Scand J Work Environ Health 1995;21(6):478-486
https://doi.org/10.5271/sjweh.64
Issue date: Dec 1995

Humeral epicondylitis among gas- and waterworks employees

by Ritz BR

The following articles refer to this text: 2001;27(4):268-278; 2002;28(2):109-116

Key terms: cumulative exposure; job history; mechanics; MSD; multivariate analysis; musculoskeletal disorder; pipefitter; welder; work-related factor

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/8824754

Print ISSN: 0355-3140 Electronic ISSN: 1795-990X

Scand J Work Environ Health 1995;21:478—86

Humeral epicondylitis among gas- and waterworks employees

by Beate R Ritz, MD[1]

Ritz BR. Humeral epicondylitis among gas- and waterworks employees. *Scand J Work Environ Health* 1995;21: 478—86.

Objectives In this cross-sectional study 290 male employees of the public gas- and waterworks of Hamburg, Germany, were examined for symptoms of epicondylitis. Forty-one workers were diagnosed with symptoms of lateral or medial epicondylitis. The effect of employment in different job categories on the prevalence of epicondylitis was explored.

Methods The diagnosis of epicondylitis was based on the study's own criteria and compared with criteria used in former studies. Jobs were categorized into high, moderate, and no exposure groups according to tasks regarded as strenuous for the elbow. The data were analyzed with the help of multivariate logistic regression.

Results With the study's diagnostic criteria, the prevalence odds ratio (OR) for 10 years of high exposure to elbow straining work was 1.7 [95% confidence interval (95% CI) 1.04—2.68] for currently held jobs and 2.16 (95% CI 1.08—4.32) for formerly held jobs. For workers regarded as moderately exposed in current jobs the odds ratio for 10 years was 1.4 (95% CI 1.00—1.93). Very similar results were obtained for current exposure when stricter diagnostic criteria were employed.

Conclusions The results suggest a cumulative exposure effect with length of employment. Workers with high exposure in former jobs compared with employees with high exposure in their current job exhibited more residual or slight epicondylitis symptoms upon examination.

Key terms cumulative exposure, job history, mechanics, multivariate analysis, musculoskeletal disorder, pipefitters, welders, work-related factors.

For a long time knowledge of the occurrence of the epicondylar pain syndrome in occupational settings was clinical and anecdotal, that is, based solely on case reports (1). Only during the last 15 years have epidemiologic occupational studies employing comparison groups been published. Most of these investigations studied food-processing workers (2—8), while one examined blue-collar workers in a modern engineering plant (9). All but two (6, 7) employed one-time cross-sectional examinations in order to diagnose prevalent cases of epicondylitis. Epicondylitis is a relatively rare disorder, with the overall prevalence in the general population reported to be less than 5% (10). Since study populations have not exceeded 550 employees, the number of expected and observed cases among the workers in these industries was small, being less than 50. Consequently, these studies have had insufficient statistical power to detect a moderate effect (eg, a twofold increase in risk) for the dichotomous exposure variables commonly reported. The number of exposed workers employed by a certain industry imposes limits on increasing the sample size and thus on study power. However, improving exposure assessment by abandoning exposure dichotomies for measures which include intensity and duration might achieve the goal to boost power.

Another important issue in studies of the occurrence of epicondylitis in occupational settings involving hand-intensive work is bias due the healthy-worker effect, specifically healthy worker "survival," (ie, longer term employment in a particular job). A person with epicondylitis in a nonmanual occupation might very well be able to perform his tasks. But epicondylitis symptoms preclude work requiring substantial hand or wrist movements. Especially if such tasks induce recurrent illness episodes, workers with epicondylitis are likely to leave their jobs earlier than healthy workers. Thus one would expect cases to be selected out of such jobs at a higher rate and thus cause an underestimation of the epicondylitis prevalence for workers in hand-intensive jobs. Results from studies that offer no means of controlling for this type of potentially severe selection bias are difficult to interpret.

This study improves exposure classification and examines some selection bias issues.

1 University of California, Los Angeles, California, United States.

Reprint requests to: Dr BR Ritz, Department of Epidemiology, School of Public Health, UCLA, Box 951772, Los Angeles, CA 90025—1772, USA.

Subjects and methods

Study population

During the first three months of 1986, all male employees of the Hamburg Gas- and Waterworks who received a routine medical check-up at the company occupational health center were also examined for musculoskeletal problems. Check-ups are scheduled for all employees on an annual or biannual basis according to insurance requirements. Employees were not included in the study sample if they were on sick leave at the time of the scheduled examination or came to the health center for medical treatment, preemployment check-ups or to file a workman's compensation claim. Anyone who showed signs of recent trauma or surgery of the spine or extremities and persons with rheumatic or metabolic diseases, osteoporosis, autoimmune and circulatory diseases, joint infections, or neuromuscular disorders were also excluded from the study (ie, individuals suffering from disorders that can cause elbow pain that is unrelated to epicondylitis). One physician employed by the study examined the subjects without knowledge of the examinee's occupational status or history. The physician was specially instructed to maintain diagnostic criteria throughout the study period. Of the total work force, 290 male employees, approximately 10%, were examined. The mean age of this group was 46.2 (range 18—64) years.

