

Etiologic fractions for physical work load, sports and overweight in the occurrence of coxarthrosis

by Ole Olsen, MSc,¹ Eva Vingård, MD,² Max Köster, BA,² Lars Alfredsson, PhD^{2,3}

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OBJECTIVES — The aim of this study was to estimate the impact of physical work load, sports, and overweight on the incidence of coxarthrosis.

METHODS — A case-referent study was made of 239 male recipients of a hip prosthesis and 302 men randomly selected from the general population. Information was obtained by means of an interview and questionnaire. Exposures to physical work load and sports were measured as the cumulative number of hours of exposure up to 49 years of age. Overweight was measured as the estimated body mass index at 30 or 40 years of age.

RESULTS — The etiologic fraction related to the three risk factors was 40% for physical work load, 55% for sports, and 15% for overweight. Various measures of physical work load were considered, but they all proved to be correlated.

CONCLUSIONS — Approximately 80% of the idiopathic coxarthrosis was explained by the presence of the three risk factors.

KEY TERMS — case-referent study, dynamic work load, hip, lifting, occupation, osteoarthritis, prevention, static work load.

Musculoskeletal diseases are among the most important diseases in Western societies today when measured in terms of sick leave, disability pension, or "lost good years of life" (1). The objective of the present study was to estimate the impact of physical work load, sports, and overweight on the incidence of one of these diseases, coxarthrosis.

Similar estimations of occupational etiologic fractions have been carried out previously for the incidence of major and lethal diseases such as cardiovascular diseases (2) and cancer (3—6). However, the epidemiologic quality of the studies published on musculoskeletal diseases has been, in general, not as high (7—9) as for cancer and cardiovascular diseases, and therefore obtaining a reliable estimate is more difficult. Furthermore, the aim of most studies in occupational musculoskeletal epidemiology is to identify occupational risk factors, and rather few studies are left which have examined the population distribution of the risk factors and thus allow a population-based estimation of etiologic fractions.

The etiologic fraction (population attributable risk) has been introduced as an appropriate parameter for quantifying the disease-producing role of an etiologic factor, and population-based case-referent studies might directly provide the measures required (2, 10, 11).

Subjects and methods

From a case-referent study (12—14) of first-time prosthesis of the hip at four large hospitals in Stockholm, Sweden, the quantitative importance of physical work load, sports, and overweight to the development of coxarthrosis has been studied. The etiologic fraction was calculated with the use of the following operational entities for "physical work load": cumulative number of hours exposed to dynamic work loads, cumulative number of hours working in a twisted locked position, cumulative number of tons lifted, total number of heavy lifts, and cumulative number of jumps. The cumulative numbers were collected up to the age of 49 years, as were the numbers of hours spent in sports activities.

The study base comprised all Swedish men who were between the ages of 50 and 70 years and lived in the referral areas of four large hospitals in Stockholm. Information was collected from 1984 to 1988. The cases were the men in the study population who received a first-time prosthesis of the hip joint as a result of idiopathic osteoarthritis. The referents were randomly selected from the study base. The main as-

¹ Department of Occupational Medicine, National Institute of Occupational Health, Denmark.

² Department of Occupational Medicine, Karolinska Hospital, Stockholm, Sweden.

³ Department of Epidemiology Institute of Environmental Medicine, Karolinska Institute, Stockholm, Sweden.

Reprint requests to: Dr O Olsen, National Institute of Occupational Health, Lersø Parkallé 105, DK-2100 Copenhagen Ø, Denmark.

pects of the design, material, and methods of the study have been presented elsewhere (12–14).

All information about the participants' health status, smoking habits, education, sports activities, and occupational career was obtained in a telephone interview. According to this information, each subject's occupational career was divided into different periods with similar work tasks. For each such period the study participants were asked to complete a questionnaire about the specific physical work loads in that type of work. The subjects were asked how many hours per week were spent in different work positions, how many kilograms were lifted per week, and other such questions. Information regarding exposure was collected from the start of the occupational career to the year of the diagnosis for the cases and to the year of the interview for the referents. Exposure was then aggregated for the men's worklife up to 49 years of age. Three exposure groups were defined according to the loads in the reference group. Those unexposed and the 5% least exposed were considered to have low exposure. The rest of the exposed men were divided into two equally large groups, classified as the medium-exposed and the high-exposed group.

