Knee Osteoarthritis Compromises Early Mobility Function: The Women's Health and Aging Study II

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ABSTRACT. ***Objective***. To examine associations between osteoarthritis (OA) of the knee and early functional limitations in a cohort of high-functioning older women, and evaluate the contributions of muscle strength, body weight, and pain severity to these limitations.

Methods. Cross sectional analyses were conducted on baseline data of the Women's Health and Aging Study II (WHAS II), an observational study of disability transitions in a cohort of women aged 70–79 upon entry and who were representative of the one-third highest-functioning community-resident women. Standardized questionnaires and examinations were used to assess knee OA features, medication use, pain severity, knee extensor muscle strength, and body weight. Functional limitation was assessed using validated performance measures and self-report measures of task modification and task difficulty.

Results. Sixty-nine women classified as "symptomatic" for knee OA, 48 with "asymptomatic/intermittently symptomatic," knee OA, and 285 with "no knee OA" were included in the final analysis. Despite selection for their high level of self-reported function, performance was slower and task modification was more frequently reported among women with knee OA than women without knee OA. Lower knee extensor strength, higher body weight, and greater pain severity were associated with knee OA, and also with functional limitations.

Conclusion. Knee OA appeared to be associated with early functional limitations in this cohort of high-functioning, older, community-resident women. Lower knee extensor strength, higher body weight, and pain severity were closely associated with these limitations. The extent to which modification of these factors attenuates knee OA associated functional decline should be investigated. (J Rheumatol 2003;30:114–20)

Key Indexing Terms:
KNEE OSTEOARTHRITIS MOBILITY FUNCTION

Osteoarthritis (OA) is highly prevalent among older adults[1] and is strongly linked to late-life disability[2-6]. Knee OA is particularly prevalent in older women, who are more likely to report pain[7] and physical disability[2,8], and who also have less skeletal muscle mass than men[9].

Cross sectional and longitudinal studies have clearly established that knee OA is closely associated with mobility disability[10-14] and with disability progression[15]. Such studies have commonly used questionnaires that assess whether or not, or the extent to which, a given task is perceived to be difficult. However, less is known of changes in function before the development of task difficulty. Data from the Women's Health and Aging Study (WHAS) II has provided evidence that self-reported task difficulty is preceded by task modification — a preclinical stage of disability[16,17]. Early functional deficits associated with knee OA can be examined in the context of this well-functioning cohort. We sought to (1) characterize knee OA associated preclinical disability, and (2) examine pain severity, knee extensor muscle strength, and body weight as potential mediators of impaired performance and knee OA associated functional limitations. These characteristics were selected on the basis of their close association with knee OA and their potential for modification with interventions.

MATERIALS AND METHODS

Design. Cross sectional analyses were conducted on baseline data of the WHAS II. WHAS II is a prospective, population based observational study designed to elucidate the transition from well-functioning to preclinical and clinical disability in community-resident older women.

Study population. The detailed methodology for screening and recruitment

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of the WHAS II sample has been published[16-18]. In brief, the WHAS II sample was based on age stratified random samples drawn from the Health Care Financing Administration Medicare files that list all female beneficiaries age 70–79 years in 12 contiguous zip code areas in Baltimore city and county, Maryland. A screening interview was conducted to assess cognition and function in 4 domains: mobility, upper extremity function, household management and tasks requiring higher function, and basic self-care. Women were eligible to participate if they reported difficulty in only one of these domains, and scored ≥ 24 on the Folstein Mini-Mental Status Examination[19]. Of the 1630 screened, 880 were eligible to participate, and 436 women (49.5%) agreed to participate in the extensive examination. Women who were eligible but declined participation were less educated, had lower income, and were more likely to rate their health status as fair or poor[18].

Data collection. Study participants were evaluated in the Johns Hopkins Functional Status Laboratory by trained evaluators following standardized protocols[16,17].

Sociodemographic and clinical factors. Questionnaires administered during an interview were used to determine participant age (years), race, marital status, whether they live alone or with another person, and disease diagnoses reported by a physician. Self-reported diseases were verified by questionnaires completed by the participants' physicians or by medical record review. The total number of diseases reported and verified was summed. WHAS staff verified medications taken for arthritis and for other conditions as described by Pahor, *et al*[20]. The Geriatric Depression Scale (GDS) was used to assess depressive symptoms[21].