Job description and analysis

The subjects were employed in 46 different job categories at the time of the examination. Lifetime employment histories revealed a total of 99 different occupational titles. The mean length of employment in current jobs was 14.3 (median 13, range 1—49) years and the mean length of lifetime employment was 29 (median 31, range 2—49) years.

All current and former job titles were evaluated by two members of the study team according to possible biomechanical strain to the elbow and grouped into categories of high, moderate, and no work-related exposure. The exposure categorization was based on company job descriptions, interviews with employees, and workplace observations. This classification attributed the highest amount of occupational elbow strain to pipefitters and welders, who install and repair various pipe connections for the company. The routine fitting of pipes is physically strenuous for the elbow region, since the tasks require forceful rotation in the elbow joint while heavy pipes are being gripped, held, and fitted. The work conditions are especially strenuous during emergencies of water- or gas leaks. Furthermore, the work environment is often very restricted with respect to space and thus requires work in awkward positions with minimal equipment. Nine current and an additional seven former job titles were considered moderately stressful for the elbow region. They were mechanic, plumber, electrician, certain construction jobs, and filter maintenance worker. All of these jobs required the routine use of wrenches, the driving of screws, or tasks that involve rotation of the elbow and continuous forceful gripping and rotation of the lower arm.

Forty-six men in our sample were currently active pipefitters and welders at the time of the examination. Seventeen of these 46 men had also been exposed at a moderate level in a previous job. Thirty-one employees had been transferred from pipefitting and welding to other less demanding jobs; 19 of them had also been exposed at moderate levels in previous occupations, that is, before they became pipefitters or welders. Moderate levels of elbow strain were experienced by 52 subjects in their current jobs and another 79 workers in their former jobs. Eighty-two employees were classified as never having been exposed. They were currently holding jobs regarded as nonstrenuous for the elbow and had a lifetime work history of no exposure according to the criteria. The distribution of job categories in this group included such diverse occupations as office worker, engineer, meter reader, health care worker, janitor, lifeguard, supervisor, maintenance worker, and driver.

Exposure was classified as current (ie, exposure received in jobs held at the time of the examination) or previous (ie, exposure received in jobs prior to the one held at the time of the examination). Exposure duration was defined for all the subjects as the total number of years spent in the highest lifetime exposure category. Thus this duration measure disregarded previous exposure at moderate levels for all workers who were or had ever been highly exposed. A value of zero for duration indicated that a subject was never exposed during his life to occupational elbow strain.

Diagnostic criteria

In most studies, the clinical diagnosis of epicondylitis is made if pain is elicited in both of two functional tests. The first test evaluates local tenderness to palpation at the epicondyle. The second is designed to detect pain during resisted movements of the wrist and fingers (extension or flexion of the wrist or fingers with an extended elbow). A review of diagnostic criteria (4) revealed that these two functional tests constitute the most commonly employed signs in all major clinical studies conducted during the previous 30 years. They are referred to as the Waris et al criteria (3, 7, 9, 11) in this report. Other clinical signs used less commonly for the diagnosis of epicondylitis are an increase in pain during the carrying of bags or the lifting of a chair, that is, pain induced by a forceful grip, a decrease in hand-grip power when the left and right hand are compared, swelling at the epicondyle; radiographic changes, and muscle atrophy. None of these signs are considered necessary for the diagnosis per se, and all but a positive "chair lifting test" and the hand-grip power reduction are observed in small percentages of epicondylitis patients. Usually, these clinical signs provide additional information for defining the stage or severity of the disease.

The diagnosis of epicondylitis for this study was based on the two pain provocation tests referred to as Waris et al criteria plus elbow pain during the lifting of a chair. All pain sensations were elicited and reported by the examining physician. Information on the "chair lifting test" along with distinctions in the severity of the pain inflicted in each test were recorded. Thus it was possible to create the scale of epicondylitis severity that is described and compared with the Waris et al criteria in the appendix. According to this scale, epicondylitis was categorized as severe (grade II and grade III) if both functional tests were positive and as moderate (grade I) if the only symptom was a severe tenderness to palpation or a moderate pain in the resistance test. This classification — which differs from the Waris et al criteria — was prompted by physicians' reports describing that patients who return from sick leave after an episode of acute epicondylitis show a tenderness to palpation as the only residual sign (3). However, since pain during palpation of the epicondyle might depend on the force of pressure applied and on interpersonal differences in sensitivity to pain induced by pressure, a moderate pain reaction to palpation alone was not regarded as sufficient for the diagnosis (7). Since the examinee does not anticipate pain at the epicondyle when performing a hand or wrist movement against resistance, this sign is considered more specific than pain inflicted by pressure and any degree of such pain qualified a subject in this study for the diagnosis of moderate epicondylitis. Thus the diagnostic approach of the study takes into account that a cross-sectional study includes prevalent cases at different stages of the disease, such as incipient disease or residual signs of a previous clinical stage disease.

