third, we identified 396 participants free of baseline hip or knee chronic joint symptoms and also free of baseline rOA (Sub-sample III). This allowed us to simultaneously estimate incident radiographic and symptomatic OA as well as two new outcomes--the incidence of isolated chronic joint symptoms and isolated rOA—in a cohort more likely to be free of subclinical OA at baseline.

Primary Independent Variable—Walking time was assessed using a manual stopwatch in 2 trials over an 8 foot distance; the 2 trials were averaged and walking speed in meters/second was calculated. Participants also reported whether they experienced pain during the test ("pain during walking test"—see Table 1), which was entered into models as a potential confounder. The 8 foot walk test has been reported to have good reliability among adults 60+ years of age, with intra-class correlation coefficients (ICC) of 0.79 [26] and 0.72 [27] for intra-observer reliability and ICC= 0.52 for inter-observer reliability [27]

Covariates—All covariates were measured at baseline and were included because they relate or may relate to walking speed or OA-related outcomes. Education and marital status were used as proxies for socioeconomic status; income data were not available for the whole sample. Age, gender, race (Caucasian versus African American), education (≤ high school graduate versus other) current marital status (married versus not married), and measured body mass index (BMI; weight in kilograms/height in meters squared [kg/m^2]) were described. The number of 13 self-reported physician-diagnosed chronic conditions (asthma, tuberculosis, chronic bronchitis, emphysema, "other" lung conditions, hypertension, stroke, high cholesterol, myocardial infarction, cancer, anemia, diabetes, and Parkinson's disease) were summed and grouped (0, 1, 2, 3+), along with the number of prescription medications (0, 1–2, 3+). Depressive symptoms were assessed using the Centers for the Epidemiological Studies of the Elderly Depression Scale (CESD, range 0–60) [28]. Self-rated health was recorded as excellent, good, fair or poor. To control for potential confounding by existing functional limitations that might influence walking speed or mobility, self-reported (primarily lower-body) functional limitations were selected from the Health Assessment Questionnaire [29], and the number of limitations was summed for items involving dressing, standing, transferring bed to chair, walking outside, up five steps, lifting 5 pounds, running errands or shopping, transferring in and out of a car, doing chores, bathing, and toileting (0, 1–2, 3+). Current smoking (yes/no) and any physical activity (yes/no response to the question "During the past month, did you participate in any physical activities or exercises such as running, calisthenics, golf, gardening, or walking for exercise?") were also recorded.

Statistical Analysis—Incident cases of OA-related outcomes were identified, and logistic regression was used to estimate the effect of baseline walking speed (increment in the odds ratio per each clinically meaningful increment of walking speed, defined as 0.10 m/sec) [3] on OA-related outcomes. This definition of walking speed has been shown to be an important walking speed difference between individuals that is related to poorer health outcomes. All analyses were adjusted for age, gender, race, education, marital status, BMI, number of comorbidities, depressive symptoms, number of medications, physical activity level, current smoking, self-rated health, pain during walking speed trials, and number of lower body limitations. To explore the effect of an alternate definition of rOA on estimates, we conducted post-hoc sensitivity analyses with K-L ascertainment of rOA of scores of 1 or more (which typically are not regarded as indicative of rOA). All analyses used performed using STATA 10.0/SE. Additionally, the inclusion of men, but not women, from the 45–50 years age range may bias results of the hip OA outcomes, and we conducted post-hoc sensitivity analyses to compare hip OA outcome results with and without the men under the age of 50 (N=341). The adjusted models included many covariates, and we considered the addition of baseline injury, although the covariates of lower body limitations and pain with walking likely accommodated this potential confounder. We conducted a post-hoc sensitivity analysis comparing results with and without injury as a covariate.

RESULTS

Table 1 shows baseline characteristics of the overall study cohort and the three sub-samples. For the overall cohort, the average age was 60.1 years. The majority were female, white,

married and without more than a high school diploma. Approximately one-fourth rated their health as fair or poor and, on average, participants were overweight (mean BMI=29.2 kg/m^2 [30]. Depressive symptoms were low (median=3) [28]. Approximately 15% had 3 or more comorbidities, 36% were taking 3 or more prescription medications, 18% were current smokers, and 46% did not have any physical activity. Almost one-third reported lower body functional limitations. Baseline mean walking speed (0.87m/s) was slower than reported normal speeds of 1.2 m/s for healthy older adults (65 + years old) and also below 1.0 m/s, which is highly predictive of 1-year mortality in population-based cohorts of adults 70–79 years of age [9].

