

ORIGINAL CONTRIBUTIONS

Individual Risk Factors for Hip Osteoarthritis: Obesity, Hip Injury, and Physical Activity

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Hip osteoarthritis is a major cause of pain and disability. The authors explored individual risk factors for hip osteoarthritis in a population-based case-control study. The study was performed in two English health districts (Portsmouth and North Staffordshire) from 1993 to 1995. A total of 611 patients (210 men and 401 women) listed for hip replacement because of osteoarthritis over an 18-month period were compared with an equal number of controls selected from the general population and individually matched for age, sex, and family practitioner. Information about suspected risk factors was obtained by a questionnaire administered at interview and a short physical examination. Obesity (odds ratio (OR) = 1.7, 95% confidence interval (CI) 1.3–2.4; highest vs. lowest third of body mass index), previous hip injury (OR = 4.3, 95% CI 2.2–8.4), and the presence of Heberden's nodes (OR = 1.6, 95% CI 1.2–2.2) were independent risk factors for hip osteoarthritis among men and women. Hip injury was more closely related to unilateral as compared with bilateral disease. There was a negative association between cigarette smoking and osteoarthritis among men and a weak positive association with prolonged regular sporting activity. Obesity and hip injury are important independent risk factors for hip osteoarthritis, which might be amenable to primary prevention. Hip osteoarthritis may also arise as part of the polyarticular involvement found in generalized osteoarthritis. *Am J Epidemiol* 1998;147: 516–22.

arthroplasty; hip joint; obesity; osteoarthritis; risk factors

Hip osteoarthritis is a major public health problem. Radiographic evidence of the disease is found in some 10 percent of people aged 65 years and older, and about half of these radiographic cases are symptomatic (1). The condition often causes disability, and it accounts for a substantial majority of the 30,000 total hip arthroplasties carried out each year in England and Wales (2).

The known causes of hip osteoarthritis (3, 4) include primary inflammatory arthritides, such as rheumatoid arthritis and ankylosing spondylitis; acromegaly and various other metabolic diseases; and anatomical deformities of the joint resulting from developmental disorders, such as congenital hip dislocation, Perthes disease, and slipped capital epiphysis. Together, how-

ever, these account for only a minority of cases. Other suggested risk factors include obesity, mechanical insults to the joint from acute injury or repeated loading (e.g., by heavy lifting or sporting activities), and constitutionally determined predisposition to the development of osteoarthritis at multiple joint sites. The development of effective, population-based, preventive strategies against hip osteoarthritis requires more information about these risk factors and the ways in which they interact.

To obtain such information, we have carried out a case-control study of surgically treated hip osteoarthritis in two geographically defined populations. In this paper, we report the results for nonoccupational risk factors. The findings in relation to occupational activities, such as heavy lifting, are described in a companion paper (5).

MATERIALS AND METHODS

The study area comprised two health districts in England (Portsmouth and North Staffordshire), with a combined population of around one million residents. These districts were selected for the following reasons:

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Abbreviations: CI, confidence interval; OR, odds ratio.

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1) they have a centralized orthopedic facility for assessment and treatment of hip osteoarthritis, 2) the local orthopedic surgeons were willing to enter all patients into the study, and 3) they have a diverse socioeconomic profile with inclusion of relatively affluent, as well as deprived, areas.

A register was established in each district whereby the orthopedic surgeons recorded all men and women aged 45 years and over, who were placed on the waiting list for primary total hip arthroplasty over an 18-month period. The medical records of each subject were reviewed, and patients were excluded if they had sustained a hip fracture within the past year; fulfilled American College of Rheumatology criteria (6) for rheumatoid arthritis or modified New York criteria (7) for ankylosing spondylitis; or had a history of Perthes disease, congenital hip dislocation, slipped capital epiphysis, or other established causes of secondary osteoarthritis. Patients who lived outside the two districts under study were also excluded. The pelvic radiographs of each case were evaluated for the presence of osteoarthritis using previously published methods. Measurements were made of minimal joint space (8), overall Kellgren/Lawrence score (9), and the anatomical pattern of joint involvement (superolateral or medial/concentric).