Since the movements suspected to cause epicondylitis syndrome in the studied work force varied, damage was not necessarily expected to occur at a certain epicondyle. Therefore clinical signs of epicondylitis greater than grade 0 at one or more of the four anatomical sites was considered sufficient for the diagnosis.

Statistical analysis

A multivariate analysis was conducted using a logistic regression model to estimate the unconditional maximum likelihood (12). In a preliminary step, we performed stratified analyses. We also assessed the relationship between suspected risk factors and epicondylitis in our population in logistic regression models that included only one risk factor at a time. These procedures helped to identify the shape of the function for continuous variables in the logistic model. Instead of using tertiles, exposure duration categories of equal length (0, 1—14, >15 years of exposure) were formed in order to make parameter estimates from different models for current and previous exposure comparable. The midpoint of each duration category was used as the score value to obtain a test for trend (13). We report the 95% confidence intervals for all estimates and the P-values for trend for the trichotomized exposure duration variable.

Since the relationship between epicondylitis prevalence and age did not appear to be linear, age adjustment in the multivariate model was achieved by entering a term for age in continuous form centered around its mean value and, in addition, a term for the square of this age variable. All the logistic regression models presented in this paper contain age, age-squared, and an indicator term for "history of cervical spine symptoms" (yes, no), known as a risk factor for elbow pain. The influence of the following other potential confounders was also assessed: having ever played tennis, squash, other racquet sports, rowing and bowling, and the duration of having played these sports, injuries involving the elbow joint, the ponderal index as a height-weight function, handedness, and former surgical treatment for epicondylitis. These variables can be suspected to act as independent risk factors for epicondylitis symptoms and could be differentially associated with certain job titles which are proxy measures of socioeconomic status as much as exposure. None of these variables was significantly ($P < 0.05$) associated with the outcome or changed the estimates for exposure by more than 10% when deleted from the multivariate logistic model and were therefore not included in the final regression models (14). The variable "time (in years) since retired from a job with high or moderate exposure" made a substantial difference only for the parameter estimates in the model for workers formerly employed in high-exposure jobs when duration of exposure was trichotomized and thus was retained in this model. (See table 3 in the Results section.)

For current exposure, we also employed cumulative odds models in which the outcome variable is ordinally scaled rather than dichotomized. The use of all available information for the outcome (ie, a scale of symptom severity instead of a diagnostic dichotomy) can increase statistical efficiency, and it helps avoid having to choose a single cut-point to define an arbitrarily positive response (15).

Results

According to our criteria, 41 employees were diagnosed as suffering from epicondylitis, 33 of whom would have been diagnosed if the Waris et al criteria were employed

Table 1. Site-specific and overall epicondylitis prevalence in occupational groups exposed to various degrees of elbow-straining tasks.

Level of exposure	Location of epicondylitis								Affected subjects[a]				Total group (N)
	Right elbow				Left elbow				Diagnostic criteria of study		Diagnostic criteria of Waris et al		
	Lateral		Medial		Lateral		Medial						
	N	%	N	%	N	%	N	%	N	%	N	%	
High exposure													
Current	5	10.9	1	2.2	3	6.5	3	6.5	8	17.4	8	17.4	46
Previous	7	22.6	0	0.0	3	9.7	0	0.0	7	22.6	4	12.9	31
Moderate exposure													
Current	4	7.7	3	5.8	7	13.5	1	1.9	9	17.3	8	15.4	52
Previous	5	6.3	1	1.3	5	6.3	1	1.3	9	11.4	7	8.9	79
No exposure	6	7.3	2	2.4	6	7.3	2	2.4	8	9.8	6	7.3	82

[a] The number of cases does not equal the sum over all sites since some subjects suffered epicondylitis in more than one location.

instead. The age-specific prevalences were 0, 7.9, 13.2, and 22% in the age groups 18—29, 30—39, 40—49, and 50—64 years, respectively. The distribution of the diagnoses by anatomical site is presented in table 1.

Among 15 employees, both arms and, in six instances, the lateral and medial epicondyle were involved. For 33 cases the disease occurred in the arm of the dominant hand. The mean age of the 41 cases was 49.2 (range 32—60) years, while the mean age of the workers not suffering from the elbow disorder was 45.7 (range 18—64) years. The cases and noncases did not differ with respect to the mean length of employment in the current occupation (14.2 years), but the mean length of overall employment was slightly longer in the case group (31.8 versus 28.6 years). Thirty-seven cases and 32 noncases reported a history of elbow pain. The mean duration of past or current pain in the elbow region was 3.7 years among the cases (table 2). A total of 53.6% of all cases described their elbow pain as occurring during daily tasks, and 26.8% experienced it during physical exertion.