The etiologic fractions were calculated as follows for the work loads: static + dynamic work, lifted tons, number of lifted heavy burdens (>40 kg), and number of jumps. The etiologic fraction for sports activities was calculated in the same way as for exposure from work load. The exposure from sports activities was quantified as low, medium, and high according to the total amount of hours spent in sports. The etiologic fractions for overweight were calculated so that the lean group (BMI < mean BMI - 1 SD) was considered unexposed and the rest were considered exposed, with the use of unadjusted odds ratios, or so that the lean group was considered the reference group and only those at least slightly obese (BMI > mean BMI + 1 SD) were considered exposed, with the use of adjusted odds ratios.

The etiologic fractions were estimated according to principles outlined by Miettinen (11). The etiologic fraction for all the cases in the study population (EF_p) was calculated as $\Sigma EF \times CF$, where CF is the fraction of cases (fraction of all cases) in each category of the determinant and EF_e is the etiologic fraction for the exposed. EF_e was calculated as $(RR - 1)/RR$, where RR is the adjusted odds ratio for those exposed in each exposure category in comparison with those with the lowest exposure. The adjusted odds ratios were obtained from stratified Mantel-Haenszel analyses (12–14). The 95% confidence intervals for the EF_p were based upon the standard error given by Walter (15). Where indicated, overall etiologic fractions for two or more factors were calculated by means of Miettinen's formula (11):

$$EF(\text{total}) = 1 - [1 - EF(1)] \times [1 - EF(2)] \times \dots [1 - EF(n)].$$

Results

The etiologic fractions due to occupational exposures are presented in table 1 for each of four operationalizations of work load. Analyses of cumulative work load up to 29 years of age instead of up to 49 years did not change the etiologic fractions by more than 7%. The various work loads were highly correlated; only 3 of the 31 cases with low exposure to static and dynamic forces had experienced exposure to any of the other loads. An analysis with a reference group comprised of those who had experienced no exposure to any of the variables listed in table 1 yielded an etiologic fraction of 40%. All of these estimates were adjusted for age, body mass index, smoking habits, and sports activities (12).

The etiologic fraction due to sports activities up to 49 years of age was estimated to be 55% (table 2). The overall etiologic fraction due to occupation and sport can be estimated from tables 7 and 8 in reference 13. With the use of the subjects unexposed to both sports activities and occupational loads as the reference category (only 14 cases), the combined etiologic fraction for occupation or sport or both was estimated to be 66%. However, in table 7 of reference 13, the numbers of hours of sports activities were cumulated only up to 29 years of age. If sports activities are, instead, cumulated up to 49 years of age, the number of unexposed persons becomes smaller, and the relative risks become larger (13). If this larger etiologic fraction for sports activities (55%) is combined with the etiologic fraction for occupation (40%) according to Miettinen's formula, the combined etiologic fraction for occupation and sport is estimated to be 73%.

The etiologic fractions due to overweight are presented in table 3. They range from 13 to 17% depending on the choice of reference group and the choice of age at which the body mass index was estimated. With the use of the subjects unexposed to both sports activities (up to 49 years of age) and overweight (at 30 years of age) as the reference category (only 7 cases), the combined etiologic fraction for overweight and sport was estimated to be 82%. If sports activities up to only 29 years of age were used instead, the estimation would be based on 11 cases and the etiologic fraction would be estimated to be 66%.

The combined estimates were subject, however, to large sampling errors based as they were on very few unexposed cases. If the etiologic fractions for occupation (40%), sports activities (55%), and overweight (15%) are combined according to Miettinen's formula, the total etiologic fraction for these exposures is 77%.

Discussion

To estimate the fraction of disease that can be avoided by reducing or eliminating the population expo-

Table 1. Etiologic fraction (EF) estimates for various types of physical work loads.