Study group classification. Participants were classified as "symptomatic OA of the knees," "asymptomatic/intermittently symptomatic OA of the knees," "possible OA of the knees," or "no OA of the knees" using an algorithm modeled on the American College of Rheumatology (ACR) classification criteria[22] for OA (Figure 1)[23]. Self-report, examination, and radiographic data incorporated in this algorithm were acquired in the following manner. Self-report of a physician diagnosis of arthritis was assessed by asking participants, "Has a doctor ever told you that you had arthritis?" and also, "Which type of arthritis do you have? Is it rheumatoid arthritis, osteoarthritis or degenerative arthritis, or some other type?" All self-reported diagnoses were confirmed by questionnaires completed by each participant's primary care physician. Both knees were examined for tenderness on palpation, painful or limited passive motion, deformity and crepitus, and bony enlargement. Available knee radiographs were scored independently by 2 rheumatologists independently. Disagreements about readings were adjudicated between the 2 reviewers together. Subjects were classified as "symptomatic" based on a positive response to the question, "During the past year, have you had pain, aching or discomfort in your knees on most days for at least one month?" or as "asymptomatic or intermittently symptomatic" based on a negative response to this question.

Assessment of hypothesized intermediary variables. Maximal isometric strength of the knee extensor muscles was measured using a handheld dynamometer (Nicholas Manual Muscle Tester, Model BK-7454, Fred Sammons Inc., Burr Ridge, IL, USA). During testing, participants were strongly encouraged to gradually increase the force to the greatest possible level while the tester was opposing[24]. Strength is expressed as kilograms of force the examiner had to apply to break the isometric contraction. One standard deviation (0.0084 kg) was used as the comparison unit of strength in the regression analyses. Participants were asked to rate the average pain they experienced with specific activities on a 1–10 scale using questions obtained from the Western Ontario and McMaster OA Index (WOMAC)[25]. Severity reported for stair climbing and walking was averaged and used in the analyses. Body weight (kg) was measured with a calibrated medical scale.

Assessment of performance, task modification, and task difficulty. Participants were assessed using validated timed performance tasks and self-report of task modification. Performance measures for each participant included the time (seconds) required to complete a 4 m walk at usual and rapid pace, perform 5 sequential chair stands as rapidly as possible with arms folded in front of the chest, and climb, then descend a flight of stairs[26]. Task modification was assessed by asking participants if they walked a half-mile, walked up 10 steps, performed bending, stooping or crouching, and transferred into or out of a car or bus[16,17] differently or less often than they used to. Task difficulty was assessed by asking participants, "For health or physical reasons, do you have any difficulty" with each of the aforementioned tasks[27].

Data analysis. Women with concurrent hip OA and/or rheumatoid arthritis, and those adjudicated as "possible knee OA" were excluded from these analyses to enable us to focus on knee OA associated functional decrements. Analysis of variance (ANOVA) and chi-square analysis were used to compare baseline characteristics of women with knee OA to women with no knee OA. Associations between knee OA with clinical disability were analyzed using multiple logistic regression, and with task performance using multiple linear regression. Separate models were constructed for each task. Pain severity, knee extensor strength, and weight were individually added to each of the models to assess whether these were independently associated with performance, and their roles as potential mediators of the disease-performance association. All analyses were conducted with adjustment for age, years of education, living situation, and depression score with sampling weights applied.

RESULTS

Of the 436 women of the WHAS II cohort, 69 were classified as having "symptomatic" knee OA, 48 "asymptomatic/intermittently symptomatic" knee OA, and 285 with "no knee OA." The "asymptomatic/intermittently symptomatic" group will be referred to here as "asymptomatic." As shown in Table 1, the 3 groups were comparable with regard to number of comorbidities and demographic characteristics, except for a trend to a lower proportion of women who reported living alone in the "symptomatic knee OA" group than in the "no knee OA" or "asymptomatic" groups. With regard to characteristics associated with knee OA, women with "knee OA" reported greater pain severity ($p < 0.001$) despite higher use of arthritis medications ($p < 0.001$), were heavier ($p < 0.001$), and had lower knee extensor strength ($p = 0.017$) than women with "no knee OA."

