The Relationship Between Prospectively Assessed Body Weight and Physical Activity and Prevalence of Radiological Knee Osteoarthritis in Postmenopausal Women

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ABSTRACT. ***Objective.*** To determine the effect of weight and physical activity on the prevalence of radiological knee osteoarthritis (OA) in a cohort of middle-aged women.

Methods. The longitudinal phase of the Melbourne Women's Mid-life Health Project is a population-based prospective study of 438 Australian-born women who have been followed annually over 11 years. Of these women, 257 (59%) remained in longitudinal assessment at eleventh year of followup, and 224 of these women agreed to undergo radiographs of their knees. Radiographs were scored for features of OA [osteophytes and joint space narrowing (JSN)] using a validated scale, by 2 investigators who were blinded to questionnaire results. Data were obtained by both self-administered and face-to-face interview questionnaires.

Results. The average weight increase over the study period of 11 years was 4 kg (range –14 to 25 kg). Of the 224 women evaluated, 65 (29%) had knee joint osteophytes and 95 (42%) had evidence of knee JSN. Current weight and weight at baseline were independent factors associated with a higher prevalence of both osteophytes and JSN in all compartments of the knee. The average amount of physical activity over the 11 years of followup was a significant factor independently associated with an increased prevalence of patellofemoral JSN and approached significance for tibiofemoral osteophytes and total knee JSN.

Conclusion. Our study supports a longterm detrimental effect of weight on the knee joint and suggests the importance of longterm weight maintenance programs in preventing knee OA. The average amount of physical activity was associated with an increased prevalence of some features of knee OA. (First Release Aug 1 2006; J Rheumatol 2006;33:1835–40)

Key Indexing Terms:
RADIOLOGICAL OSTEOARTHRITIS MENOPAUSE BODY WEIGHT PHYSICAL ACTIVITY

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Osteoarthritis (OA) is the most common musculoskeletal disease, affecting more than one-quarter of the population over 60 years of age[1-3]. Pain and limitation of function caused by the symptoms of OA affect many aspects of an individual's health and quality of life[4]. Given that the treatment of OA is largely symptomatic, prevention is likely to play a large part in reducing the prevalence of disease.

Obesity is a major international epidemic[5]. Given that women at midlife have an increased tendency for gaining weight[6,7], the investigation of the relationship between the development of OA and weight is particularly important in this population. Obesity is a strong risk factor for the development of OA and also plays a significant role in worsening the disability of established OA[8-11]. The magnitude of the weight increase that significantly increases the risk of OA may be small. In a twin study, twins with OA were on average 3–5 kg heavier than their co-twins[12]. If such subtle changes in weight can affect the development of OA, this has significant clinical relevance, as small weight loss may be more easily achieved than dramatic weight loss. A twin study examining the association of body mass index (BMI) and knee OA implied that environmental factors are greater in influence than genetics[13]. Identification of such modifiable risk factors in the development of this disease, which has limited treatments, is of enormous clinical importance.

A number of studies have suggested that intensive physical activity increased the risk of knee OA[14,15]. However, it is still unclear whether there is a different effect of physical activity on radiological OA, where the definition depends on osteophytes rather than joint space narrowing (JSN)[16]. This is important, since osteophytes may be a consequence of forces applied to joints, but it is JSN that is a surrogate marker of knee cartilage. There is some emerging evidence for a beneficial effect of physical activity on joint cartilage[17].

We examined a cohort of healthy middle-aged women to determine whether weight and physical activity over 11 years followup were independently associated with final knee OA.

MATERIALS AND METHODS

The Melbourne Women's Mid-life Health Project is a population-based prospective study of Australian-born women. The study began in 1991 (baseline) with the use of random digit dialing to interview 2,001 Australian-born women between 45–55 years old and residing in Melbourne. The response rate was 71%. Of these women, 779 were eligible for longitudinal assessment (they had menses in the prior 3 months and were not taking oral contraceptives or hormone therapy)[18], of whom 438 (56%) were recruited for longitudinal assessment. Two hundred fifty-seven (59%) of the longitudinal cohort attended the office for the eleventh year of followup. Of these women, 224 agreed to undergo radiographs of their hands and knees in the following year.