As expected, sub-samples I-III were generally healthier than the overall cohort, since individuals with prevalent OA-related outcomes at baseline were removed from the population at risk (those with rOA at baseline were removed from sub-sample I, those with symptomatic OA were removed from sub-sample II, and those with any symptoms or radiographic findings in any knee or hip joint were removed from sub-sample III). Table 1 shows that sub-sample III had the best self-rated health, least comorbidity and medication use, lowest self-reported lower body functional limitations, fastest walking speeds, and the lowest frequencies of pain while walking.

Table 2 shows the results of the logistic regression analyses in the three sub-samples. The results are presented as an incremental increase of gait speed, showing an inverse association between faster walking speed and knee OA outcomes. An inverse association between faster walking speed and incident OA implies a positive relationship between slower walking speed and incident OA. In 2a–c, results are shown first for the incident OA outcome (or, for Subsample III, outcomes) at any joint in the sub-sample, followed by outcomes in either knee and either hip at T1 follow-up. (Results for the left and right knee and hip are shown in Supplementary Table S1.) Table 2a, for example, shows that faster walking speed was generally associated with lower incident rOA at either knee, but not at either hip; thus, slower walking speed is associated with higher incident knee rOA. Table 2b shows that in those at risk for symptomatic OA (Subsample II), faster baseline walking speeds also were associated with lower incident symptomatic OA at the knee (i.e., slower walking speed associated with higher incident symptomatic knee OA) but not the hip. Finally, Table 2c shows the healthiest cohort, i.e., those least likely to be biased by subclinical disease. Faster walking speed again was significantly associated with lower incident rOA at the knee (i.e., slower walking speed associated with higher incident knee rOA), but not at the hip. Faster speed was also associated with lower incident isolated rOA at either joint site (see data in Table 2c for incident rOA at T1 and for incident *isolated* rOA at T1). ORs for incident symptomatic knee OA, other measures of incident isolated rOA, and incident isolated symptoms showed no statistically significant associations.

Results of post-hoc sensitivity analyses with rOA defined as K-L grade of 1 or more at baseline (Supplementary Table S2) could only be reasonably estimated for symptomatic OA outcomes due to small counts for radiographic OA and radiographic OA/joint symptoms outcomes. The symptomatic OA outcomes defined as K-L grade of 1 or more did not differ substantially from results presented in this paper using a definition of K-L grade of 2 or more. Post-hoc sensitivity analyses comparing results with and without the men under the age of 50 (Supplementary Table S3) and results with and without history of injury (Supplementary Table S4) also reveal similar estimates.

DISCUSSION

The principal result from the current study is that in a cohort of mid-to-older age adults, slower walking speeds (in increments that have been previously demonstrated to be

clinically significant between individuals, i.e., 0.10 m/sec as described above) are associated with higher incidence of radiographic and symptomatic knee OA, while faster walking speeds appear to be associated with lower incidence. Estimates in a smaller subsample designed to eliminate possible preclinical disease supported this result. There were no significant findings of walking speed related to hip OA-related outcomes.

A number of studies suggest that faster walking speeds might alter the overall biomechanics of walking. Biomechanical studies have shown increased angular excursions at the knee during the swing phase of faster versus slower walking, at least partly due to higher passive coriolis and centrifugal forces [31], possibly resulting in altered alignment at heel strike (i.e., decreased knee extension) for slower versus faster walking. The relative contributions of different muscles and muscle activation patterns also appear to play a functional role in the known altered biomechanics of faster versus slower walking [31]. Faster walking results in a decrease in the percentage of the walking cycle spent in stance phase (62.6% at self-selected normal speed versus 60.6% at faster speed) [32], which would decrease the total duration of weight bearing load on a joint over time [33]. Studies of children and young adults have demonstrated that joint moments and powers in the lower extremity are increased with faster walking speeds [34, 35], although patterns of joint loading and muscle activation differ among older adults [36–38]. Finally, there is a relatively greater magnitude of lower extremity musculotendinous activity and coactivation at the knee and ankle observed among older adults during faster versus slower walking speed [36] which may increase joint loading or may provide more stability to the joints to help attenuate overall joint moments (e.g., cushioning) [31].