Knee OA associated mobility performance, task modification, and difficulty. As shown in Table 2, women in the knee OA groups required more time to complete all of the performance tests than women in the "no knee OA" group, except for completion of the 4 m walk. Higher proportions of women with knee OA also reported modification of how or how often they walked a half-mile ($p = 0.035$), transferred into or out of a car or bus ($p < 0.001$), and climbed or descended stairs ($p = 0.080$) than the "no knee OA" group. However, the proportions of the 3 groups that reported modification of bending and stooping and 2 or more mobility tasks did not differ. Mobility difficulty was also reported more frequently by women in the knee OA groups for each individual task ($p < 0.02$) and for multiple tasks ($p < 0.001$).

Post-hoc ANOVA conducted to examine differences in function between the 2 knee OA groups revealed trends toward slower performance on the stair climb task and

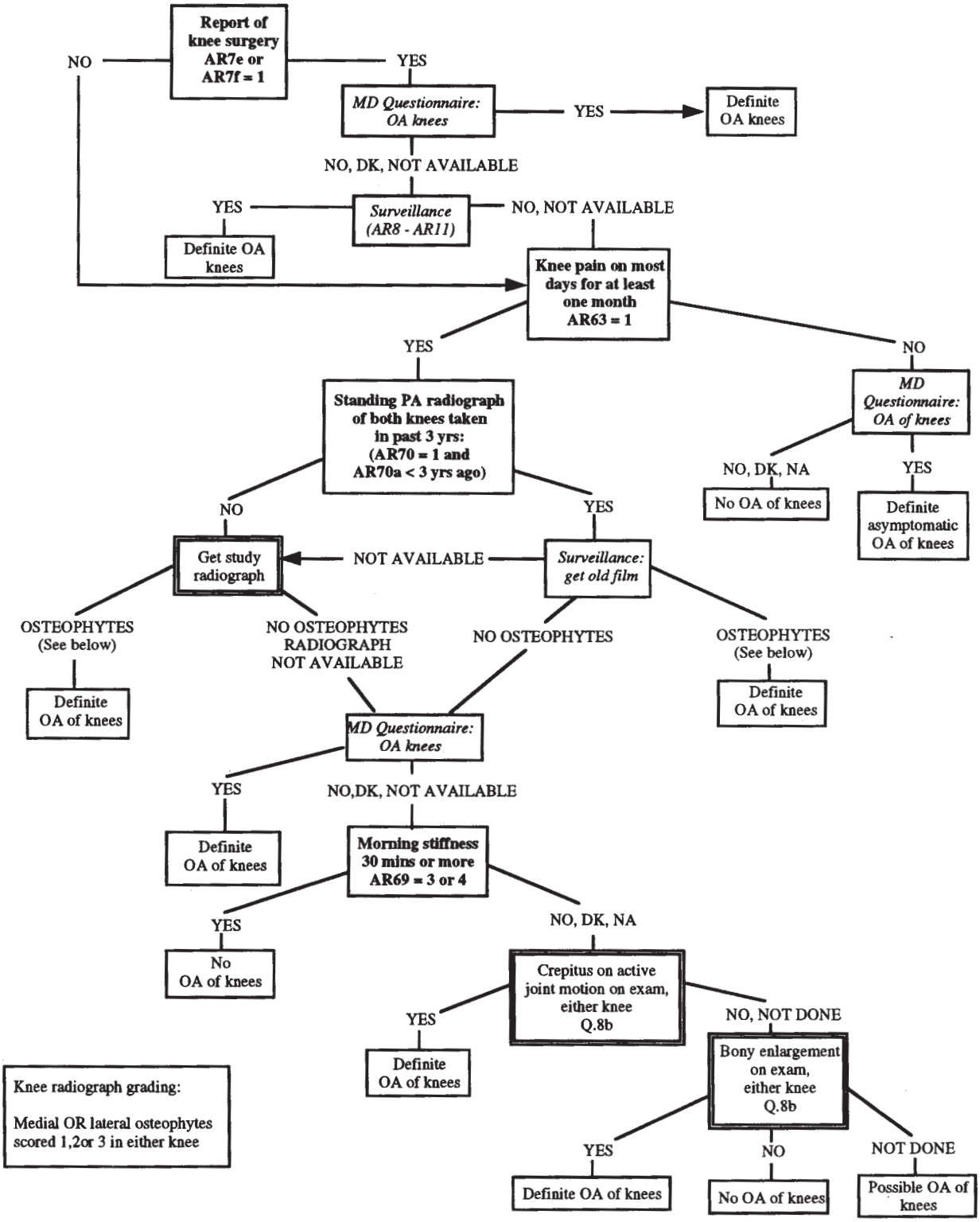

Figure 1. Algorithm for classification of knee OA incorporates multiple data sources. Self-report of a physician diagnosis of OA is supplemented with symptom presence, physical signs elicited on examination, radiographic findings, and confirmation of the diagnosis by physician completed questionnaires and/or medical record review and abstraction. This algorithm was applied to the WHAS II sample to classify participants as "symptomatic knee OA," "asymptomatic or intermittently symptomatic knee OA," and "no knee OA." The interrater kappa score for this algorithm is 1.0[24].

Table 1. Demographic and clinical characteristics of 3 groups of high-functioning women by knee OA category.

	Symptomatic OA, n = 69	Asymptomatic OA, n = 48	No OA, n = 285	p
Demographic variables				
Age, mean yrs ± SEM	74.13 ± 0.37	73.98 ± 0.43	73.77 ± 0.16	0.592
Education, mean yrs ± SEM	11.86 ± 0.44	12.5 ± 0.46	12.71 ± 0.19	0.161
Live alone, %	39.13	58.33	52.58	0.074
Number of chronic diseases	2.07 ± 0.10	2.04 ± 0.13	1.97 ± 0.05	0.679
Clinical variables				
Average of pain severity reported between stair-climbing and walking	4.20 ± 0.30	2.57 ± 0.62	2.68 ± 0.23	0.003
