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OCCUPATIONAL PHYSICAL LOADS AND HIP OSTEOARTHRITIS: FINAL PERFORMANCE REPORT

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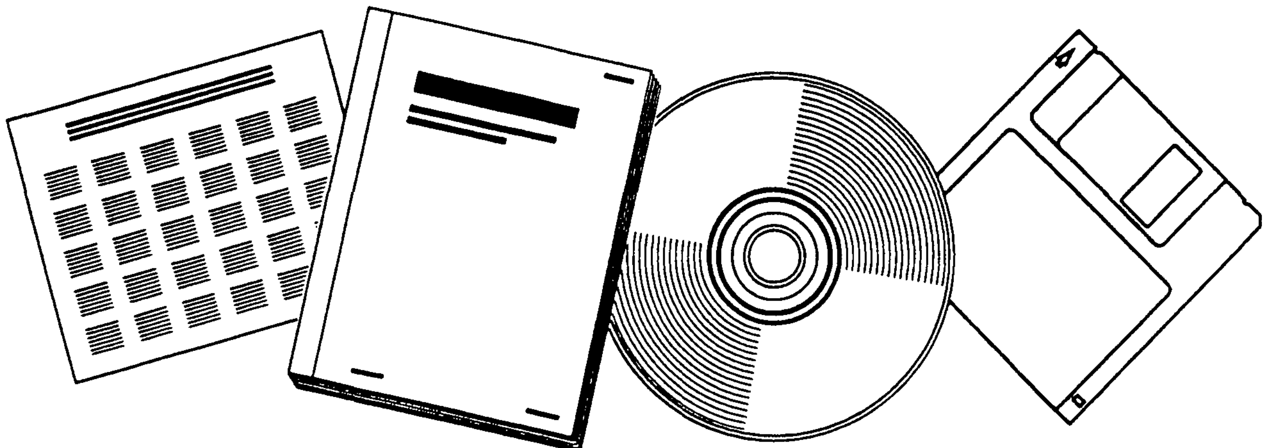

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16. Abstract (Limit: 200 words) A case/control study was conducted to determine whether lifetime physical job demands are associated with a higher risk of hip osteoarthritis. Cases were individuals aged 50 to 72 who underwent hip replacement for primary osteoarthritis. There were 185 cases and 211 controls, matched for age, gender and geographic area. Subjects completed a three part questionnaire, concerning demographic and medical history, occupational exposure history, and recreational history. Job strength requirements were estimated for each job held. Years of medium, heavy or very heavy work were associated with the development of hip osteoarthritis in men and women, as were lifetime pounds lifted, standing and walking, and jumping from one level to another. The author concludes that cumulative occupational physical exposures were associated with the development of severe hip osteoarthritis.

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Occupational Physical Loads and Hip Osteoarthritis: Final Performance Report

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SIGNIFICANT FINDINGS

Cumulative occupational physical exposures are associated with the development of severe hip osteoarthritis. This finding has been previously reported for men, but not for women. In this study, which adjusted for body mass and recreational exposures, the following exposures were significantly associated with the development of severe hip osteoarthritis: years of "medium", "heavy" or "very heavy" work, lifetime pounds lifted, standing and walking, and jumping from one level to another. These exposures were all associated with more than two fold increases in risk of hip replacement for osteoarthritis.

USEFULNESS OF FINDINGS

Osteoarthritis, a common degenerative joint disease, causes substantial morbidity and disability with large attendant economic costs. Occupational physical activities which lead to heavy physical loading of the hips may lead to osteoarthritis as a result of cumulative wear or microtrauma. As shown in this study, osteoarthritis at some anatomic sites can be considered a cumulative trauma disorder, although the effects of work exposures on disease prevalence may not be seen for decades.Strengthening the evidence of an association between osteoarthritis and heavy physical exposures may give further impetus to efforts aimed at reducing harmful physical exposures in the workplace.

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ABSTRACT

Study Aim: To determine if lifetime physical job demands are associated with higher risk of hip osteoarthritis.

Method: A case-control study evaluated 185 cases and 211 controls (173 men, 223 women). Cases were persons aged 50-72 who underwent hip replacement for primary (idiopathic) osteoarthritis. Controls drawn from the same health care plan were matched for age, gender, and geographic area. All subjects completed a self-administered questionnaire, with follow-up telephone interview. Subjects completed a lifetime occupational history which included specific job physical activities, a lifetime recreational physical activities questionnaire, and a medical history including body weight at different ages. Logistic regression was used to calculate Odds Ratios (OR) for different physical activities after controlling for recreational activities and Body Mass Index (BMI).

Results: For both men and women, occupational exposures were strongly associated with hip osteoarthritis, although BMI was the strongest predictor of subsequent hip replacement. The table below presents the OR for the highest tertile of self-reported lifetime cumulative occupational exposure compared to the lowest tertile, adjusted for BMI and for recreational activity.