Interestingly, our results -- that slower walking is associated with higher incidence of knee OA are not consistent with a hypothesis that the mechanical effects of faster walking may have contributed to the development of knee or hip OA in this study and also are counter to recent hypotheses that reduced walking speed and/or “mindfulness walking” may help to reduce peak adduction moments and joint loads at the knee [39, 40],and also help reduce knee joint symptoms [41]. Most of these studies are cross-sectional, with some investigators supporting, but others more neutral, on slower walking as an appropriate intervention to decrease knee joint loads.

Our findings may have important implications for prevention and treatment because pharmaceutical and exercise interventions have documented impact on walking speed [42]. During fast walking, the rate of joint loading increases, as well as the rate of energy absorption, particularly at the knee [43]. A healthy knee joint (one that does not have OA) would theoretically be able to tolerate a greater rate of joint loading. In a knee joint with damaged or weakened articular cartilage, faster walking may not be tolerated because the cartilage is less able to dissipate forces [44]. Potentially, individuals without radiographic or symptomatic OA at baseline in this study may have had early joint changes that were not detectable. If so, such individuals may have slower self-selected walking speeds, as observed at baseline, to reduce the rate of joint loading, and possibly later developed detectable OA. The individuals who could walk more quickly at baseline may have also maintained better joint health during the study, contributing to decreased OA at follow-up. In an attempt to adjust for potential confounder effects, we controlled for lower extremity joint limitations and self-reported pain during walking test, and examined progressively more restricted (i.e., healthier) cohorts to reduce prevalent OA as a possible explanation for our findings.

One novel result of this study was the discrepancy in effects at the knee and hip. Incidence of hip OA is estimated to be approximately 88 per 100,000 person-years, compared to 240 per 100,000 person-years at the knee [45]. The lower outcome incidence rates of the hip

compared to the knee would reduce the power of this study to detect significantly significant associations, but not the magnitude of the association Neither the magnitude nor the direction of our hip ORs suggest the potential presence of a real effect at the hip. Possibly, the knee is more susceptible than the hip to joint load variations that occur with slower and faster walking speeds, as previously suggested by studies that report an association between obesity (resulting in a greater joint load) and knee OA [20], but inconsistently with hip OA [46]. Our results suggest that slower walking speed is likely a better marker for identifying those at risk of developing OA-related outcome for the knee but not for the hip.

General strengths of this study include the large, community cohort, the prospective study design, adequate representation of Caucasians and African Americans, and the fact that case ascertainment at baseline and follow-up was confirmed by clinical and radiographic assessment. In addition, in Sub-sample III, we were able to create a cohort more likely to be free of possible subclinical disease and report for the first time the simultaneous incidence of radiographic and symptomatic OA as well as the onset of isolated rOA and isolated symptoms.

There are several limitations as well. First, we do not have data on OA at other important lower extremity locations (ankles/feet) that could potentially impact our findings, and there were no lower extremity muscular strength, kinematic, or kinetic data collected that would allow us to further explore our findings. Anterior-posterior films of the knee were available, but other views, such as patellofemoral joint films, were not included in this analysis; alternate views may have provided additional evidence of radiographic disease of the knee. Second, the definition of OA (K-L grade ≥ 2) is primarily driven by the presence of an osteophyte, although osteophyte formation may not be the first feature that develops in all individuals. Assessments of individual radiographic features (i.e., separate examination of osteophyte formation or joint space narrowing) and their location (medial or lateral compartment) were not available for this cohort during the study period. Third, we assume that a clinically important difference in walking speed for individuals (0.10 m/sec) is also an important difference in walking speed when comparing populations. Previous work in the geriatrics literature has shown that differences between individuals in walking speed in increments as small as 0.10 m/sec are clinically significant for survival and functional mobility [3]. There is little in the literature assessing important differences in walking speeds when comparing populations, but in a study of older veterans hospitalized for geriatric evaluation and management, each positive difference in walking speed at hospital admission of 0.10 m/s between people was associated with improved physical function as indicated by a 4.5 point higher standardized Short Form-36 score, 2.1 point higher standardized Physical Functioning subscale score on the Short Form-36, and 0.63 fewer total activities of daily living (ADL) disabilities [3]. Fourth, approximately 40% of participants did not return for follow-up. Participants who did not return tended to be slightly older, African-American, and male compared to those who completed the follow-up visit. Analysis was limited to participants who were more likely to be younger and healthier at baseline, possibly biasing the association.

Although our analyses controlled for a variety of potential confounders, residual confounding is always possible in observational research. A randomized clinical trial design of a walking speed intervention and incident OA-related outcomes might more clearly describe the nature of the associations we observed and perhaps suggest additional avenues for future intervention development, although this type of study would require many years of observation.