Currently taking medications commonly used for arthritis, %	36.23	19.15	11.46	0.000
Knee strength, kg/weight, kg	0.26 ± 0.01	0.28 ± 0.01	0.30 ± 0.01	0.017
Body weight, kg	74.52 ± 1.48	72.61 ± 1.69	65.58 ± 0.82	< 0.001

p values represent comparisons between OA and non-OA groups.

Table 2. Associations of knee OA with performance, task modification, and task difficulty.

Variables	Symptomatic OA, n = 69	Asymptomatic OA, n = 48	No OA, n = 285	p
Task performance*				
4 m rapid pace	3.02 (69)	2.77 (48)	2.81 (288)	0.092
Chair-stand time	14.94 (64)	13.71 (48)	13.06 (281)	0.001
Stair-climb time	9.67 (67)	8.13 (47)	7.67 (284)	< 0.001
Combined chair-stand + 4 m walk times	26.94 (63)	24.68 (47)	23.46 (277)	< 0.001
Self-reported task modification**				
Walking 1/2 mile	30.00 (50)	26.83 (41)	16.13 (248)	0.035
Transferring	20.83 (48)	7.89 (38)	4.35 (253)	< 0.001
Climbing stairs	33.96 (53)	20.45 (44)	20.00 (255)	0.080
Stooping	16.67 (18)	19.23 (26)	18.60 (172)	0.975
≥ 2 of the above tasks	13.33 (15)	20.00 (20)	13.01 (146)	0.696
Self-reported task difficulty**				
Walking 1/2 mile	26.47 (68)	14.58 (48)	13.15 (289)	0.024
Transferring	30.43 (69)	20.83 (48)	12.11 (289)	0.001
Climbing stairs	23.19 (69)	6.38 (47)	11.46 (288)	0.012
Stooping	73.91 (69)	45.83 (48)	40.14 (289)	< 0.001
≥ 2 of the above tasks	46.38 (69)	20.83 (48)	20.62 (291)	< 0.001

p values represent comparisons between OA and non-OA groups.
* Mean time (seconds) required to complete each task and the number of subjects tested (n). ** Percentage and number (n) of subjects that reported that they had either changed how often they engaged in each task, or changed the method used to achieve each task. *** Percentage of subjects assessed (n) that reported difficulty with each task.

higher proportions who reported modification of each of the mobility tasks in the "symptomatic" than in the "asymptomatic" group. Consistent with the trends observed for task modification with few exceptions, higher proportions of "symptomatic" women also reported difficulty for individual tasks than "asymptomatic" women.