Compared to participants who presented for radiographs (n = 224), the remaining women who entered the longitudinal study (n = 214) were significantly more likely to be older and to have smoked more at baseline. Ethics approval was obtained from the Melbourne Health Research Directorate, the University of Melbourne Human Research Ethics Committee, and Monash University Ethics Committee.

The height and weight of participants were measured by field workers and BMI calculated. Average weight over 11 years of followup was calculated by summation of weight in each year, then divided by the number of years. Physical activity was assessed by the question "How often do you participate in physical activities or sports for fitness or recreational purposes?" with a scale from 0 – 7 (every day, 4 – 6 times a week, 2 – 3 times a week, once a week, a few times a month, less than once a month, never). Data was transformed with frequency described by 4 categories: "Daily" physical activity was defined as activity reported every day or 4 – 6 times per week, "weekly" as once to 2 – 3 times per week, "monthly" as less than once to a few times per month, and "never" as never does sport[19]. This form of assessing physical activity was validated as comparable to the longer "Minnesota leisure-time physical activity" questionnaire[20]. Average physical activity was calculated by summing the score from each year and dividing by the number of years of followup.

Both knees were radiographed in each participant. Radiographs were conducted of the knees, both in a weight-bearing anteroposterior view in full extension and in skyline view in 45° flexion using a perspex positioning wedge. Patellofemoral joint disease was based on the radiological findings on the skyline view[21].

The tibiofemoral and patellofemoral joint compartments of the knee were graded on a 4-point scale (0 – 3) for both JSN and osteophytes and scored using a standard atlas[21], by 2 investigators who were blinded to questionnaire results. The variable called "total knee osteophytes" was defined as an osteophyte present at any one of the knee compartments. Total knee narrowing variable was defined as JSN at any one of the knee compartments.

Characteristics for the study population (n = 224) at baseline and eleventh year of followup were compared using independent t-test or chi-squared analysis. Variables selected for the analysis were identified as important by review of the literature. Logistical regression was used to determine the effect of weight and physical activity over the study period on the prevalence of OA. Variables selected for this multivariate analysis were those found to be significant in the bivariate analysis and not highly intercorrelated. Statistical package SPSS 13.1 was used for all analyses.

RESULTS

Questionnaires were completed by 257 participants in the eleventh year of followup and 224 women underwent radiographic assessment.

Table 1 shows the characteristics of the study population at first year of longitudinal followup and eleventh year of followup. At baseline the mean age of participants was 49.7 years (SD 2.5). At the eleventh followup year, participants' mean age was 60.0 years (SD 2.5) and they were heavier (72.7 kg vs 68.6 kg) with an average weight gain of 4 kg (range –14 to 25 kg). For the 159 participants who gained weight over the period, the mean weight gained was 6.25 kg (range 0.5 to 25 kg). Thirty-six women recorded a weight loss over the study period with average weight loss of 4.3 kg (range 0.5 – 14 kg). The mean BMI of the cohort increased from 25.9 (SD 4.8) to 27.7 (SD 5.5).

At baseline, 56 (25%) participants reported daily physical activity and 46 (20%) reported doing no physical activity. In 2002, 89 (40%) participants reported daily physical activity and 29 (13%) no activity. Compared to baseline, in 2002 participants were more likely to report exercising frequently (p = 0.005). When radiographed, 65 (29%) participants had knee joint osteophytes and 95 (42%) had evidence of knee JSN (Figure 1). With respect to radiological assessment of OA, there was good agreement of results between observers. Correlation coefficient was 0.992 (p = 0.01) and 0.968 (p = 0.01) for intraobserver and interobserver knee scoring, respectively.

Weight at baseline was a predictor of both osteophytes and narrowing in all compartments of the knee in 2003, independent of current age, current level of physical activity, hormone therapy (HT) use, and smoking (Table 2). Current weight at eleventh year of followup was associated with osteophytes in both tibiofemoral and patellofemoral compartments and the total knee osteophyte score, as well as narrowing in the tibiofemoral but not the patellofemoral joint. This relationship persisted after adjusting for age, current level of physical activity, HT use, and smoking (Table 2) for all variables except tibiofemoral osteophytes.