Given the consistency of our findings across the different subsamples, walking speed may be a marker of knee joint health. We recommend further research to confirm these findings

and consideration of walking speed assessment during clinic visits as a means to help identify patients at greatest risk of developing OA, especially at the knee, and who may benefit from pharmaceutical and/or preventive interventions. Other performance-based measures and self-report physical function measures should be explored in future research to determine their utility alone and in combination with walking speed for identifying those at risk of developing lower extremity OA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Innovation

- Habitual walking speed has been shown to be a strong predictor of hospitalization, mortality, and a variety of morbidities, but few studies have examined the association between walking speed and disabling conditions, like osteoarthritis (OA), over time.
- Individuals with OA may have early signs of the disease, such as slower walking speed or other functional impairments, well before OA is detectable on examination or on diagnostic images.

Significance

- Slower walking speed may be a marker of poorer knee joint health. This marker may assist in the identification of individuals at greater risk for knee OA who may benefit from pharmaceutical and/or preventive interventions.

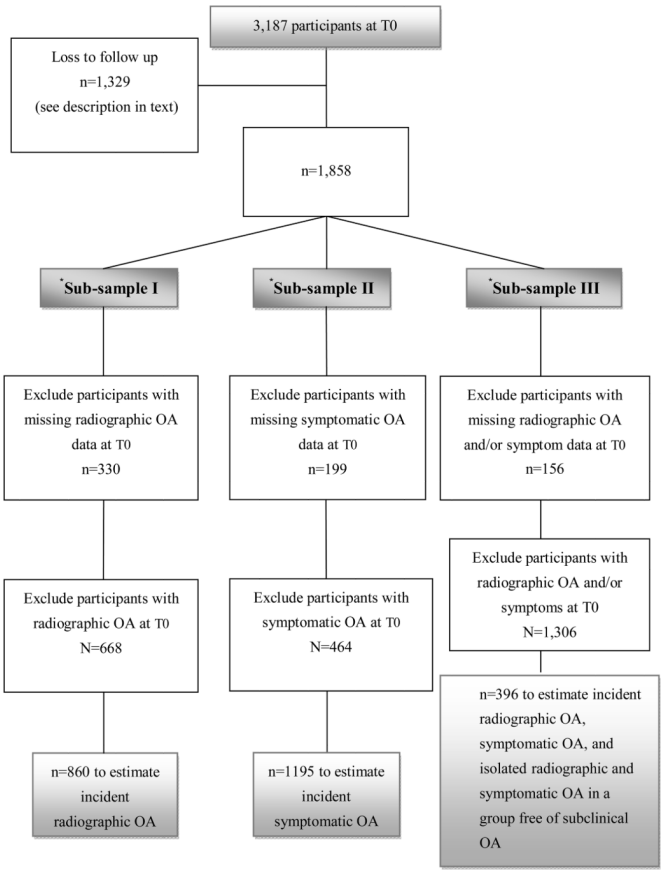

Figure 1.
Composition of the three baseline incidence samples used in analysis.
*Subsamples are not mutually exclusive.

Table 1

Selected Characteristics of the Study Sample and Sub-samples

	Total Sample	Sub-sample I (Without Radiographic OA at Baseline)	Sub-sample II (Without Symptomatic OA at Baseline)	Sub-sample III (Without Radiographic OA or Symptoms at Baseline
Case number	1858	860	1195	396
Mean Follow-Up Time (SD*) in years	6.1 (1.4)	5.9 (1.4)	6.0 (1.4)	5.8 (1.3)
Age (SD*)in years	60.07 (9.86)	58.90 (8.43)	58.76 (9.11)	58.51 (8.73)
% Gender				
Male	34.8	40.3	38.5	46.2
Female	65.2	59.7	61.5	53.8
% Race				
White	70.2	75.2	72.2	72.5
Black	29.8	24.8	27.8	27.5
% Education				
1–12 years	68.4	66.6	64.5	59.6
13+ years	31.6	33.4	35.5	40.4
% Marital status				
Married	64.5	69.7	69.2	70.2
Not currently married	35.5	30.3	30.8	29.8
% Self-rated health				
Excellent	25.3	29.4	30.3	37.1
Good	48.2	47.8	50.1	50.0
Fair or poor	26.5	22.8	19.6	12.9
Mean (SD*)Body Mass Index in kilograms/meter^2	29.18 (5.91)	28.43 (5.01)	28.31 (5.14)	28.00 (5.09)
Median Depressive symptoms (IQR†)	3 (8)	3 (8)	3 (7)	2 (6)
% Number of Comorbidities				
0	32.0	33.3	35.8	39.5
1	32.1	33.8	34.0	35.0
2	21.2	20.9	19.1	18.6
3+	14.7	12.0	11.1	6.9
% Number of prescribed medications				
0	27.7	31.3	33.3	40.2
1–2	37.3	36.4	37.8	34.8
3+	36.0	32.3	28.9	25.0
% Any physical activity				
No	45.7	42.1	42.0	42.4
Yes	54.3	57.9	58.0	57.6
% Lower body limitation				
0	65.2	69.9	76.0	88.5
1–2	14.0	13.2	11.1	7.7