Table 3 shows the odds ratios for previously and currently, as well as moderately and highly, exposed workers, as estimated by eight different multivariate logistic regression models. In four of the models, exposure was treated as ever versus never. The other four models incorporated the information on length of exposure as trichotomies. None of the interval estimates for ever or never exposure excluded the null value. However, when the information on duration of exposure was included, trends appeared for currently exposed workers; with increasing duration of exposure the risk of being diagnosed with epicondylitis also increased. The magnitude of the P-value for these trends was dependent on the categorization, that is, the chosen cutoffs defining the number of years in each category. This instability of the estimates was due to the small number of cases within each category. Furthermore, these models did not involve adjustment for possible selection of healthier workers into the exposed groups. Regardless of age, no case of epicondylitis was diagnosed if a worker had been exposed for less

Table 2. Mean duration of elbow pain experienced by the cases (N = 41).[a]

Exposure	N	Mean (years)	Range
High exposure			
Current	8	2.9	0—5
Previous	7	4.2	0—10
Moderate exposure			
Current	9	4.4	1—8
Previous	9	3.0	0—8
No exposure	8	7.8	2—20
Total	41	3.7	0—20

[a] For each person the longer period of pain experienced in either arm was used to calculate the mean.

than five years. When anybody exposed for less than 5—10 years was defined as unexposed, all trends for duration among currently exposed workers and those with previously high exposure became statistically significant at the 5% level (models not presented here).

A model containing exposure duration as a continuous variable is presented in table 4. In this model all the exposure parameters were simultaneously estimated and thus adjusted for each other, as well as for the confounding variables. The strongest effect of occupation on epicondylitis symptoms according to the diagnostic criteria of the study was associated with former high exposure followed by current high and moderate exposure. Former moderate exposure had no effect on the prevalence of epicondylitis in this population. The point estimates of the prevalence odds ratios for 10 years of work in highly or moderately exposed current jobs were 1.7 and 1.4, respectively, and they increased for 30 years of work to 4.7 and 2.7. Having previously worked in a high-exposure job for 24 years, the maximum duration reported in this subgroup, was associated with a 6.3-fold increase in the epicondylitis prevalence. Classifying epicondylitis according to the Waris et al criteria resulted in very similar estimates for currently exposed employees, but the effect for former high exposure disappeared.

Table 3. Prevalence odds ratios (OR) for epicondylitis associated with work-related exposure and exposure duration, estimated by multiple logistic regression.[a] (95% CI = 95% confidence interval)

Exposure category	Total (N)	Case (N)	OR[b]	95% CI	P-value (for trend)[d]
High exposure in current job					
Ever versus never	128	16	2.77	0.85—8.98	·
Duration of exposure (years)					
0	82	8	1.00	·	·
1—14	23	2	1.82	0.56—5.93	·
15—38	23	6	3.32	0.88—12.51	0.07
High exposure in previous job					
Ever versus never	113	15	10.65[c]	1.13—100.24	·
Duration of exposure (years)					
0	82	8	1.00	·	·
1—14	19	4	11.43[c]	1.02—127.86	·
15—24	12	3	9.74[c]	0.79—119.89	0.19
Moderate exposure in current job					
Ever versus never	134	17	2.93	0.93—9.20	·
Duration of exposure (years)					
0	82	8	1.00	·	·
1—14	19	2	1.06	0.10—10.70	·
15—49	33	7	3.78	1.11—12.82	0.03
Moderate exposure in previous jobs					
Ever versus never	161	17	1.34	0.30—6.05	·
Duration of exposure (years)					
0	82	8	1.00	·	·
1—14	50	5	1.39	0.13—14.30	·
15—39	29	4	1.34	0.29—6.10	0.76

[a] The parameters were estimated by eight different logistic models.
[b] Adjusted for age, age-squared, and "history of cervical spine problems (yes, no)."
[c] Also adjusted for "time since retired from high-exposure job (in years)".
[d] The midpoint of each duration category was used as the score value in each model.

Table 4. Prevalence odds ratios (OR) for exposure intensity and duration on epicondylitis according to the diagnostic criteria of the study and Waris et al, as estimated by a multiple logistic regression (N = 290).[a] (95% CI = 95% confidence interval)

Exposure intensity	OR[b]	95% CI	P-value (for trend)
No exposure	1.00	·	·
10 years of moderate exposure			
Current job			
Diagnostic criteria of the study	1.40	1.00—1.93	0.05
Diagnostic criteria of Waris et al	1.43	1.00—2.04	0.05
Former job			
Diagnostic criteria of the study	0.99	0.60—1.64	0.80
Diagnostic criteria of Waris et al	0.94	0.53—1.66	0.83
10 years of high exposure			
Current job			
Diagnostic criteria of the study	1.67	1.04—2.68	0.04
Diagnostic criteria of Waris et al	1.89	1.16—3.09	0.01
Former job			
Diagnostic criteria of the study	2.16	1.08—4.32	0.03
Diagnostic criteria of Waris et al	1.49	0.67—3.33	0.33

[a] All the odds ratios were estimated simultaneously (ie, in one logistic model).
[b] Adjusted for age, age-squared, and "cervical spine symptoms"; the estimate for duration of exposure was derived from a continuous variable measuring duration in years.