Associations of pain severity, muscle strength, and body weight with knee OA and with mobility function. The results of the adjusted multiple linear regression analyses of knee OA, pain severity, knee extensor strength, and body weight with performance on 2 representative tasks are summarized in Table 3. "Symptomatic knee OA" was significantly associated with slower performance on the stair-climb and chair-stand tasks. Higher body weight was independently associated with slower performance on both tasks, and pain severity with slower stair-climb performance. Women with greater knee extensor strength completed both performance tasks in less time than women with lower strength. Further, the addition of knee extensor strength and body weight to the knee OA model exerted similar effects on the relationship between "symptomatic knee OA" and performance on the chair-stand task. Inclusion of pain severity in the model

Table 3. Univariate linear regression analyses of knee OA, weight, strength, and pain with performance (n = 405). Analyses were conducted on data acquired from 405 women with adjustment for age, education, living alone, and depression score. B-coefficients and odds ratios are provided for each model. The pain variable represents average of pain severity reported with stair-climbing and walking. One unit of strength is 1 SD.

Chair-stand performance†				
Independent variables	(ß)	(ß)	(ß)	(ß)
Symptomatic knee OA	1.63***	2.10**	1.39**	1.18*
Pain severity	—	0.17	—	—
Strength			–0.78***	—
Body weight				0.05**
Stair-climb performance(s)††				
Independent varibles	(ß)	(ß)	(ß)	(ß)
Symptomatic knee OA	1.88***	1.64*	1.55***	1.59***
Pain severity	—	0.37**	—	—
Strength			–2.73***	—
Body weight				0.04**
Self-reported stair-climbing difficulty				
Independent variables	OR	OR	OR	OR
Symptomatic knee OA	2.13*	1.34	2.11*	2.09*
Pain severity		1.16	—	—
Strength			0.53*	—
Body weight				1.00

* p < 0.05, ** p < 0.01, *** p < 0.001. † Time(s) required to stand 5 times from a seated position. †† Time(s) required to ascend a flight of stairs.

with knee OA attenuated the relationship between "symptomatic knee OA" and stair-climb performance. Although the relationship between body weight, pain, and self-reported function varied between the tasks assessed, the protective influence of knee extensor strength upon knee OA associated function remained consistent whether the task was performance based or self-reported. The model for stair-climbing difficulty is presented in Table 3 as an example of this.

DISCUSSION

This study illustrates the functional consequences of knee OA in the early stages of disablement. Knee OA was significantly associated with functional limitations assessed by performance and task modification as well as task difficulty in this sample of women who were representative of the one-third highest-functioning women age 70–79 years old residing in the community. We also observed greater pain severity; lower knee extensor muscle strength and higher body weight are features that are both associated with knee OA and poorer performance in this cohort. Finally, by observing the effects of adding pain severity, strength, and body weight to knee OA in regression models predicting function, we were able to explore their potential mediating effects on the knee OA–function relationship.

The study's large sample size and use of standardized measures of performance and task modification in well-functioning women selected to represent the one-third highest-functioning, community-resident women provide a unique perspective from which knee OA can be examined. The use of validated state-of-the-art algorithms that incorporate multiple sources of clinically relevant data to classify subjects with knee OA and other chronic conditions is an additional strength, which allowed us to rigorously adjust for comorbidities and other potential confounding factors.

Painful symptoms appear to be associated with poor function in this well-functioning cohort of older women. The observed trends of slower stair-climb performance and more reported task modification among the "symptomatic" than among the "asymptomatic or intermittently symptomatic knee OA" support this. Interestingly, differences between the "symptomatic" and "asymptomatic" groups were not observed for modification of bending and stooping and for 2 or more mobility tasks, as was observed for reported difficulty. Although the participants were recruited to represent a high-functioning cohort, one could speculate that whether symptomatic or not, women with knee OA had already attempted and failed at modification of bending and stooping prior to the WHAS baseline evaluation. Alternatively, the bending and stooping task may not be amenable to modification. One could also speculate that the significant association between pain and stair-climbing performance but not stair-climbing difficulty in the regression analyses may be explained by avoidance of stair-climbing, and could be explored further.