For each case, a control of the same sex and age (to within 4 years) was selected from the list of the same general practice held by the county Family Health Service Association. In England and Wales, almost everyone is registered with a general practitioner so that these lists essentially provide an enumeration of the general population. Controls who had undergone previous hip surgery for osteoarthritis were excluded, and controls who declined to participate were replaced.

After giving informed consent, cases and controls completed a structured interviewer-administered questionnaire, inquiring about their medical history, lifestyle, and leisure time physical activities. The lifetime history of leisure activity included information on

participation in sports since leaving school and the frequency and duration of other leisure activities such as walking, cycling, gardening, and dancing. Measurements were made of body height and weight using portable scales and a stadiometer, and the hands of all subjects were examined for the presence of Heberden's nodes (a marker for constitutional predisposition to generalized osteoarthritis) as previously described (10).

The data were analyzed by conditional logistic regression, and the results were summarized as odds ratios with 95 percent confidence intervals. Odds ratios were obtained for categories of exposure, and tests for trend were performed across the categories.

RESULTS

We identified 868 men and women aged 45 years and over, who were consecutively listed for total hip arthroplasty in Portsmouth and North Staffordshire over the 18-month study period. Of these, 726 (84 percent) fulfilled the criteria for entry into the study as cases. The reasons for exclusion were as follows: underlying inflammatory arthritis (6 percent), lower limb fracture during the year prior to listing (2 percent), Paget's disease (1 percent), documented childhood hip dysplasia (1 percent), and residence out of the area (8 percent). Of the 726 eligible cases, 643 (89 percent) agreed to participate. To recruit the 643 matched controls, we approached 1,060 subjects registered with general practitioners in the two districts, for an overall response rate among controls of 60 percent. Of the potential controls who did not take part, 128 (12 percent) were deemed unfit to participate by their general practitioners, and a further 289 (27 percent) declined interview. This analysis is based on the 611 case-control pairs who provided complete information on the main risk factors under study.

Table 1 shows the clinical and radiographic characteristics of the 210 men and 401 women with primary hip osteoarthritis who were included as cases in the

TABLE 1. Clinical and radiographic characteristics of 210 men and 401 women with primary hip osteoarthritis, resident in Portsmouth/North Staffordshire, who were listed for arthroplasty during 1993-1995

	No.	Age (years)		Pair duration (months)		Minimum joint space* (% ≤ 1 mm)	Radiographic grade* (% K/L ≥ 3)	Radiographic pattern (%)*	
		Mean	SD†	Median	IQR†			Superolateral	Medial/concentric
Men	210	68	9	36	24-72	83	97	61	36
Women	401	71	9	36	18-60	75	95	41	55
All	611	70	9	36	20-66	78	96	48	49

* Radiographic grade and pattern not known for 15 cases.

† K/L, Kellgren/Lawrence; SD, standard deviation; IQR, interquartile range.

study. Their mean age was 70 years (standard deviation, 9 years). They had suffered hip pain for a median of 3 years, and the overwhelming majority had severe radiographic evidence of osteoarthritis. Male and female cases were similar with regard to their mean age, median duration of pain, and severity of radiographic changes. Overall, there was a slight excess of medial or concentric cartilage loss over superolateral disease. However, the radiographic pattern differed markedly between the sexes, with medial/concentric disease being significantly more frequent among women than among men.

Table 2 shows the relation between body mass index, Heberden's nodes, previous hip injury, and the risk of hip osteoarthritis. The risk increased significantly with body mass index (p for trend < 0.001), such that men and women in the highest third of the distribution (>28.0 kg/m²) were 1.7 times more likely to have hip osteoarthritis than those in the lowest third (<24.5 kg/m²). The relation between obesity and hip osteoarthritis was apparent among both men and women, although the linear trend across the distribution of body mass index was clearer in the women. There was a statistically significant association between the presence of Heberden's nodes and hip osteoarthritis. Men and women who had one or more definite Heberden's nodes were 1.6 times more likely to have hip osteoarthritis when compared with those who did not have nodes. Despite the greater prevalence of Heberden's nodes among women (53 percent of controls) than among men (19 percent of controls), the association between hip osteoarthritis and the presence of Heberden's nodes was stronger among men than among women.