	MEN		WOMEN	
Exposure	OR	(95% c.i.)	OR	(95% c.i.)
Years of heavy to very heavy work	2.48	(1.07-5.76)	2.30	(0.93-5.69)
Years of medium to very heavy work	2.96	(1.20-7.30)	2.68	(1.22-5.91)
Summary job exertion rating	1.65	(0.83-3.30)	2.32	(1.14-4.72)
Sum lifetime lifting (lbs)	2.59	(1.13-5.97)	1.63	(0.79-3.38)
Standing and walking	0.97	(0.42-2.18)	2.39	(1.15-4.97)
Jumping from one level to another	2.13	(0.94-4.82)	0.94	(0.43-2.07)

Results were not substantially altered when we examined exposures to age 50 instead of lifetime exposures, nor when we controlled for other measures of health status. In addition, significant ($p<.05$) dose-response trends were seen among men for years of heavy to very heavy work and lifetime lifting, and among women for standing and walking.

Conclusion: Cumulative occupational physical exposures are associated with the development of severe hip osteoarthritis. This has been previously reported for men, but not for women. The weaker associations seen in women may be in part related to exposure misclassification resulting from the difficulty in estimating exposures resulting from housework and childcare activities.

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BACKGROUND AND SIGNIFICANCE

Osteoarthritis, the most prevalent joint disease, ranks among the most common disabling medical conditions and is a leading cause of disability among people during their working years[1]. The disease can affect one or several joints; common sites include the hip, knee, shoulder, and fingers. Among persons aged 55 or older, 5-15% have evidence of hip osteoarthritis; knee osteoarthritis is even more common[2]. Osteoarthritis has a wide range of severity, from an asymptomatic state evident only on radiographs to symptomatic states which severely limit an individual's working abilities and daily activities. In severe cases, joint replacement may be performed. Osteoarthritis is the leading indication for hip and knee replacement; an estimated 120,000 persons undergo total hip replacement annually in North America3.

Osteoarthritis is classified as idiopathic (primary), or as secondary to some recognized disease entity such as infection, trauma, or developmental abnormality. Most cases are idiopathic, and the biologic or biomechanical processes underlying this disease are largely unknown. One hypothesis is that osteoarthritis occurs when repeated stresses at a joint exceed the ability of joint tissues to withstand those stresses, leading to "microtrauma" and cumulative damage. Heavy physical loading from work or sports may thus play a causal role in osteoarthritis when they create imbalances between mechanical stresses and the ability of joint tissues to withstand those stresses. Several European studies have provided evidence that heavy physical work is a risk factor for developing osteoarthritis of the hip[4,5,6,7].

A recent Swedish cohort study grouped workers by long-term occupational titles and assessed relative risks of hospitalization for hip osteoarthritis[5]. Several individual jobs or occupational categories demonstrated statistically significant excess risks. Analyzing across all job titles, the relative risk of hospitalization was 2.1 for workers highly exposed to physical loads compared to those in the lowest exposure group. Exposure was estimated by grouping occupational titles by a consensus ranking of static and dynamic physical loads at the hip. Due to the operational definition of long-term employment, there were few women in the study.

A Swedish case-control study examined men hospitalized for total hip replacement due to idiopathic osteoarthritis4. Occupational exposures of the cases and community controls were assessed retrospectively via interviews and questionnaire. In an analysis that controlled for body-mass index, smoking, and athletic activities, men with the highest occupational physical load had a relative risk of 2.4 for hip osteoarthritis, while those in the medium exposure category had a risk of 1.8. Sub-group analyses showed excess risks for workers exposed both to static and dynamic loads.

These two Swedish studies are the best evidence to date that occupational factors and other physical activities may play a causal role in this important degenerative disorder. Confirmation of these findings in a different group would significantly strengthen these results and could have important implications for the prevention of this major cause of morbidity. Studying this association in women is also important, especially given the increasingly common employment of women in heavy trades. Risk attributable to occupational factors is potentially preventable through changes in job design or use of protective equipment such as sorbothane shoe inserts[8,9]. The nature and extent of occupational factors must be better documented before any preventive efforts will be undertaken.

This case-control study used self-reported physical acitvity as the primary measure of exposure. One problem in studying the role of past physical exposures in osteoarthritis is the lack of reliable and valid data collection instruments. In the previous case-control studies of physical factors in hip osteoarthritis, no significant validations of the data collection instruments were performed. There is scant information available from other studies regarding the validity or reliability of self-reporting of past occupational physical activities and leisure-time physical activities. Thus an important first step in this project was the development and testing of questionnaires which assess physical exposures to the lower extremities.

SPECIFIC AIMS:

Evidence from animal and human studies suggests that the likelihood of developing osteoarthritis is increased by cumulative physical loading. The overall goal of this study was to provide information that may eventually reduce the burden of disease from osteoarthritis.

Our original aim was to test the hypothesis that repetitive loading at the hip by work activities is associated with higher relative risks of developing severe osteoarthritis. Specific aims of the study included the following:

1.) To determine if an association exists between severe osteoarthritis and a history of heavy occupational exposure to loads at the hip.

2.) To assess which occupational exposures contribute most strongly to any observed risks of severe osteoarthritis.

3.) To determine whether gender and age at exposure modify observed risks for osteoarthritis.