Treatment of arthritis pain remains the primary therapeutic objective for OA management[28]. However, only 36% of women with "symptomatic knee OA" reported taking medications for arthritis; 19% of the "asymptomatic" group also reported taking medications for arthritis. The assumption here is that the "asymptomatic" group did not experience or report painful symptoms because of their use of

arthritis medications. Undertreatment of arthritis pain in the "symptomatic" group may stem from multiple factors that might include patient underreporting of pain to their physician, physician's underestimation of the seriousness of reported complaints, and intolerance to and/or expense of prescribed medications. The proportion of women whose painful symptoms were undertreated was even higher in the WHAS I cohort, which comprised moderately to severely disabled older women, than in this well-functioning WHAS II cohort[20]. The observed associations between presence and severity of painful symptoms with poor performance and task difficulty in this well-functioning cohort are consistent with functional decline reported in already disabled adults[15], and emphasize the functional relevance and importance of effective pain management.

Several investigations have shown that lower knee extensor strength is associated with knee OA and with poor mobility function in clinical patient samples[14,29]. In this cohort of well-functioning older women, we were able to observe an association between knee OA, lower knee extensor strength, and functional limitations. Based on data from the OASIS study, strength also appears to be a mediator of further functional decline in adults with clinically apparent disability[15]. Although the differences observed between the "symptomatic," the "asymptomatic," and the "no knee OA" groups were not dramatic, the nonlinear relationship between strength and mobility performance described by Buchner and colleagues[30] suggests that these subtle differences may translate to substantial differences in mobility function.

Few studies have examined the association of excess weight with disability[4,31,32], despite the abundance of reports that have linked excess weight to development, bilaterality, and progression[33,34] of knee OA. The results of this study suggest that higher body weight is independently associated with mobility performance and difficulty with multiple tasks and with walking a half-mile. Although associations we observed appear modest, one should keep in mind that the odds ratios and beta-coefficients reported represent estimates associated with a single kilogram difference. Not shown here but also observed, the odds of difficulty walking a half-mile were 30% higher for a woman weighing 75 kg (the mean weight of the symptomatic knee OA group) than a woman weighing 70 kg, and even higher than a woman weighing 66 kg (the mean weight of the no knee OA group).

Finally, we observed that knee OA models were often not significant when intermediary variables were added. For example, the odds of difficulty reported for 2 or more mobility tasks for symptomatic knee OA were 3.12 ($p < 0.001$), and they were 1.19 ($p > 0.05$) for symptomatic knee OA after adjustment for pain severity. Similarly, the odds of difficulty walking a half-mile were 2.05 ($p < 0.05$) for symptomatic knee OA, 1.85 ($p > 0.05$) with adjustment for strength. This suggests that these factors (pain severity, strength) are inextricably associated with knee OA. Alternatively, these factors may exert mediating effects upon the knee OA–function relationship early in the development of disability.

Potential weaknesses of this study include the following. First, the study includes only women. However, the focus on women is appropriate given the higher prevalence of knee OA and greater disability in women with knee OA than in men. Second, radiographic data were not available for all subjects. However, the ACR classification system for OA[22] provides the basis for the validated algorithm by which participants were classified and incorporates multiple sources of clinical information. Finally, the study's sample size restricted our examination of the potential mediating effects of pain, strength, and weight on preclinical disability to that which was assessed by mobility task performance.

This study illustrates that knee OA is associated with functional limitations in a cohort of women representative of the one-third highest-functioning community-resident women age 70 to 79 years. The implication is that knee OA has a deleterious effect on mobility function early in a preclinical phase that precedes the development of disability perceived by patients and clinicians. Our results also imply an opportunity to reverse functional limitations in women with symptomatic knee OA by targeted intervention upon lower knee extensor strength, higher pain, and greater weight. This intervention could potentially also prevent disability development in these high-functioning women. The improvement in function that paralleled improvement in painful symptoms and strength with exercise intervention in disabled older adults with knee OA suggests that several factors can be and should be modified simultaneously[35-38].

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