Forty-seven cases (17 men, 30 women) and 12 controls (1 man, 11 women) reported a significant hip

injury at least 1 year before the onset of hip pain. Hip injuries were defined with the aid of a mannequin and were considered significant if they resulted in an inability to bear weight for at least 1 week. The majority of recorded injuries arose through falls from standing height or greater ($n = 26$), road traffic accidents ($n = 10$), or sports injuries ($n = 5$). Previous hip injury was associated with an overall 4.3-fold increase in the risk of hip osteoarthritis, the element of risk being substantially greater among men (odds ratio (OR) = 24.8, 95 percent confidence interval (CI) 3.1–199.3) than among women (OR = 2.8, 95 percent CI 1.4–5.9). Of the 47 cases reporting a hip injury, 43 reported the age at injury and the age at onset of their hip pain. The median age at hip injury was 53 years (interquartile range, 26–65 years), while that for the age at onset of hip pain was 66 years (interquartile range, 55–71 years).

We explored potential interactions between body mass index, Heberden's nodes, and the risk of hip osteoarthritis (table 3). Subjects in the highest third of the distribution of body mass index with definite Heberden's nodes had 3.2 times greater odds of hip osteoarthritis than those without Heberden's nodes in the lowest third of the body mass index distribution. There was no statistically significant interaction between the two risk factors. The frequency of hip injury was insufficient for comparable analyses using this variable.

There was no overall association between cigarette smoking or alcohol consumption and the risk of hip osteoarthritis (table 4). However, there was a significantly lower risk of hip osteoarthritis among men who were current cigarette smokers when compared with men who had never smoked (OR = 0.4, 95 percent CI

TABLE 2. Association of body mass index, Heberden's nodes, and hip injury with the risk of hip osteoarthritis among residents of Portsmouth/North Staffordshire who were listed for arthroplasty during 1993–1995

Risk factor	Men			Women			All		
	Cases (no.)	Controls (no.)	Odds ratio*	Cases (no.)	Controls (no.)	Odds ratio*	Cases (no.)	Controls (no.)	Odds ratio*
Body mass index (kg/m ²)									
≤24.5	54	68	1.0	130	164	1.0	184	232	1.0
24.6–27.9	80	90	1.0 (0.6–1.7)†	125	119	1.3 (0.9–1.9)	205	209	1.2 (0.9–1.6)
≥28.0	76	52	1.9 (1.1–3.3)	146	118	1.7 (1.2–2.4)	222	170	1.7 (1.3–2.4)
p trend			$p = 0.02$			$p = 0.005$			$p < 0.001$
Heberden's nodes									
None	91	110	1.0	92	115	1.0	183	225	1.0
Possible	51	60	1.2 (0.7–2.0)	78	75	1.4 (0.9–2.3)	129	135	1.3 (0.9–1.8)
Definite	68	40	2.7 (1.5–4.9)	231	211	1.5 (1.0–2.1)	299	251	1.6 (1.2–2.2)
p trend			$p = 0.002$			$p = 0.07$			$p = 0.001$
Previous hip injury									
No	193	209	1.0	371	390	1.0	564	599	1.0
Yes	17	1	24.8 (3.1–199.3)	30	11	2.8 (1.4–5.8)	47	12	4.3 (2.2–8.4)

* Odds ratios mutually adjusted for the other two variables.

† Numbers in parentheses, 95% confidence interval.

TABLE 3. Body mass index, Heberden's nodes, and the risk of hip osteoarthritis among 553 cases and controls without hip injury from Portsmouth/North Staffordshire who were listed for arthroplasty during 1993–1995

Heberden's nodes	Body mass index by third		
	Lower (odds ratio)	Middle (odds ratio)	Upper (odds ratio)
None	1.0	1.1 (0.7–1.8)*	1.6 (1.0–2.7)
Possible	1.5 (0.8–2.7)	1.5 (0.8–2.6)	2.0 (1.1–3.6)
Definite	1.4 (0.9–2.3)	2.2 (1.4–3.7)	3.2 (1.9–5.4)

* Numbers in parentheses, 95% confidence interval.

0.2–0.9). This tendency was not observed among women.