4.) To study the role of body mass index in modifying risk for osteoarthritis

RESEARCH DESIGN AND METHODS

Reliable occupational data are not easily linked to medical outcome data in the United States. Thus, although hip osteoarthritis is a relatively common disorder, a case-control design was a more practical approach than cohort studies in assessing the relationship of occupational exposures to this disease.

Study population:

Cases and controls were drawn from members of the Group Health Cooperative of Puget Sound (GHC). This health maintenance organization provides comprehensive medical care to its 474,000 members, comprising about 20% of the population in the Puget Sound area. GHC members enjoy equal access to health care, minimizing any potential problems of ascertainment bias caused by differential access to medical procedures.

Cases were persons aged 50-72 who underwent hip replacement surgery for primary (idiopathic) osteoarthritis. No exclusions were made with respect to race or ethnicity. Cases were selected by automated search of GHC's hospital discharge records for the years 1990-1993. Initial search yielded 302 persons aged 50-72 discharged from the hospital with both the procedure codes for hip replacement and the ICD9 code for primary hip osteoarthritis. Before occupational or other exposure date were collected, all hospital charts were reviewed to determine diagnosis. 41 cases were excluded from analysis because they had an identifiable cause of secondary osteoarthritis. These causes included avascular necrosis, congenital hip dislocation or dysplasia, Legg-Calve-Perthes disease, polio, acetabular fracture, and osteomyelitis.

Control subjects were chosen from the general membership roster of patients enrolled in the Group Health Cooperative. Three potential controls were matched to each case by age (2-year strata), gender, length of enrollment in GHC, and hospital catchment area. Controls were recruited to the study only after the corresponding case was recruited. If the first potential control subject refused to participate or could not be contacted, the second and

then the third were asked. Delays in determining participation status resulted in two controls being recruited for some cases.

Data collection:

Following recruitment, a self-administered three-part questionnaire was mailed to each participant. Subjects who did not respond were mailed a second questionnaire; those who did not return the second questionnaire received a telephone follow-up. Subjects who returned an incomplete questionnaire were called to complete the questionnaire items by telephone. The interviewer was blinded to case or control status.The three parts of the questionnaire were the demographic and medical history form, the occupational exposure history, and the recreational history.

The demographic and medical history form asked basic demographic information, general health status and co-morbidities, current height and weight, weight during each decade of adult life, and smoking habits.

The occupational exposure history consisted of a listing of all jobs held for a year or more, with job titles, type of industry, and years worked. A separate short questionnaire was completed for each job held (up to ten jobs). The short questionnaire included questions on lifting, work postures, whole-body vibration, stair and ladder climbing, and jumping from one level to another. Also included was a five-point scale to estimate overall physical work demands, patterned after the US Department of Labor Dictionary of Occupational Titles[10]. In preparation for this proposed grant activity,two validation studies were carried out with the Occupational Exposure Questionnaire[11] The first was a test-retest study in a convenience sample of retired adults; the second was a study of active workers in an aluminum reduction plant.

In the first study, a convenience sample of retirees was chosen from the population of the Group Health Cooperative (from which study subjects were drawn in the case-control study). Fifty-three subjects were invited to participate; 41 (77%) returned the self-administered questionnaire which asked subjects to complete a short job description questionnaire for each job (up to 8) held for a year or more. Following a six week interval, an identical questionnaire was distributed to the 41 initial participants; 36 returned the second questionnaire (68% of entire sample / 88% of initial respondents). There were 32 female and 9 male respondents; mean age was 68.9 years.

In the initial survey, job descriptions were obtained for 146 past jobs held by the respondents. Re-test information was obtained for 117 of these jobs, many of which were during the 1940's and 1950's. The statistic used for measuring reproducibility of these measures was the intra-class correlation coefficient (ICC), which can be used for both continuous and categorical data[12]. For categorical data, the ICC is equal to the weighted kappa[13].

One exposure measure tested was a measure of overall exertion, with jobs rated on a five-point scale as sedentary, light, medium, heavy, or very heavy. Test-retest of this measure showed excellent correlation (ICC=0.84). As a measure of construct validity, self-reported exertion on each job was compared to the strength requirement listed by the Dictionary of Occupational Titles (DOT), with matching done by job title and type of industry. This comparison of self-reported exertion to the exertion measure listed in the DOT showed good correlation (ICC=0.67). In addition to these global measures of physical demands, test-retest reliability data were obtained for individual exposure variables. Respondents were asked to rate exposures on a five-point scale from "never" to "constantly".

Table 1Test-retest reliability of exposure variables

Exposure	ICC	(n)
squatting, bent or twisted posture	0.73	60
exposure to whole-body vibration	0.34	61
used foot pedal while standing	0.19	61
frequency of lifting 10 pounds	0.60	60
frequency of lifting 25 pounds	0.76	59
frequency of lifting 50 pounds	0.87	59
frequency of lifting 100 pounds	0.59	58
jumping from one level to another	0.51	59
climbing stairs or ladder	0.57	61

These data show that this questionnaire instrument can reproducibly generate data regarding past occupational physical exposures, even when these exposures occurred in the distant past. The good correlation of the questionnaire data with the DOT data (ICC = 0.67) suggests that this part of the questionnaire was a valid construct. Further testing of validity was done in the aluminum plant study.