Type of work load	Number of cases	Risk ratio ^a	EF for exposed (EF _e)	EF for all cases (EF _p)
Static + dynamic work				
Low exposure	31	1		
Medium exposure	68	1.82	0.45	0.16
High exposure	94	2.42	0.59	0.29
Medium + high exposure	162	-	-	0.44
95% confidence interval	-	-	-	0.24—0.64
Tons lifted				
Low exposure	44	1		
Medium exposure	66	1.58	0.37	0.13
High exposure	83	1.84	0.46	0.20
Medium + high exposure	149	-	-	0.32
95% confidence interval	-	-	-	0.11—0.53
Number of lifts (> 40 kg)				
Low exposure	87	1		
Medium exposure	41	1.38	0.28	0.06
High exposure	65	2.48	0.60	0.20
Medium + high	106	-	-	0.26
95% confidence interval	-	-	-	0.13—0.39
Number of jumps				
Low exposure	103	1		
Medium exposure	44	1.83	0.45	0.10
High exposure	46	1.52	0.34	0.08
Medium + high exposure	90	-	-	0.18
95% confidence interval	-	-	-	0.05—0.31

^a Adjusted for age, body mass index, smoking, and sports activities. From table 5 in reference 12.

Table 2. Etiologic fraction (EF) estimates for sports activities.

	Number of cases	Risk ratio ^a	EF for exposed (EF _e)	EF for all cases (EF _p)
Sports activities				
Low exposure	44	1		
Medium exposure	55	2.6	0.62	0.18
High exposure	94	4.5	0.78	0.38
Medium + high exposure	149	-	-	0.55
95% confidence interval	-	-	-	0.40—0.70

^a Adjusted for age, body mass index, smoking, and physical loads from occupation. From table 4 in reference 13.

sure to a given etiologic agent is a prerequisite for evaluating disease-preventing strategies. However, estimates of etiologic fractions must be interpreted with caution, as they presuppose that the observed relations between factors and disease are causal relationships, and not merely statistical associations. The associations studied in this paper fulfill most of Bradford Hill's relevant criteria (16, 17) for causality, namely, strength of the association (relative risks above 2, except for overweight), dose-response effect present except for the small group with extreme overweight, lack of temporal ambiguity, the hypothesis about "wear and tear" (common for all three of the studied risk factors) biologically plausible, supportive experiments on animals available (12), consistency of the findings [the association between coxarthrosis and occupational load being repeated in a large, long-term, prospective register study (18), the association between coxarthrosis and sports activi-

ties being repeated in the two best of three studies on top athletes (13), but the quality of studies on overweight being generally of lower quality and giving inconsistent results].

The sources of bias, misclassification, and confounding in the present study have been discussed earlier (12—14), and they are generally expected to be of minor importance. As far as the given estimates represent causal relationships, they contribute to the discussion on the proportions of coxarthrosis which might be due to physical work load, sports, and overweight and which thereby could theoretically have been prevented.

As "occupational exposure" is an inaccurate description of exposure to a multitude of specific physical work loads during a work career, the estimates of the fraction of a disease due to "occupational exposure" are highly dependent upon the definition and categorization of the exposure variable. Etiologic

Table 3. Etiologic fraction (EF) estimates for overweight. (BMI = body mass index)

BMI	Number of cases ^a	Risk ratio ^b	EF for exposed (EF _e)	EF for all cases (EF _p)
30 years of age				
Lean (BMI < mean BMI - 1 SD)	31			
Normal (mean BMI - 1 SD ≤ BMI ≤ mean BMI + 1 SD)	116	1.04	0.03	0.02
Slightly overweight (mean BMI + 1 SD < BMI < mean BMI + 2 SD)	48	1.69	0.41	0.09
Severely overweight (BMI ≥ mean BMI + 2 SD)	27	1.28	0.22	0.03
Information unavailable	17	0.83		
	222			0.13
The slightly and severely overweight as a fraction of the population	0.34	1.81 ^c		0.15
95% confidence interval				0.05–0.25
40 years of age				
Lean (BMI < mean BMI - 1 SD)	35			
Normal (mean BMI - 1 SD ≤ BMI ≤ mean BMI + 1 SD)	124	1.11	0.1	0.06
Slightly overweight (mean BMI + 1 SD < BMI < mean BMI + 2 SD)	43	1.79	0.44	0.09
Severely overweight (BMI ≥ mean BMI + 2 SD)	17	1.67	0.4	0.03
Information unavailable	20	1.02		
	219			0.17
The slightly and severely overweight as a fraction of the population	0.27	2.49 ^c		0.16
95% confidence interval				0.07–0.25

^a From table 5 in reference 14.^b Unadjusted and with the lean subjects as the reference group.^c Adjusted for age, occupational physical work load, and sports activities, the slightly overweight subjects plus the severely overweight subjects being compared with the lean subjects. From table 6 in reference 14.

fractions for four different measures of physical work load were presented. These measures were, however, so closely correlated that it was impossible to distinguish the specific effects of the various risk factors. Thus the data simply indicated that approximately 40% of the coxarthroses might have been prevented if all occupational work loads had been eliminated.