There was a tendency for the risk of hip osteoarthritis to be elevated among men and women who had participated in regular sporting activity during their earlier years (OR = 1.2, 95 percent CI 0.9–1.6; table 5). The risk was significantly elevated among women who had played tennis or engaged in swimming at least once a week for 3 months each year, for a period of at least 10 years, since they had left school.

We examined differences in the risk factor profile for superolateral and concentric/medial hip osteoarthritis separately. Superolateral disease was more closely associated with obesity and previous hip injury than was concentric/medial disease, but these differences were not statistically significant. Heberden's nodes showed similar associations with each variant. Table 6 shows the relations between obesity, Heberden's nodes, hip injury, and the risks of unilateral or bilateral osteoarthritis. Previous hip injury was more closely associated with unilateral osteoarthritis. There was no clear evidence of a difference for obesity or Heberden's nodes.

DISCUSSION

The results of this population-based case-control study suggest that obesity, previous hip injury, and a tendency to polyarticular involvement are independent risk factors for hip osteoarthritis. The segregation of these risk factors with unilateral or bilateral hip osteoarthritis provides insight into the roles of systemic and biomechanical influences in the pathogenesis of the disorder. Hip injury was more closely related to unilateral as compared with bilateral disease; obesity and Heberden's nodes were associated with both patterns of involvement. The effects of all three risk factors were apparent among men and women, although hip injury was more closely linked to osteoarthritis risk among men. In addition, the study revealed a negative association between cigarette smoking and osteoarthritis among men and a weak positive association with prolonged, regular sporting activity, particularly tennis.

While the profile of risk factors for knee osteoarthritis has been well characterized in several epidemiologic studies (11–14), comparable data are not yet available for hip disease. One difficulty in conducting such studies is the lower prevalence of moderate-severe radiographic hip osteoarthritis than of hand or knee osteoarthritis, in the general population. Thus, one cross-sectional North American study (15) utilizing data from 2,490 subjects who underwent pelvic radiography identified 73 cases with radiographic disease, and the majority of these would most probably have had moderate rather than severe radiographic involvement. We adopted a complementary approach, identifying cases from a defined population who presented with sufficiently severe hip osteoarthritis to be listed for arthroplasty by an orthopedic surgeon. The benefit of this approach is that it maximizes statistical power, but this is achieved at the expense of potential referral bias. We tried to minimize such bias by assiduous tracing of listed cases and by including patients who consulted orthopedic surgeons privately, as well as those being treated under the National Health Service. Case records were carefully scrutinized to exclude patients with hip osteoarthritis secondary to other musculoskeletal disease, such as inflammatory arthritis and childhood hip disorders. Finally, the hip radiographs of all cases were evaluated according to a strict protocol, and the majority of subjects were shown to have severe radiographic osteoarthritis (96 percent had Kellgren/Lawrence grades 3–4, and 78 percent had a minimum joint space ≤ 1 mm).

Two broad mechanisms are believed to underlie the pathogenesis of osteoarthritis at any joint site: mechanical stress and a generalized predisposition to the disorder. The relative importance of these two mechanisms to the etiology of hip osteoarthritis is unknown, but our study suggests that both play a role. Obesity is known to be strongly associated with the risk of knee osteoarthritis (16). However, epidemiologic studies have been less conclusive with regard to hip osteoarthritis. Tepper and Hochberg (15) were unable to show an overall association between obesity and hip osteoarthritis in their population-based case-control study, but they found a statistically significant influence of this risk factor on bilateral hip osteoarthritis. In a previous case-control study (17) of men aged 60–76 years, we observed a doubling of risk for hip osteoarthritis among those in the highest third of body mass index distribution, as compared with those in the lowest third, although the increased risk was not statistically significant. Obesity did emerge, however, as a significant risk factor for hip osteoarthritis in a later cross-sectional study (18) that we performed in elderly men, as well as in studies of women with hip osteo-

TABLE 4. Cigarette smoking, alcohol consumption, and the risk of hip osteoarthritis among residents of Portsmouth/North Staffordshire who were listed for arthroplasty during 1993–1995