This study was performed at a primary aluminum reduction plant in Spokane, WA. Detailed analyses of two jobs at the plant were performed as part of an investigation by the Safety and Health Assessment and Research Program of the Washington State Department of Labor and Industries. Analyses were focused on two jobs, "carbon setter" and "crane operator." Job Description questionnaires were completed by 62 carbon setters (48% participation) and 35 crane operators (55% participation), as well as by a few dozen workers in 4 other jobs. Subjects described their current jobs as well as past jobs at the plant. All subjects had worked at one time as a carbon setter, the entry-level job at this plant.

Observational measures of job physical demands used posture and task analysis using videotapes coded by a process similar to the Keyserling method, as well as job sampling by direct observation at random intervals. These data allowed aggregate estimates of the physical exposures incurred by workers in these two jobs. These physical exposure estimates were then compared to self-reported estimates to ascertain the degree of correlation. The questionnaire responses discriminated well between the different jobs and correctly indiccated the direction of difference for 11 of the 13 variables studied.

In an analysis of the reporting of historical job exposures, we asked 54 aluminum plant employees who had previously worked as a carbon setter at this plant to complete an occupational exposure questionnaire for the carbon setter job. Their responses were compared to those of 65 current carbon setters. In comparing current vs. former carbon setters, we found no significant differences in their reported estimates of heavy lifting, stair climbing, or global physical exertion. Exposure to whole-body vibration was the only exposure variable for which responses differed significantly.

Recreational Activities: This section attempted to assess exposures since age 18 to sports which involve high mechanical stresses on the lower body (strenuous weight-bearing sports or sports involving whole-body vibration), as well as less demanding recreational activities. Although recreational activities prior to age 18 may also be of importance, data on earlier sports participation are felt to be less reliably obtainable. This questionnaire was administered to the retired adults in the first part of this study described above. Reliability (ICC=0.25.0.35) testing did not show this variable to be as reliable as the occupational exposure variables.

Data Analysis

Completed surveys were coded and entered. Exposure variables were calculated. These calculated variables included body mass index (BMI= kg/m2), job-title based physical demands, and weighted exposure variables.

Job-title based estimates were the "job strength requirements" obtained by matching the job title and industry with those in the Dictionary of Occupational Titles. These job strength requirements are defined in a 5-point scale of sedentary, light, medium, heavy, or very heavy based on postures and the weight of objects which are frequently lifted or moved. Where no exact listing for a job could be found in the Dictionary of Occupational Titles, a rating was derived through the values given for closely related jobs. Some common categories of jobs including student and homemaker are not included in the Dictionary of Occupational Titles. "Student" was assigned a sedetary job rating. "Homemaker" was assigned a rating of medium for ages 20-35 for those women who had children, and light for subsequent years or among women who had no children. All job ratings were done without knowledge of subjects' case or control status. Summary job exertion ratings were obtained by converting this 5 point scale into a numerial scale and summing the job exertion rating from each year worked.

Reporting of other job exposures was on the basis of hours worked per week and frequency (times per hour or hours per day) of other activities such as lifting or stair and ladder climbing. Summary exposure measures were calculated in two ways. Weighted exposure measures were normalized to a standard workweek and represent the proportion of work time spent in a given posture or work task. Unweighted exposures are the simple sums of exposures, for instance lifts per hour X hours worked per week X 50 wks/yr X number of years in that job, summed for all reported jobs.

Crude univariate odds ratios were calculated for variables of interest. These univariate odds ratios were used in the calculation of dose-response trends using the chi-square test for trend. Multiple logistic regression was then performed using the SAS program to calculate adjusted odds ratios. Statistical precision of effect estimates was determined by calculation of 95 percent confidence intervals. Exposure categories for these calculations were made by tertiles, with subjects divided into high, medium, and low exposed. Exposure classification into tertiles was made separately for each variable. Men and women were analyzed separately because of the wide differences in their exposure histories.

RESULTS

Completed questionnaires were obtained for 188 of 261 cases and 211 of 364 invited controls (response rate = 72% in cases, 58% in controls). The cases and controls were similar in age, gender, and race. A larger proportion of cases were employed at the time of interview.

Table 2: Demographic data

	cases (n=188)	controls (n=211)
Mean age	66.9(52-75)	66.9 (53-77)
Male	45%	44%
Female	55%	56%
White race	97%	96%
Employment:		
Full-time	22%	16%
Part-time	14%	12%
Retired	62%	70%
Disabled	3%	2%

Effects of Body Mass:

For both men and women, BMI was the strongest predictor of subsequent hip replacement. Subjects in the highest tertile for BMI had elevated risks of subsequent hip replacement at all ages studied (at age 40, highest tertile of BMI was >=27kg/m^2 for men and >=25 kg/m^2 for women).

Table 3: Crude OR for hip replacement, comparing subjects in the highest third for BMI versus the lowest third at different ages.