	Total Sample	Sub-sample I (Without Radiographic OA at Baseline)	Sub-sample II (Without Symptomatic OA at Baseline)	Sub-sample III (Without Radiographic OA or Symptoms at Baseline
3+	20.8	16.9	12.9	3.8
% Currently smoking				
No	82.1	80.3	81.3	81.0
Yes	17.9	19.7	18.7	19.0
Mean walking speed (meters/second)	0.87 (0.28)	0.93 (0.27)	0.92 (0.27)	0.98 (0.26)
% Pain during walking test?				
No	82.8	88.4	90.6	96.6
Yes	17.2	11.6	9.4	3.4

Note: Sub-sample I is free of radiographic OA at baseline; sub-sample II is free of symptomatic OA at baseline; sub-sample III is free of radiographic OA and symptoms at baseline.

*SD=standard deviation

†IQR=interquartile range

Table 2

The Impact of Faster (per 0.1 m/sec) Baseline Walking Speed on Incidence of OA-related outcomes

OA	Incidence (percentage)	Adjusted OR	95% CI
a) Sub-sample I: 860 Subjects without Radiographic OA (K-L grade 2+) at T0			
Incident Radiographic OA at T1			
Any joint radiographic OA	214/835 (25.6)	0.93	[0.86, 1.02]
---Either knee radiographic OA	148/849 (17.4)	0.88†	[0.79, 0.97]
---Either hip radiographic OA	83/842 (9.9)	1.01	[0.90, 1.13]
b) Sub-sample II: 1195 Subjects without Symptomatic OA at T0			
Incident Symptomatic OA at T1			
Any joint symptomatic OA	167/1156 (14.5)	0.92	[0.84, 1.01]
---Either knee symptomatic OA	118/1165 (10.1)	0.84‡	[0.75, 0.95]
---Either hip symptomatic OA	58/1174 (4.9)	1.06	[0.93, 1.20]
c) Sub-sample III: 396 Subjects without Any Radiographic OA or Joint Symptoms at T0			
Incident Radiographic OA at T1 (K-L grade 2+)			
Any joint radiographic OA	91/385 (23.6)	0.87†	[0.76, 0.99]
---Either knee radiographic OA	61/393 (15.5)	0.82†	[0.70, 0.97]
---Either hip radiographic OA	41/386 (10.6)	0.97	[0.82, 1.13]
Incident Isolated Radiographic OA at T1 (K-L grade 2+; no joint symptoms)			
Any joint radiographic OA only	47/390 (12.1)	0.82†	[0.69, 0.98]
---Either knee radiographic OA only	38/394 (9.6)	0.87	[0.72, 1.06]
---Either hip radiographic OA only	33/388 (8.5)	0.90	[0.75, 1.09]
Incident Symptomatic OA at T1(K-L grade 2+; positive joint symptoms)			
Any joint symptomatic OA	27/394 (6.9)	0.94	[0.75, 1.17]
---Either knee symptomatic OA	20/395 (5.1)	0.78	[0.58, 1.05]
---Either hip symptomatic OA	7/395 (1.8)	1.49	[0.97, 2.27]
Incident Isolated Symptoms at T1 (symptoms; K-L grade <2)			
Any joint symptoms only	93/391 (23.8)	0.99	[0.87, 1.11]
---Either knee symptoms only	74/395 (18.7)	0.96	[0.85, 1.09]
---Either hip symptoms only	68/394 (17.3)	1.02	[0.90, 1.17]

† P<0.05

‡ P<0.01

Results of modeling have been adjusted for the following variables: age, gender, race, education, marital status, self-reported health, BMI, depressive symptoms, number of comorbidity, number of prescribed medications, participation of any physical activity, number of low body limitations, smoking status, presence of pain during walking speed assessment.