Risk factor	Men			Women			All		
	Cases (no.)	Controls (no.)	Odds ratio*	Cases (no.)	Controls (no.)	Odds ratio*	Cases (no.)	Controls (no.)	Odds ratio*
Cigarette smoking†									
Never	72	52	1.0	214	220	1.0	286	272	1.0
Previous	121	131	0.6 (0.3–1.0)‡	148	143	1.1 (0.8–1.4)	269	274	0.9 (0.7–1.2)
Current	17	27	0.4 (0.2–0.9)	38	37	1.1 (0.7–1.9)	55	64	0.8 (0.5–1.3)
<i>p</i> trend			<i>p</i> = 0.02			<i>p</i> = 0.6			<i>p</i> = 0.3
Alcohol (units/week)									
0	67	57	1.0	221	233	1.0	288	290	1.0
≥1	143	153	0.8 (0.5–1.4)	180	168	1.3 (1.0–1.7)	323	321	1.1 (0.9–1.5)

* Odds ratios adjusted for body mass index, Heberden's nodes, and hip injury.

† Cigarette smoking information unavailable for one case, so one case-control pair excluded.

‡ Numbers in parentheses, 95% confidence interval.

TABLE 5. Sporting activity and the risk of hip osteoarthritis among residents of Portsmouth/North Staffordshire who were listed for arthroplasty during 1993–1995

Sport*	Men			Women			All		
	Cases (no.)	Controls (no.)	Odds ratio†	Cases (no.)	Controls (no.)	Odds ratio†	Cases (no.)	Controls (no.)	Odds ratio†
Tennis	32	29	1.0 (0.6–2.0)‡	81	46	1.9 (1.3–2.8)	113	75	1.6 (1.1–2.2)
Swimming	65	56	1.2 (0.7–1.9)	91	54	1.8 (1.2–2.7)	156	110	1.5 (1.1–2.0)
Soccer	97	86	1.1 (0.7–1.6)	0	2		97	88	1.1 (0.7–1.6)
Cricket	51	52	0.9 (0.5–1.5)	3	4	0.5 (0.1–2.6)	54	56	0.9 (0.5–1.4)
Golf	36	22	1.5 (0.8–2.9)	15	12	1.2 (0.5–2.6)	51	34	1.4 (0.9–2.3)
Any sport	177	175	1.0 (0.5–1.9)	294	274	1.3 (0.9–1.7)	471	449	1.2 (0.9–1.6)

* Participation in sports at least weekly for 3 months each year for a period of at least 10 years since leaving school, contrasted with no sporting activity.

† Odds ratios adjusted for body mass index, Heberden's nodes, and hip injury.

‡ Numbers in parentheses, 95% confidence interval.

arthritis performed in the United States (19) and the Netherlands (20). The results of the current study confirm an association between obesity and osteoarthritis at this lower limb site and are in accord with the US data suggesting a detectable effect on bilateral hip involvement (15). Obesity is also known to be associated with bilateral knee osteoarthritis (21), but the strength of this association for knee disease is substantially greater than that for the hip. Although the effect could be explained by increased lower limb loading in obese subjects, it is also compatible with a generalized systemic predisposition to the disorder. Studies of obesity and hand osteoarthritis yield inconsistent results (4).

Involvement of the hip in generalized osteoarthritis is controversial (22–26). Many studies based on clinical series have suggested a low frequency of hip involvement in generalized osteoarthritis (23, 25), but the prevalence of hip disease is lower than that of hand or knee disease at any given age. Our observation that hand involvement increases the risk of hip osteoarthritis is compatible with that from previous population studies and with a recent anal-

ysis of the pattern of joint involvement in generalized osteoarthritis in women (26), which found a greater frequency of hip involvement than would be expected by chance alone. It is also in accord with observations made in the Study of Osteoporotic Fractures (27), where the risk of hip osteoarthritis was more than three times greater among women with hand osteoarthritis. As in our study, the US study found hand osteoarthritis to be associated with both unilateral and bilateral hip involvement. We were interested to find that the association of hip osteoarthritis with obesity and Heberden's nodes in our study was detectable among men as well as among women. It may be that the systemic tendency toward osteoarthritis can be found in both sexes but is simply less apparent among men who have a lower frequency of disease at all joint sites.