The results for cumulative odds models with ordinal outcome variables for epicondylitis according to the diagnostic criteria of the study yielded an odds ratio of 1.72 (95% CI 1.08—2.73) for 10 years of current high exposure and an odds ratio of 1.42 (95% CI 1.04—1.94) for 10 years of current moderate exposure treating exposure duration as a continuous variable. There was no increase in statistical efficiency, but it is remarkable how similar the results are to those from a model with a dichotomous outcome variable for epicondylitis.

Discussion

The main result of our study is the positive dose-response between prevalent epicondylitis and duration of employment in jobs regarded as highly stressful to the elbow as well as between prevalent epicondylitis and duration of current employment in moderately stressful occupations. In current jobs, the effect of long-term exposure to elbow straining tasks persists whether the diagnostic criteria of the study or the criteria of Waris et al are applied, whether reference group definitions are used that do or do not account for a minimum length of employment in exposed jobs or whether the outcome variable is categorized as dichotomous or ordinal. This result not only suggests that current employment in an elbow straining job is relevant to the occurrence of symptoms, but that the amount of time spent in these jobs (ie, the accumulation of exposure) is also. This finding is theoretically supported by the pathogenic model of multiple micro traumas that attributes chronic wear and tear to the tendon or tendoperiostal area as the cause of occupational epicondylitis (16).

The smaller effect of moderately exposed current job categories on the prevalence of epicondylitis is coherent with the notion that such workers should encounter less strenuous tasks. However, moderate exposure might reflect either moderately elbow-straining tasks or subsume workers with a greater variety of tasks; that is, some employees in this group might be continually exposed while others only seldom encounter elbow-straining tasks within their duties. In order to distinguish between the two possibilities, exposure assessment that includes the amount of time spent performing specific tasks would be more useful than job categories. Unfortunately a more refined exposure assessment was not available to us.

For former moderately exposed workers, all point estimates were close to unity, and none of the 95% confidence intervals excluded the null value (ie, there was no evidence for an effect for the duration of work in this exposure category on epicondylitis prevalence). All the former workers in the high-exposure group had been previously employed as pipe-fitters and welders by the Hamburg Gas- and Waterworks; in this sense they had a relatively homogeneous work history and transferred into less demanding jobs at the same company. Employees with moderate exposure in the past had been employed by other companies as well and diverse occupations have been grouped together in this category. The selection mechanisms occurring during recruitment by the company were not known.

Some results reported in the literature corroborate our finding of an exposure duration effect. A study (2) in the meat-cutting industry reported that all cases had worked for more than 15 years in the strenuous job category and had been exposed an average of five years longer than nondiseased workers. Another study (1) reported an increase in epicondylar tenderness with an increasing duration of employment for female sausage makers. A study of textile workers (17) found an increasing prevalence of epicondylitis with duration of employment; another in an engineering plant (18) reported a statistically significant correlation coefficient for lateral epicondylitis and time spent in the present job.

The results for former pipefitters and welders suggest that long-term strenuous work can leave an individual with lasting residual problems in the elbow region even after they change to less demanding jobs. An orthopedic textbook states that epicondylitis is a self-limiting disorder that seldom lasts longer than a year in persons under of 60 years of age (19). This statement does not reflect the experience of our study population for which the mean duration of subjective symptoms for cases was 3.7 years. A similar result was reported for a diverse working population for which the mean duration of epicondylitis symptoms was four years (20). According to another report, 50% of treated patients had recurrences of acute epicondylitis within an 18-month period (21). This finding suggests that acute epicondylitis is not a self-limiting disease of short duration.

In the present study, the crude prevalence for epicondylitis in men was higher than that observed in other studies of working populations (table 5). This was the case whether the extended diagnostic criteria of the study (17.4% of the currently exposed and 9.8% of the unexposed) or the criteria proposed by Waris et al (16.3% of the currently exposed and 7.3% of the unexposed) were employed. This difference might be attributable to the mean age of our study population, which was higher than the mean age of the other study populations (46.2 versus 32.1—40.7 years). Since the prevalence of epicondylitis increases more than linearly after age 40 (2—4, 16), more cases of the studied population could be expected with increasing age, unless such cases were being selected out of the work force. It is surprising that age adjustment has not been a common feature of all reported analyses. One such study (9), for example, reported a higher crude prevalence for unexposed than for exposed employees. The fact that the exposed workers were younger might account for this result.