Simple multivariate analysis, adjusting for age, showed that average weight (defined as the summation of all weights recorded over the study period divided by the number of years of followup) was associated with osteophytes at all sites and JSN at all sites except the patellofemoral joint. Total knee osteophytes showed association with average weight adjusting for current level of physical activity, HT use, and smoking (Table 3).

Table 1. Characteristics of the participants (n = 224) at baseline and at 11th year of followup.

Variable	Baseline, mean (SD) or n (%)	11 Year Followup, mean (SD) or n (%)	p for Difference
Age, yrs	49.66 (2.47)	59.91 (2.49)	< 0.005
Weight, kg	68.62 (13.59)	72.65 (14.94)	< 0.005
BMI, kg/m^2	25.92 (4.84)	27.67 (5.54)	< 0.005
Current smoker (%)	33 (15.7)	17 (7.60)	< 0.001
Daily physical activity (%)	56 (24.90)	89 (39.60)	
Weekly physical activity (%)	94 (41.80)	84 (37.30)	
Infrequent physical activity (%)	27 (12.00)	9 (4.00)	
No physical activity (%)	46 (20.40)	29 (12.90)	< 0.005
Hormone therapy ever used (%)	21 (11.5)	80 (43.5)	
Hormone therapy never used (%)	162 (88.5)	104 (56.5)	< 0.001

BMI: Body Mass Index.

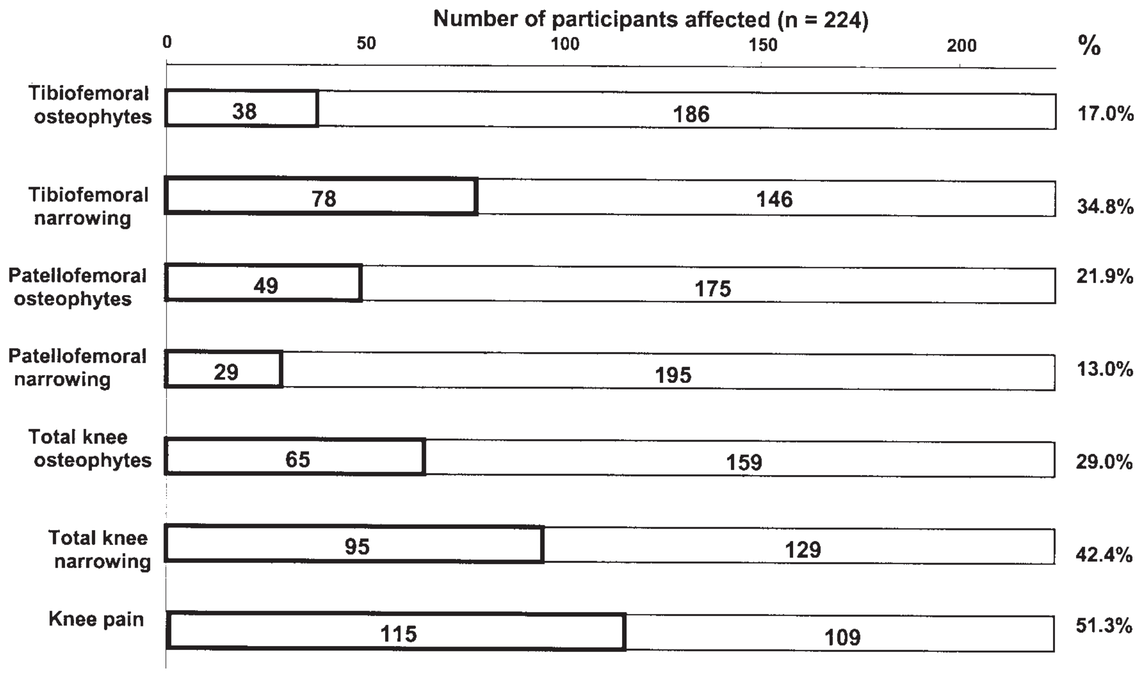

Figure 1. The prevalence of knee osteoarthritis in this cohort of women. Results are reported for various compartments and features of knee OA. No. of patients = 224.