	MEN		**WOMEN**	
AGE	**OR**	**(95% c.i.)**	**OR**	**(95% c.i.)**
20	2.44	(1.10-5.40)	1.89	(0.98-3.65)
30	1.91	(0.87-4.20)	2.75	(1.40-5.41)
40	2.38	(1.12-5.05)	2.46	(1.31-4.62)
50	4.13	(1.95-8.76)	2.30	(1.21-4.36)

Significant ($p<.05$) dose-response trends were seen at all ages evaluated -- those in the middle tertile for BMI had risks of hip replacement intermediate between those in the lowest and highest tertiles. Results were not altered substantially when we controlled for other measures of health status (activity limitation due to cardiac, respiratory, or other disease).

In order to control for occupational and recreational activities, we calculated adjusted odds ratios for BMI at age 35 and age 50. For BMI at age 35 we used the mean of age 30 and age 40 values (age 35 was chosen because it is the midpoint of the accumulated lifetime exposures measured between ages 20 and 50). Occupational exposures and recreational exposures were calculated to age 35 and to age 50 and entered into the model. As shown in Table 4, adjusted odds ratios for BMI were higher than the crude odds ratios.

Table 4: OR for hip replacement comparing subjectts in the highest and middle tertiles for BMI with those in the lowest tertile at age 35 and 50. (OR adjusted for occupational exposures and recreational activities)

Men	**Highes Tertile**		**Middle Tertile**	
BMI(kg/m^2)	OR	(95%CI)	OR	(95% CI)
age 35	5.40	(1.73- 16.86)	2.17	(0.81-5.81)
age 50	5.32	(2.28- 12.39)	2.49	(1.06-5.89)
current	4.38	(1.94- 9.92)	3.61	(1.42-9.18)
Women	**Hi/Low**		**Mid/Low**	
BMI(kg/m^2)	OR	(95%CI)	OR	(95%CI)
age 35	3.26	(1.45- 7.35)	1.69	(0.75-3.80)
age 50	2.57	(1.26- 5.23)	1.18	(0.59-2.39)
current	2.19	(1.06- 4.52)	1.07	(0.53-2.17)

Effects of Occupational Exposures:

Odds ratios for a number of different occupational exposures were calculated from our data. There was a high degree of covariation between many of the occupational exposure variables. In multivariate models containing more than one exposure variable, much of the variability was accounted for by whichever variable was entered first into the model. We have thus entered occupational exposure variables one at a time into a model which contains age, BMI, and three recreational activity variables.

Table 5 shows odds ratios for lifetime cumulative occupational exposures based on the five-point physical exertion rating of each job. This was a single question on each job held in the self-reported data. Job-title based estimates were those based on the Dictionary of Occupational Titles as described in the Methods section above. The summary job exertion rating is simply the sum of physical exertion ratings from each year worked.

Table 5: OR for the highest tertile of lifetime cumulative occupational exposure compared to the lowest tertile, adjusted for age, BMI, and recreational activity.

	MEN		WOMEN	
Exposure	OR	(95% c.i.)	OR	(95% c.i.)
Years of heavy to very heavy work (self-report)	2.48	(1.07-5.76)	2.30	(0.93-5.69)
Years of heavy to very heavy work (job-title based estimate)	1.45	(0.63-3.31)	3.20	(0.31-32.55)
Years of medium to very heavy work (self-report)	2.96	(1.20-7.30)	1.56	(0.77-3.16)
Years of medium to very heavy work (job-title based estimate)	1.71	(0.74-3.91)	1.65	(0.84-3.23)
Summary job exertion rating (self-report)	2.12	(0.88-5.12)	1.56	(0.76-3.21)
Summary job exertion rating (job-title based estimate)	1.63	(0.69-3.82)	1.65	(0.83-3.30)

Individual exposure variables were evaluated using both weighted and unweighted models as described in the Methods section. Unweighted models were the simple sum of reported exposures; weighted exposures were adjusted for total hours worked to corrected for differences in reporting working hours. Our a priori assumption was that the weighted values would give a less biased estimate of lifetime exposures. As shown in Table 6, there was little difference between OR calcualted using these two different methods.

Table 6: OR for the highest tertile of lifetime cumulative occupational exposure compared to the lowest tertile, adjusted for age, BMI, and recreational activity. Weighted and Unweighted exposure models.

Men:

	Weighted		Unweighted (lifetime sum)	
Exposure	OR	(95% c.i.)	OR	(95% c.i.)
Sitting	0.36	(0.15-0.87)	0.59	(0.27-1.32)
Standing and walking	0.97	(0.43-2.18)	1.41	(0.59-3.33)
Bent or kneeling	1.69	(0.72-3.97)	1.53	(0.65-3.56)
Stair or ladder climbing	1.30	(0.57-3.00)	1.24	(0.55-2.79)
Jumping from one level to another	2.13	(0.94-4.82)	2.20	(0.97-4.96)
Sum of lifetime lifting	2.59	(1.13-5.97)	1.44	(0.65-3.23)
Whole-body vibration	1.21	(0.55-2.68)	3.18	(1.31-7.68)

Women:

	Weighted		Unweighted life sum	
Exposure	OR	(95% c.i.)	OR	(95% c.i.)
Sitting	1.04	(0.52-2.11)	1.66	(0.82-3.37)
Standing and walking	2.39	(1.15-4.97)	2.02	(0.98-4.16)
Bent or kneeling	1.50	(0.76-2.96)	1.71	(0.86-3.42)
Stair or ladder climbing	0.45	(0.23-0.89)	0.59	(0.30-1.15)
Jumping from one level to another	0.94	(0.43-2.07)	1.33	(0.60-2.91)
Sum of lifetime lifting	1.63	(0.79-3.38)	1.63	(0.80-3.31)

As shown in Table 7, many exposure variables showed positive dose-response trends, with larger odds ratios in the highest tertile compared to the middle tertile. Chi-square test for trend showed statistically significant dose-response trends in the following exposures variables: sum of lifetime lifting and self-reported years of heavy to very heavy work in men, and standing/walking in women.

Table 7: Crude OR for lifetime occupational exposures, Middle and Highest tertiles vs. Lowest tertile, including test for trend

Men

Exposure	OR Middle tertile (CI)	OR Highest (CI)	p value, test for trend
Sitting	0.541 (0.254 - 1.151)	0.504 (0.227 - 1.119)	0.253
Standing and walking	0.835 (0.384 - 1.820)	0.975 (0.454 - 2.095)	1.0
Bent or kneeling	1.297 (0.624 - 2.696)	1.915 (0.880 - 4.164)	0.138
Stair or ladder climbing	1.050 (0.486 - 2.270)	1.302 (0.611 - 2.776)	0.815
Jumping from one level to another	1.348 (0.610 - 2.977)	2.007 (0.941 - 4.278)	0.15
Sum of lifetime lifting	1.335 (0.594 - 3.000)	2.831 (1.333 - 6.015)	0.011
Summary job exertion rating (job-title based estimate)	1.222 (0.578 - 2.584)	1.597 (0.741 - 3.441)	0.48
Summary job exertion rating (self-report)	1.078 (0.511 - 2.276)	1.964 (0.936 - 4.118)	0.206
Years of heavy to very heavy work(job-title based estimate)	1.063 (0.491 - 2.301)	1.494 (0.711 - 3.136)	0.44
Years of heavy to very heavy work (self-report)	1.054 (0.505 - 2.196)	2.496 (1.171 - 5.321)	0.034
Years of medium to very heavy work (job-title based estimate)	1.054 (0.482 - 2.307)	1.865 (0.861 - 4.040)	0.303
Years of medium to very heavy work (self-report)	1.425 (0.683 - 2.973)	2.296 (1.079 - 4.887)	0.157
Lifetime sum of hours worked	2.469 (1.157 - 5.269)	2.257 (1.045 - 4.872)	0.117
Whole-body vibration	1.067 (0.510 - 2.233)	1.186 (0.564 - 2.490)	0.8

Women

Exposure	OR Med (CI)	OR Hi (CI)	P value, test for trend
Sitting	1.704 (0.867 - 3.347)	1.041 (0.528 - 2.053)	0.97
Standing and walking	3.208 (1.612 - 6.385)	2.314 (1.151 - 4.653)	0.043
Bent or kneeling	1.177 (0.599 - 2.315)	1.242 (0.652 - 2.368)	0.808
Stair or ladder climbing	0.439 (0.220 - 0.876)	0.544 (0.283 - 1.045)	0.155
Jumping from one level to another	0.921 (0.432 -1.965)	0.923 (0.426 - 1.998)	0.976
Sum of lifetime lifting	0.834 (0.429 -1.624)	1.495 (0.756 - 2.955)	0.28
Summary job exertion rating (job-title based estimate)	1.007 (0.527 - 1.926)	1.604 (0.838 - 3.072)	0.27
Summary job exertion rating (self-report)	1.097 (0.563 - 2.140)	1.319 (0.681 - 2.554)	0.62
Years of heavy to very heavy work(job-title based estimate)	unable to calculate	2.648 (0.262 - 26.817)	
Years of heavy to very heavy work (self-report)	unable to calculate	1.778 (0.741 - 4.264)	
Years of medium to very heavy work (job-title based estimate)	1.161 (0.583 - 2.313)	1.503 (0.786 - 2.875)	0.31
Years of medium to very heavy work (self-report)	0.814 (0.414 - 1.602)	1.271 (0.653 - 2.476)	0.58
Lifetime sum of hours worked	1.243 (0.648 - 2.386)	1.337 (0.687 - 2.602)	0.92

Effects of possible biases and confounders

Several sources of bias or confounding were adressed in the data analysis. One possible bias might be a tendency for persons actively engaged in more physically demanding jobs to seek earlier hip replacement than persons with the same degree of arthritis but a less demanding job. Persons might also migrate into less physically demanding jobs years before hip replacement due to hip pain. We examined OR for occupational exposures after truncating exposures at age 50, two years before any subject in our study had received a hip replacement (average age at replacement was 65). Little difference was seen between lifetime OR (truncated at time of enrollment) and OR truncated at age 50.