With regard to the external validity of the occupational etiologic fraction, the Greater Stockholm area, in which the study was performed, is somewhat more urbanized than the average for the country. However, one of the hospitals in the study covered a rural region, and, due to migration and urbanization in the 1950s and 1960s, the study base probably comprised a sample of work careers that was fairly representative for Sweden. The estimate, however, is historical, as it was based on, and primarily appropriate for, the generations who worked in the middle of this century. If society had been in steady state, it would cause no problem to apply the obtained estimate to future generations as well. But some of the physical work loads that were previously common or at high levels are now, to a large extent, controlled (at least in our part of the world). Thus it can be expected that the occupational etiologic fraction will decrease in the future. However, due to similar occupational structures and similar changes in it, the estimate is probably applicable to middle-aged and elderly generations in other Nordic countries.

Calculations similar to the ones made in the present paper have been performed in only one oth-

er study, a Finnish study based on a representative sample of the population aged 30 years or over and including both men and women (19). In that study the total etiologic fraction for prior trauma of the lower limbs, physical stress at work, and overweight was 59% (note that sports were not included). The etiologic fractions for physical stress at work and overweight can be calculated with the aid of table 2 in reference 19, and the etiologic fractions are 37 and 24%, respectively. The former is very close to the 40% calculated in the present paper, and the 24% for overweight is within the confidence limits of the estimate for overweight presented in the present paper.

No other studies allow similar calculations of an etiologic fraction for coxarthrosis. However, using a case-referent study of disability pension due to musculoskeletal disorders (20), we were able (with the aid of table 4 in the paper) to calculate an occupational etiologic fraction from the occupational titles for the hip cases (EF_p = 72%), knee cases (EF_p = 75%), neck and shoulder cases (EF_p = 69%), and low-back cases (EF_p = 71%). These etiologic fractions should, however, be interpreted with great caution, as they may reflect both a causal relationship and the difficulty in continuing work in certain occupations while suffering from a musculoskeletal disorder. In the cross-sectional HANES I study (21), an occupational etiologic fraction of radiographic osteoarthritis of the knee was estimated to be 32%. Unfortunately the studies of neck and shoulder disorders (7–9) and of low-back pain (22, p 28) are generally of low epidemiologic quality and do not

permit etiologic fractions to be estimated. The few good studies, however, provide large odds ratios and suggest that the etiologic fractions may be appreciable.

The etiologic fraction for sports activities of all kinds was 56%. The most hazardous sports seemed to be track and field, racket sports, and soccer (13). However, the participants in individual sports were few, and the results must be interpreted with caution on this level. The estimate of the etiologic fraction for sports activities in general was, however, so large that it warrants further research into the different loads and possible later deleterious effects of various sports. This finding is important, especially in light of the many positive aspects of sports activities in general.

It should be pointed out that the individual etiologic fractions of two factors contributing to a multifactorial disease are not invalidated, although their sum exceeds 100%, and each estimate must be interpreted as a measure of disease reduction if the factor in question was the first to be eliminated (22). It is furthermore possible to calculate etiologic fractions for preventive strategies covering the simultaneous elimination of several factors (23). The present study indicates that approximately half of the occurrences of coxarthrosis in the present generation might have been prevented by the elimination of either of the single factors occupational exposure or sports activities. Approximately 75% of the occurrences might have been prevented if physical work load, sports, and overweight had all been eliminated.

Although, clinically, idiopathic coxarthrosis has been considered a disease "occurring without known cause" (24), we conclude that the occurrence of the disease, from an epidemiologic point of view, turns out to be highly explainable, understandable, and preventable.

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