The mean amount of exercise performed by the individual over the study period was associated with tibiofemoral osteophytes and patellofemoral JSN in simple multivariate analysis and persisted after adjusting for BMI, HT use, current level of physical activity, and smoking status for patellofemoral narrowing (Table 4).

DISCUSSION

Our study supports the role of weight as an important factor associated with osteophytes and JSN in all compartments of the knee. We showed that the weight of women at baseline was associated with the development of OA 11 years later. Our data also suggest that the average amount of physical activity is associated with some features of knee OA.

Few studies have looked at the influence of weight over time associated with subsequent development of OA. Our findings are consistent with similar findings in men[22], where weight in youth was predictive of latent knee OA. We also found that the average weight carried over 11 years was predictive of OA after adjusting for HT use, current physical activity, and smoking status. As radiological OA was assessed at one timepoint only, it is possible that the increase in weight may have been due to the presence of knee OA that reduced activity due to pain and limited movement. However, our community-based subjects had mild radiological OA and

Table 2. Relationship between radiological knee OA and weight at baseline and 11th year of followup.

	Weight at Baseline				Weight at 11 Year Followup			
	Simple Multivariate Analysis†		Multivariate Analysis††		Simple Multivariate Analysis†		Multivariate Analysis††	
	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p	OR (95% CI)	p
Tibiofemoral								
Osteophytes	1.02 (1.00–1.05)	0.05	1.01 (1.00–1.05)	0.04	1.02 (1.00–1.04)	0.08	1.03 (1.00–1.06)	0.06
Narrowing	1.03 (1.01–1.05)	0.01	1.03 (1.01–1.05)	0.01	1.03 (1.01–1.05)	0.01	1.03 (1.01–1.05)	< 0.001
Patellofemoral								
Osteophytes	1.05 (1.02–1.07)	< 0.001	1.05 (1.02–1.07)	0.001	1.04 (1.02–1.07)	< 0.001	1.04 (1.02–1.07)	0.001
Narrowing	1.02 (1.00–1.05)	0.06	1.02 (0.98–1.05)	0.14	1.02 (0.99–1.04)	0.21	1.02 (0.99–1.05)	0.24
Total knee								
Osteophytes	1.04 (1.02–1.07)	< 0.001	1.04 (1.02–1.07)	0.001	1.04 (1.02–1.06)	< 0.001	1.04 (1.02–1.06)	< 0.001
Narrowing	1.02 (1.00–1.04)	0.03	1.02 (1.00–1.05)	0.05	1.02 (1.00–1.04)	0.04	1.02 (1.00–1.04)	0.03

† Simple multivariate analysis with age in the regression equation. †† Multivariate analysis with age, current level of physical activity, hormone therapy use, and smoking in the regression equation.

Table 3. Relationship between radiological knee OA and average weight over study period.

	Average Weight Over 11 Years of Followup*			
	Simple Multivariate Analysis†		Multivariate Analysis††	
	OR (95% CI)	p	OR (95% CI)	p
Tibiofemoral				
Osteophytes	1.03 (1.00–1.05)	0.07	1.03 (1.00–1.06)	0.11
Narrowing	1.03 (1.01–1.05)	0.02	1.03 (1.00–1.06)	0.05
Patellofemoral				
Osteophytes	1.51 (1.02–1.07)	0.001	1.04 (1.02–1.08)	0.002
Narrowing	1.02 (0.99–1.05)	0.15	1.01 (0.98–1.04)	0.62
Total knee				
Osteophytes	1.04 (1.02–1.07)	0.001	1.03 (1.01–1.07)	0.02
Narrowing	1.02 (1.00–1.05)	0.05	1.03 (1.00–1.05)	0.03

* Summation of weight in each year divided by the number of years. † Simple multivariate analysis with age in the regression equation. †† Multivariate analysis with age, current level of physical activity, hormone therapy use, and smoking in the regression equation.

Table 4. Relationship between radiological knee OA and average physical activity over 11 years.