Table 8a: Lifetime occupational exposures compared to exposures to age 50, adjusted for age, BMI, and recreational physical activities - Men.

Men:

	Lifetime Exposure		Exposure to age 50	
Exposure	**OR**	**(95% c.i.)**	**OR**	**(95% c.i.)**
Years of heavy to very heavy work (job-title based estimate)	1.45	(0.63-3.31)	1.48	(0.66-3.33)
Years of heavy to very heavy work (self-report)	2.48	(1.07-5.76)	2.10	(0.93-4.71)
Years of medium to very heavy work (job-title based estimate)	1.71	(0.74-3.91)	1.34	(0.60-3.01)
Years of medium to very heavy work (self-report)	2.96	(1.20-7.30)	2.72	(1.17-6.33)
Summary job exertion rating (job-title based estimate)	1.63	(0.69-3.82)	1.22	(0.53-2.76)
Summary job exertion rating (self-report)	2.12	(0.88-5.12)	1.77	(0.79-3.98)
Sitting	0.36	(0.15-0.87)	0.42	(0.18-0.95)
Standing and walking	0.97	(0.43-2.18)	1.06	(0.48-2.35)
Bent or kneeling	1.69	(0.72-3.97)	1.67	(0.74-3.80)
Stair or ladder climbing	1.30	(0.57-3.00)	1.00	(0.43-2.35)
Jumping from one level to another	2.13	(0.94-4.82)	2.21	(0.98-5.01)
Sum of lifetime lifting	2.59	(1.13-5.97)	3.30	(1.45-7.51)
Whole-body vibration	1.21	(0.55-2.68)	1.42	(0.65-3.11)

Table 8b: Lifetime occupational exposures compared to exposures to age 50, adjusted for age, BMI, and recreational physical activities - Women.

Women:

	Lifetime Exposure		Exposure to age 50	
Exposure	**OR**	**(95% c.i.)**	**OR**	**(95% c.i.)**
Years of heavy to very heavy work (job-title based estimate)	3.20	(0.31-32.55)	2.98	(0.29-30.88)
Years of heavy to very heavy work (self-report)	2.30	(0.93-5.69)	1.93	(0.78-4.79)
Years of medium to very heavy work (job-title based estimate)	1.65	(0.84-3.23)	1.17	(0.59-2.35)
Years of medium to very heavy work (self-report)	1.56	(0.77-3.16)	1.23	(0.59-2.56)
Summary job exertion rating (job-title based estimate)	1.65	(0.83-3.30)	1.55	(0.77-3.12)
Summary job exertion rating (self-report)	1.56	(0.76-3.21)	1.65	(0.79-3.43)
Sitting	1.04	(0.52-2.11)	0.85	(0.42-1.72)
Standing and walking	2.39	(1.15-4.97)	2.37	(1.17-4.83)
Bent or kneeling	1.50	(0.76-2.96)	1.09	(0.55-2.16)
Stair or ladder climbing	0.45	(0.23-0.89)	0.54	(0.27-1.08)
Jumping from one level to another	0.94	(0.43-2.07)	1.04	(0.47-2.31)
Sum of lifetime lifting	1.63	(0.79-3.38)	1.77	(0.86-3.66)

One reason for the lower odds ratios observed in women may be the difficulty in assigning exposure values to work done as a homemaker. As outlined in the Methods section, we asked woment to report "homemaker" as a job, and assigned physical exertion values for time spent as a homemaker. This may have resulted in an underestimation of the exposures for women who worked outside the home. To evaluate this possibility, we excluded "homemaker" as a job and reclassified women using only jobs outside the home. As shown in Table 10, this resulted in much higher odds ratios for the physical exertion variables, both self-reported and those based on job titles.

Table 10: Exposures for women, including and excluding homemaker as a job category.

	Including homemaker		Excluding homemaker	
Exposure	OR	(95% c.i.)	OR	(95% c.i.)
Years of medium to very heavy work (job-title based estimate)	1.65	(0.84-3.23)	4.69	(1.77-12.40)
Years of medium to very heavy work (self-report)	1.56	(0.77-3.16)	2.68	(1.22-5.91)
Summary job exertion rating (job-title based estimate)	1.65	(0.83-3.30)	2.34	(1.17-4.67)
Summary job exertion rating (self-report)	1.56	(0.76-3.21)	2.32	(1.14-4.72)

To evaluate the possibility of reporting bias, we compared the physical exertion variable from self-reports with that calculated from job titles for each subject. Intraclass correlation coefficients showed excellent agreement between self-reports and job title based estimates, with no significant differences in agreement between cases and controls.