The trend for duration of previous high exposure depended on the fact that symptoms of moderate degree were allowed to suffice for the diagnosis. Employing the Waris et al criteria resulted in an elimination of less severe cases in this group. Out of seven former heavily exposed pipefitters and welders with epicondylitis, five experienced symptoms of grade I at the time of our examination. Similarly, six of the nine employees with epicondylitis who had formerly been exposed to a moderate degree exhibited grade I disease. To the contrary, in current jobs, 75% of the heavily exposed cases and 55% of the moderately exposed cases experienced symptoms of grade II and III. Viikari-Juntura et al (7), reporting findings of a study conducted in the meat-processing industry, mentioned that six employees known to perform strenuous work were on sick leave with a diagnosis of epicondylitis during or shortly after one of their cross-sectional examinations. Only one of these workers qualified as a case of epicondylitis at the time of the examination according to the study protocol. If epicondylar tenderness had qualified for a diagnosis in this study, the prevalence of epicondylitis in the exposed group would have increased dramatically and exposure would have been positively associated with epicondylitis (table 5). These results suggest that, if the case definition is limited to the criteria employed by Waris et al, many residual or beginning cases of epicondylitis may not be detected during cross-sectional examinations. This study also suggests that the results of the present study, which are

Table 5. Epidemiologic studies of the relationship between work exposure and epicondylitis. (OR = odds ratio, 95% CI = 95% confidence interval)

Industry	Exposure definition	Mean overall age (years)	Number of cases	Prevalence (%) Unexposed	Prevalence (%) Exposed	OR	95% CI	Author
Food production and business (shop assistants)	Exposed if worker on assembly line of food production (N = 152) and unexposed if shop assistant (N = 133)	39.0 (women)	11 women	2.3	5.3	2.4	0.63—9.3	Luopajärvi et al (4)
Meat-processing and construction	Exposed if meat cutter (N = 90) and unexposed if construction foreman (N = 72)	38 (men) 38 (men)	9 men[a] 16 men[b]	1.3 1.3	8.9 16.6	6.9 14.2	0.85—56.8 1.83—110.3	Roto & Kivi (2)
Aircraft manufacturing	Strenuous (N = 312 men and women combined) versus nonstrenuous (N = 228 men and women combined)[c] jobs	40.7	40	9.7	5.8	0.6	0.30—1.1	Dimberg (9)
Meat-processing	Strenuous (N = 152 men and 225 women) versus nonstrenuous (N = 141 men and 197 women) jobs	32 (men) 35.9 (women)	20 men 37 women	2.1[d] 1.5[d]	11.2[d] 15.6[d]	5.3 10.2	1.6—17.7 3.2—32.6	Kurppa et al (3)
Meat-processing	Strenuous (N = 130 men and 192 women) versus nonstrenuous (N = 124 men and 16 women) jobs	36.1 (men) 36 (men) 35.9 (women) 35.9 (women)	7 men[a] 17 men[b] 5 women[a] 49 women[b]	3.2 4.8 1.2 11.0	2.3 8.5 1.6 16.1	0.8 1.8 1.3 1.9	0.16—3.4 0.65—5.1 0.25—7.9 1.00—3.6	Viikari-Juntura et al (7)
Fish-processing	Strenuous (N = 35 men and 111 women) versus nonstrenuous (N = 32 men and 129 women) tasks	35.5 (men and women) 35.5 (men and women)	7 men 23 women	6.3 13.8	14.3 17.1	2.5 1.3	0.45—13.9 0.40—4.2	Chiang et al (8)

a Strict diagnostic criteria comparable to Waris et al.
b Extended diagnostic criteria (ie, epicondylar tenderness to pressure regarded as sufficient for diagnosis).
c Population 90% male.
d Cumulative incidence instead of prevalence.

based on a one-time cross-sectional examination, might suffer from a potentially large bias towards unity (ie, no effect due to the exclusion of workers on sick leave at the time of the examination).

On the other hand in the present study employees were examined who had previously worked under highly and moderately strenuous conditions in the Hamburg Gas- and Waterworks and had been allowed to transfer into other less physically strenuous jobs when symptoms occurred. If it is assumed that residual symptoms could be detected among the subjects who changed jobs within the company and that few persons left the company due to symptoms, it was possible to reduce the bias resulting from selecting diseased and exposed workers differentially out of the work force.

It was decided to distinguish between previously and currently exposed subjects since a combined estimate would falsely assume that formerly exposed workers cannot completely recover from their elbow disorders after leaving their jobs. The detection of even residual signs depended on the length of time since the workers changed jobs and on the original degree of affliction. The evaluation of the effect for former symptom severity was impossible since this information was not available. But a variable for "time since retired from a high-exposure job" was included in the regression model for previously exposed workers. The exposure duration estimate increased dramatically in a model that contained a trichotomous term for duration of previous high exposure.