Our study confirms the importance of hip injury in the etiology of hip osteoarthritis. Hip injury of sufficient severity to warrant non-weight-bearing for at least 1 week was a significant risk factor for the disorder. The risk was most pronounced among men and for unilateral, as compared with bilateral,

TABLE 6. Risk factors for unilateral and bilateral hip osteoarthritis among residents of Portsmouth/North Staffordshire who were listed for arthroplasty during 1993–1995

Risk factor	Unilateral osteoarthritis*			Bilateral osteoarthritis		
	Cases (no.)	Controls (no.)	Odds ratio†	Cases (no.)	Controls (no.)	Odds ratio†
BMI‡ (kg/m²)						
≤24.5	37	47	1.0	129	163	1.0
24.6–27.9	47	49	0.9 (0.4–1.8)§	143	138	1.3 (0.9–1.8)
≥28.0	58	46	1.6 (0.8–3.1)	140	111	1.7 (1.2–2.4)
<i>p</i> trend			<i>p</i> = 0.1			<i>p</i> = 0.004
Heberden's nodes						
None	34	44	1.0	134	160	1.0
Possible	34	36	1.4 (0.6–3.0)	87	85	1.3 (0.9–1.9)
Definite	74	62	1.8 (0.9–3.6)	191	167	1.5 (1.0–2.1)
<i>p</i> trend			<i>p</i> = 0.1			<i>p</i> = 0.03
Previous hip injury						
No	122	139	1.0	391	403	1.0
Yes	20	3	10.6 (2.4–47.4)	21	9	2.3 (1.0–5.1)

* Osteoarthritis defined as Kellgren/Lawrence grade 2 or higher.

† Odds ratios mutually adjusted for the other two variables.

‡ BMI, body mass index.

§ Numbers in parentheses, 95% confidence interval.

involvement. Our observation that the median age at hip injury among cases was 13 years before the onset of hip pain suggests that injury plays a causal role, rather than occurring as a consequence, of hip osteoarthritis. Previous studies suggest that the majority of unilateral hip osteoarthritis results from congenital dislocation of the hip, acetabular dysplasia, Perthes disease, and slipped capital epiphysis (28). The present study extends these risk factors to include hip trauma. Most, but not all, data suggest that recreational participation in such sports as running and football is not associated with osteoarthritis in the absence of joint injury (29–31). However, we did see small increases in risk for long-term participation in certain sports, particularly tennis, after adjusting for obesity, Heberden's nodes, and hip injury. A recent analysis from the Study of Osteoporotic Fractures revealed that the risk of hip osteoarthritis among women who had higher levels of physical activity during their teenage years was significantly elevated (32). The data on sports participation in our study related to exposure at least once each week, for 3 months each year, for at least 10 years since leaving school. In a substantial proportion of our subjects, this exposure occurred during their early adulthood, and it is possible that sports participation at this age has a greater impact on the risk of hip osteoarthritis than in later life. The association with swimming may have arisen because patients with hip osteoarthritis were advised to swim as a means of maintaining muscle function.

This may have been a chance finding, but further research is clearly required to determine the importance of repetitive high impact or torsional loading through sporting activities, independently of hip injury.

Some but not all previous studies have reported that smoking is negatively associated with the development of osteoarthritis (33–35). In the Framingham cohort, smokers had a 25 percent reduced risk of developing knee osteoarthritis after adjustment for age, sex, body mass index, coffee and alcohol consumption, history of knee injury, and physical activity. However, smoking is more common in symptomatic women with knee osteoarthritis than in women with radiographic knee osteoarthritis who do not report knee pain (4). Our study revealed a significant negative association between cigarette smoking and hip osteoarthritis among men but no association among women.

In summary, this analysis of individual risk factors for symptomatic hip osteoarthritis supports the notion that this condition arises through an interaction between a generalized predisposition to the disorder and specific mechanical insults to the hip. Obesity and hip injury are important independent risk factors for osteoarthritis that might be amenable to primary prevention. Our data suggest that hip osteoarthritis may also arise as part of the polyarticular involvement found in generalized osteoarthritis and that further research is required to dissect

the degree to which sporting activity adds to the risk imposed by hip injury.

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