Table 11: Intraclass correlation coefficients comparing lifetime exertion self-report vs. lifetime exertion based on job titles

	Men	Women
Case	0.83	0.84
Control	0.80	0.83

DISCUSSION

This study supports the hypothesis that cumulative physical loading on the lower extremities is associated with the development of hip osteoarthritis in both men and women. Body mass index was the most powerful predictor of subsequent hip replacement in our study; occupational exposure variables were also strongly associated with hip replacement in all models we used. Elevated odds ratios were seen for both men and women, and similar effects of exposure were seen at different ages tested. The results above address the specific aims of this project, which included the following:

1.) To determine if an association exists between severe osteoarthritis and a history of heavy occupational exposure to loads at the hip.
2.) To assess which occupational exposures contribute most strongly to any observed risks of severe osteoarthritis.
3.) To determine whether gender and age at exposure modify observed risks for osteoarthritis.
4.) To study the role of body mass index in modifying risk for osteoarthritis

This study has several limitations. The disease outcome measure was hip replacement due to idiopathic hip osteoarthritis. The spectrum of disease was thus limited to the most severely symptomatic patients, and to those persons who had no other disease process preventing the surgery. Alternate methods of case identification would include use of radiographically defined hip osteoarthritis and use of outpatient records to identify less severe cases. Both of these methods have disadvantages as well. Use of radiographs makes it difficult to select appropriate control subjects unless the radiographs are taken as part of a population study or the radiographs capture the hips incidentally as part of another examination. This latter technique was used by Croft and colleagues6, who used abdominal films to obtain views of the hips. Although this measure of disease outcome gives a standardized anatomic definition of the disease, there is poor correlation between symptom severity and radiographic severity of hip osteoarthritis. The disability associated with this disorder is more closely related to patients' symptoms than to their radiographs. Use of outpatient records to obtain diagnoses is problematic because of reporting biases and the generally poor quality of outpatient diagnostic data.

Use of hip replacement as our case definition could have biased our results toward the finding of a spurious association between occupational activities and hip osteoarthritis. Persons in physically demanding jobs may be more symptomatic at a given level of disease severity, and may be more likely to seek surgery, than a person in a less demanding job. More cases than controls were observed to be occupationally active in this study. However, lagging of exposures by truncation of accrued exposure at age 50 did not alter our results. Persons with diseases which limited physical activity may be poor surgical risks and may be both less likely to have surgery and less likely to choose a physically demanding job.

Controlling for activity limitation due to other diseases did not alter our results. Use of hip replacement as the case definition could also bias our results toward the null, as the control group very likely contained persons with hip osteoarthritis who had not had hip replacement. Persons with hip arthritis may have altered their occupational activities years before surgery, lowering observed exposures in cases. Again, truncation of exposure at age 50 did not alter our results.

Use of self-reported exposures in a case-control study raises the possibility of recall bias and observer bias. We took several steps to avoid this problem. Subjects were told that this was a study of "arthritis and other chronic diseases;" the study hypotheses were never mentioned to the subjects. The person performing telephone interviews and questionnaire coding was blinded to outcome status. When reviewing medical charts to exclude subjects with secondary osteoarthritis, the investigator had no occupational information.

Our study is unique in that it offers the possibility of evaluating possible recall biases through the use of a self-reported job exertion rating patterned after the "job strength requirement" listed in the Dictionary of Occupational Titles. These occupational strength requirements should not be considered a gold standard, due to the probably wide variability of job demands between jobs with the same job title classification. However, agreement between self-reported and job-title based measures adds credence to the results. This study showed good to excellent correlation between the self-reports and the job-title based estimates. More important are the odds ratios calculated using these different measures. It is unlikely that cases and controls would recall their job titles and years worked differently, so that job title based estimates should give an unbiased estimate of exposures, though they are likely to suffer from non-differential misclassification. Odds ratios based on job titles and those based on self-report differed in magnitude but were consistently in the same direction. For women, odds ratios based on job titles were consistently higher than those based on self-report. Thus, it is unlikely that recall bias can account for the results of this study.

Unlike other work-related musculoskeletal disorders or cumulative trauma disorders, osteoarthritis has a long latency period and typically develops decades after most people start heavy physical work. This raises the usual challenges of retrospective exposure assessment over a period of decades. This long latency period also raises a number of challenges regarding prevention of osteoarthritis, as the results of preventive efforts will not be seen for decades.

CONCLUSIONS

There has been little previous evidence linking the risk of hip osteoarthritis to heavy physical exposures in women. This study showed robust and significant risks associated with the time women spent standing and walking, and with years of work spent working outside the home at jobs requiring regular lifting of 25 pounds or more. Previous studies of occupationally related hip osteoarthritis have shown increased risk of this disease in men associated with some heavy physical exposures. Our study confirms this finding, and extends the results to specific physical exposures including the sum of pounds lifted and making frequent jumps from one level to another.

Increased body mass index in young and middle adulthood has previously been associated with hip osteoarthritis in men; our study confirms this result and extends this finding to women, in whom there are less data.

This study suggests that some of the substantial morbidity and disability caused by osteoarthritis may be preventable through modification of occupational exposures and possibly through weight reduction.

PLANNED PUBLICATIONS

Two abstracts have been submitted from this work for oral presentations at meetings. The results of the body mass index analysis were submitted to the 1996 Annual Meeting of the Society for General Internal Medicine (Washington , DC); results of the occupational exposure analysis were submitted to the 1996 International Conference on Occupational Health (Stockholm, Sweden).

Manuscripts of these two abstracts are currently in progress and will be submitted for publication in the first half of 1996.

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