Evidence suggestive of another type of selection comes from a recently published study of fish-processing workers (8). In this study, the prevalence of epicondylitis decreased from 33.3% for the workers most exposed to repetitive and forceful movements of the upper limbs who were employed less than 12 months to 0% for those employed longer than 60 months in the same exposure category. In contrast, the opposite trend with length of employment was observed for the employees who received the least exposure. In the case of the present study population such early selection of workers more prone to develop elbow problems out of highly exposed jobs could have occurred during the first year of employment, since the annual medical check-up did not include personnel hired for less than one year. The fact that not even one case of epicondylitis was found among employees working less than five years in highly exposed jobs or less than 10 years in moderately exposed jobs suggests that such an early selection did actually occur.

Kurppa et al (3) suggested a third possible source of bias. In strenuous jobs, workers often have to stop working when symptoms occur. Performing hand-intensive work is thus thought to be associated with an increase in sick leave, medical visits, and, ultimately, compensation claims independent of whether or not the job caused the disease. Studies which derive incident cases of epicondylitis from medical records may suffer from reporting bias. Thus these researchers (3) dismissed the results of their incidence study, the only reported study of occupational elbow strain and epicondylitis incidence showing a positive association between meat-cutting and the development of epicondylitis, because the incidence data were obtained from company physicians. The authors claimed that the people in nonstrenuous occupations might have greatly underreported their ailments since they did not need to seek treatment or medical leave. However, the same research team published results from three consecutive examinations in which they determined the prevalence of epicondylitis in this working population during the same time period in which the incidence study was conducted (7). In the prevalence study the authors diagnosed only one case of epicondylitis among unexposed employees that had escaped detection in their incidence study. This finding suggests that the effect of underreporting among unexposed employees is not very great.

Feasibility issues force most researchers to rely on prevalence measures, but prevalence studies are especially vulnerable to the selection of cases out of highly exposed job categories. Prevalence measures are also less informative than incidence measures because they do not allow the researcher to distinguish whether the exposure is a causal or a prognostic factor for the disorder. The restricted access to the working population sampled for the present study allowed only data to be collected on the prevalence of epicondylitis during one cross-sectional examination. If exposure increases prevalence solely by prolonging symptoms, the cases with the longest duration of disease would be expected to occur in the highly exposed group. Table 2 shows the contrary. The longest duration of symptoms was reported by employees who had never been exposed and the shortest by active pipefitters and welders (ie, employees in the highly exposed category). Although incidence data are preferable, the finding of a higher prevalence of epicondylitis in certain job categories justifies the implementation of preventive measures to avoid prolonged and chronic illness. Such an intervention would be warranted even if work is a prognostic and not a causal factor for the disease with respect to severity and duration.

Overall, when the effect of work-related factors on the occurrence of epicondylitis is studied, it is important to look at the age distribution of the study population, as well as the length of employment in the exposed job category, in order to evaluate or compare study results. Exposure measurements including degree and duration have to be developed and should replace exposure assessment via job title. Diagnostic criteria should be as explicit and standardized as possible. Since epicondylitis can only be diagnosed clinically, the diagnosis will always involve subjective judgment. The difficulty of standardized application and the evaluation of the functional tests on which the diagnosis is based allows some authors to argue that results from studies of epicondylitis in general are noncomparable (7). Thus the effort to standardize and make the diagnostic criteria and processes as explicit and reproducible as possible is crucial to the interpretation and comparison of study results, as well as to further knowledge in this field of musculoskeletal epidemiology. Prevalence measures ought to be sensitive enough to avoid the loss of many residual or beginning cases. An important and continued shortcoming of studies is, however, the inability to control for the selection bias well known in occupational epidemiology as the healthy-worker effect.

Acknowledgments

The author was supported by a fellowship from the German Academic Exchange Service (DAAD) with funds from the German Ministry for Research and Technology. Data collection was supported by a grant from the Hans-Boeckler-Stiftung/Hamburg.

The author is indebted to Professor Dr A Manz for allowing data collection in the Hamburg Gas- and Waterworks, to Dr K Brunnhoelzl for performing the physical examinations, and Professor H Morgenstern for many helpful suggestions.