	Average Frequency of Physical Activity*			
	Simple Multivariate†		Multivariate††	
	OR (95% CI)	p	OR (95% CI)	p
Tibiofemoral				
Osteophytes	10.57 (1.49–4.93)	0.02	6.99 (0.75–65.49)	0.08
Narrowing	0.60 (0.10–3.47)	0.57	0.96 (0.13–7.10)	0.97
Patellofemoral				
Osteophytes	0.57 (0.07–4.77)	0.61	1.19 (0.12–12.11)	0.88
Narrowing	15.71 (1.89–30.61)	0.01	17.17 (1.59–185.44)	0.02
Total knee				
Osteophytes	1.80 (0.30–10.68)	0.52	1.76 (0.22–13.91)	0.59
Narrowing	3.42 (0.63–18.50)	0.15	5.91 (0.87–40.10)	0.07

* Summation of reported physical activity each year/years of followup. † Simple multivariate analysis with age in the regression equation. †† Multivariate analysis with age, BMI, hormone therapy use, and smoking in the regression equation.

when we examined those with no current pain, the results were similar (data not shown). In addition, results were adjusted for levels of physical activity.

There is evidence that small changes in body weight may significantly increase the risk of OA[12]. Our study suggests that both current weight and past weight are important factors associated with knee OA. This suggests that programs to maintain longterm healthy weight are likely to play an important role in reducing the risk of knee OA, particularly in light of the evidence that environmental modification of BMI can influence OA[13].

Average physical activity over the 11 years was independently associated with a higher prevalence of tibiofemoral osteophytes and patellofemoral narrowing adjusting for age, although results remained significant only for patellofemoral narrowing after adjusting for HT use, current physical activity, current BMI, and smoking status. There was a trend towards an association with tibiofemoral osteophytes ($p = 0.08$).

Previous studies on the influence of physical activity on OA have been conflicting. Karlson, *et al* found that increased physical activity was not associated with the need for hip replacement due to OA[10]. In contrast, the Framingham Study showed a 3 times increased risk of knee OA for those in the highest quartile of physical activity[23]. In our study there was a trend for more frequent physical activity in women at first year of followup to be associated with tibiofemoral osteophytes and not with JSN. Osteophytes and joint space width represent different aspects of the pathogenesis on knee OA[24,25]. Osteophytes may reflect traction forces across joints[16], while joint space width reflects the status of articular cartilage. This may explain the different effect of physical activity on knee OA. It may also explain some of the conflicting findings in the literature, since in the past there has been an overreliance on assessment of osteophytes in defining OA. We also found that physical activity was associated with increased prevalence of JSN, but not osteophytes, at the patellofemoral joint. It may be that physical activity, as measured in our study, results in different biochemical effects at the tibiofemoral and patellofemoral joints that may explain these differences.

A potential limitation of this study is that only 57% of the initial participants had complete data over 11 years of followup. Examination of baseline characteristics between participants and nonparticipants shows those who remained in followup were younger and fewer were smoking at baseline, but they were not significantly different with respect to their weight or reported physical activity, the major risk factors examined in this study. A major limitation is the measurement of physical activity, which asked about frequency of activity or sports for fitness or recreation. This question was chosen at the start of the study as being the most feasible means of obtaining information from a large population sample from whom a large amount of information was to be obtained. Although this question has been shown to be comparable in terms of measuring time spent exercising with a more complex questionnaire[20] it does not provide information on the type or intensity of the exercise. In particular as regards our study, it does not provide information on particular joint involvement or on the weight-bearing character of the activities. However, previous data from this cohort[26] have shown that the majority of the physical activities participated in by these women involved walking or gardening — both of which have considerable involvement with the knees.

We do not have data on incident OA, since radiographs were not done at baseline. However, the strength of our study is that we prospectively collected data on weight and physical activity, the 2 risk factors of interest, over 11 years. We also used an objective, validated method for determining the presence and absence of knee OA based on radiographs.

Our findings confirm that weight is an important risk factor for OA in middle-aged women and suggest that the average amount of physical activity is associated with an increased prevalence of some features of knee OA. We found that past weight (11 years ago) and the average weight over the 11 years of followup were both independently associated with a higher prevalence of knee OA. This suggests that weight has a detrimental, longterm effect on joints and highlights the importance of longterm weight maintenance programs in preventing knee OA. Further work is needed to clarify the effect of physical activity on knee health.

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