References

1. Kurppa K, Waris P, Rokkanen P. Tennis elbow: lateral elbow pain syndrome. Scand J Work Environ Health 1979;5 suppl 3: 15—18.
2. Roto P, Kivi P. Prevalence of epicondylitis and tenosynovitis among meatcutters. Scand J Work Environ Health 1984;10: 203—5.
3. Kurppa K, Viikari-Juntura E, Kuosma E, Huuskonen M, Kivi P. Incidence of tenosynovitis or peritendinitis and epicondylitis in a meat-processing factory. Scand J Work Environ Health 1991;17:32—7.
4. Luopajärvi T, Kuorinka I, Virolainen M, Holmberg M. Prevalence of tenosynovitis and other injuries of the upper extremities in repetitive work. Scand J Work Environ Health 1979; 5 suppl 3:48—55.
5. Viikari-Juntura E. Neck and upper limb disorders among slaughterhouse workers: an epidemiologic and clinical study. Scand J Work Environ Health 1983;9:283—90.
6. Viikari-Juntura E. Tenosynovitis, peritendinitis and the tennis elbow syndrome. Scand J Work Environ Health 1984;10: 443—9.
7. Viikari-Juntura E, Kurppa K, Kuosma E, Huuskonen M, Kuorinka I, Ketola R, et al. Prevalence of epicondylitis and elbow

pain in the meat-processing industry. Scand J Work Environ Health 1991;17:38—45.
8. Chiang H-C, Ko Y-C, Chen S-S, Yu H-S, Wu T-N, Chang P-Y. Prevalence of shoulder and upper-limb disorders among workers in the fish-processing industry. Scand J Work Environ Health 1993;19:126—31.
9. Dimberg L. The prevalence and causation of tennis elbow (lateral humeral epicondylitis) in a population of workers in an engineering industry. Ergonomics 1987;30(3):573—80.
10. Allander E. Prevalence, incidence and remission rates of some common rheumatic diseases or syndromes. Scand J Rheumatol 1974;3:145—53.
11. Waris P, Kuorinka I, Kurppa K, Luopajärvi T, Virolainen M, Pesonen K, et al. Epidemiologic screening of occupational neck and upper limb disorders: methods and criteria. Scand J Work Environ Health 1979;5 suppl 3:25—38.
12. SAS Institute Inc. SAS/STAT User's Guide, version 6, 4th edition, vol 2. Cary (NC): SAS Institute Inc, 1989:1071—126.
13. Maclure M, Greenland S. Tests for trend and dose response: misinterpretations and alternatives. Am J Epidemiol 1992; 135(1):96—104.
14. Hosmer DW, Lemeshow S. Applied logistic regression. New York, Chichester, Brisbane, Toronto, Singapore: John Wiley & Sons, 1989:82—134.
15. Armstrong BG, Sloan M. Ordinal regression models for epidemiologic data. Am J Epidemiol 1989;129(1):191—204.
16. Armstrong TJ, Buckle P, Fine LJ, Hagberg M, Jonsson B, Kilbom Å, et al. A conceptual model for work-related neck and upper-limb musculoskeletal disorders. Scand J Work Environ Health 1993;19:73—84.
17. McCormack RR Jr, Inman R, Wells A, Berntsen C, Imbus HR. Prevalence of tendinitis and related disorders of the upper extremity in a manufacturing workforce. J Rheumatol 1990; 17(7):958—64.
18. Dimberg L, Olafsson A, Stefansson E, Aagaard H, Oden A, Andersson GBJ, et al. The correlation between work environment and the occurrence of cervicobrachial symptoms. J Occup Med 1989;31(5):447—53.
19. Cyriax J. Tennis elbow. In: Cyriax J. Textbook of orthopedic medicine; vol 1. London: Bailliere Tindal, 1979:268—79.
20. Manz A, Rausch W. Zur Pathogenese und Begutachtung der Epicondylitis humeri. Muenchner Med Wochenschrift 1965; 107(29):1406—13.
21. Hamilton PG. The prevalence of humeral epicondylitis: a survey in general practice. J R Coll Gen Pract 1986;36(291): 464—5.

Appendix

Clinical criteria for epicondylitis

Pain at the same epicondyle in resisted extension or flexion			Tenderness to palpation			Pain while gripping			Epicondylitis severity score		
None	Light	Severe	None	Light	Severe	None	Light	Severe	Waris et al	Own criteria for lateral epicondyle[a]	medial epicondyle[a]
X			X			X			0	0	0
X			X				X		0	0	0
X			X					X	0	0	0
X				X		X			0	0	0
X				X			X		0	0	0
X				X				X	0	1	0
X					X	X			0	1	1
X					X		X		0	1	1
X					X			X	0	1	1
	X		X			X			0	1	1
	X		X				X		0	1	1
	X		X					X	0	2	1
	X			X		X			1	1	1
	X			X			X		1	1	1
	X			X				X	1	2	1
	X				X	X			1	2	2
	X				X		X		1	2	2
	X				X			X	1	3	2
		X	X			X			0	1	2
		X	X				X		0	2	2
		X	X					X	0	2	2
		X		X		X			2	2	2
		X		X			X		2	2	2
		X		X				X	2	2	2
		X			X	X			3	3	3
		X			X		X		3	3	3
		X			X			X	3	3	3

[a] Pain while gripping ("chair test") was not relevant for the medial epicondyle.

Received for publication: 12 December 1994