ORIGINAL ARTICLE

Physical and psychosocial risk factors for lateral epicondylitis: a population based case-referent study

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Aims: To assess the importance of physical and psychosocial risk factors for lateral epicondylitis (tennis elbow).

Methods: Case-referent study of 267 new cases of tennis elbow and 388 referents from the background population enrolled from general practices in Ringkjoebing County, Denmark.

Results: Manual job tasks were associated with tennis elbow (odds ratio (OR) 3.1, 95% confidence interval (CI) 1.9 to 5.1). The self reported physical risk factors "posture" and "forceful work" were related to tennis elbow. Among women, work involving performing repeated movements of the arms was related to tennis elbow (OR 3.7, CI 1.7 to 8.3). Among men, work with precision demanding movements was related to tennis elbow (OR 5.2, CI 1.5 to 17.9). Among both males and females, the results for work with hand held vibrating tools were inconsistent, partly because of few exposed subjects. A physical strain index was established based on posture, repetition, and force. The adjusted ORs for tennis elbow at low, medium, and high strain were 1.4 (CI 0.8 to 2.7), 2.0 (CI 1.1 to 3.7), and 4.4 (CI 2.3 to 8.7). Low social support at work, adjusted for physical strain, was a risk factor among women (OR 2.4, CI 1.3 to 4.6).

Conclusion: Results indicate that being a new case of tennis elbow is associated with non-neutral postures of hands and arms, use of heavy hand held tools, and high physical strain measured as a combination of forceful work, non-neutral posture of hands and arms, and repetition. Furthermore, tennis elbow among women was associated with low social support at work. The results for precision demanding movements and for vibration were less consistent.

Lateral epicondylitis (tennis elbow) has been found to be the second most frequently diagnosed musculoskeletal disorder in the neck and upper extremity in a primary care setting.[1] The incidence and the prevalence are uncertain, partly because of differential diagnostic criteria. In a Swedish population study the annual incidence was less than 1%; the prevalence was 1–3% and up to 10% among females of around 40 years of age.[2] Tennis elbow is characterised by pain in the lateral aspect of the elbow. Pain becomes worse with strenuous use of the hand and forearm. Clinical examination reveals both direct and indirect tenderness at the lateral humeral epicondyle.[3 4]

An ongoing discussion about nomenclature reflects the uncertainty in aetiology and pathogenesis of the condition. The term lateral humeral epicondylitis indicates the presence of inflammation, although evidence for this is scarce. Elements of changes like those found in rotator cuff degeneration have been seen.[5] Some physicians have advocated using the term epicondylalgia, because pathogenesis and pathoanatomy are unknown.[6]

The evidence for specific risk factors for tennis elbow has been discussed in several reviews. Hagberg *et al* concluded that in spite of an association with occupational exposure, based on the epidemiological literature there was no convincing evidence that lateral epicondylitis is work related.[7] Another review, from NIOSH, concluded that there is strong evidence of an association between the occurrence of tennis elbow and exposure to the combined risk factors of force, repetition, and posture. Furthermore, evidence was found for an association with forceful work alone. NIOSH found insufficient evidence for an association between repetitive work, postural factors, and epicondylitis.[8] Other possible risk factors were increasing age,[9–13] longer duration of employment in strenuous jobs,[13–15] and female gender.[9 13 14] The effect of leisure time activities, including sports, is seldom elucidated. Dimberg *et al* even found fewer symptoms among those performing racket sports.[16] Psychosocial workplace factors have been in focus in the study of many musculoskeletal disorders, but rarely in the study of tennis elbow. Ono *et al* found a weak but significant association between tennis elbow and difficult interpersonal relations, poor job definition, and organisation among Japanese nurse assistants.[13]

The aim of this study was to assess the importance of physical and psychosocial risk factors at work in the development of tennis elbow.

PARTICIPANTS AND METHODS

The study was conducted as a case-referent study with identification of two referents per case, matched by gender and age.

Recruitment

Study base

The study base was established in May 1998 by inviting all 146 general practitioners (GPs) in 12 of 18 municipalities in Rinkjoebing County, in the west of Denmark to participate. The municipalities were chosen because of their proximity to the research centre. The study base consisted of all 18–66 year old persons enrolled in the practices of the 104 GPs who had agreed to participate. The regional committee on science and ethics approved the study.

Cases

The definition of a case of tennis elbow was reporting pain at the lateral humeral epicondyle, with or without concomitant pain in the adjacent extensor muscles of the forearm, and the

Abbreviations: BMI, body mass index; CI, confidence interval; GP, general practitioner; MRW, monotonous repetitive work; OR, odds ratio

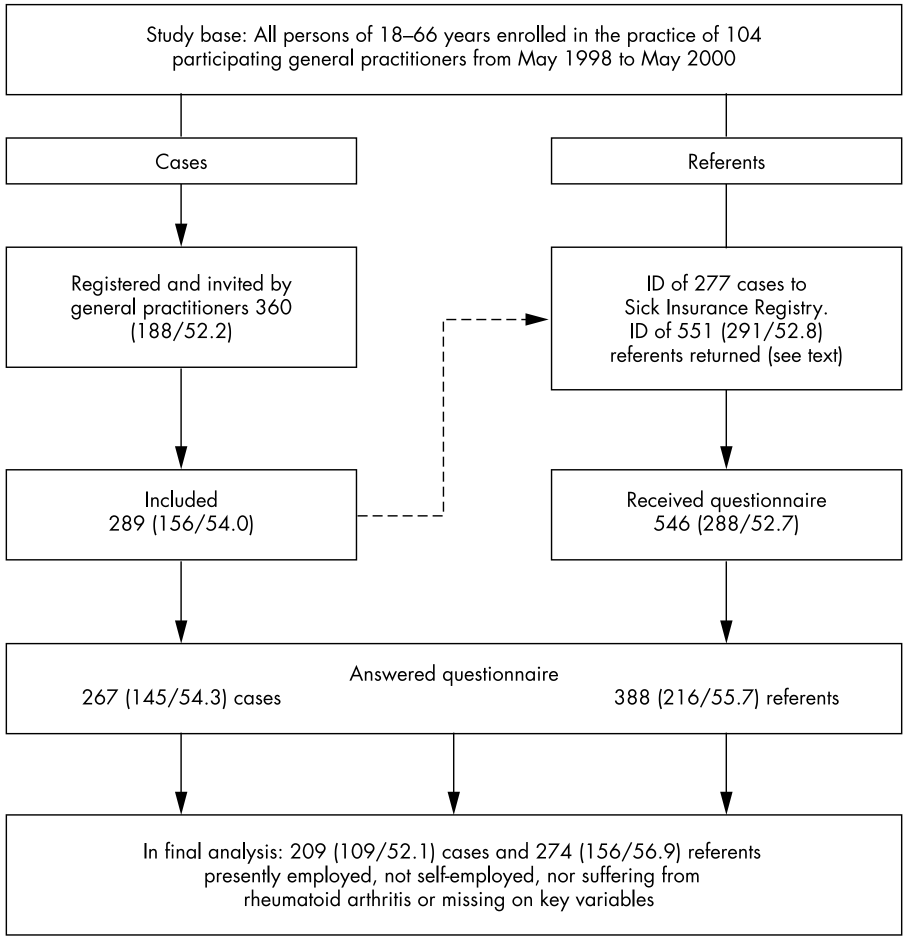

Figure 1 Number of cases and referents with distribution of gender (number and percentage of females in brackets) in the study of risk factors for tennis elbow in Ringkjoebing County, 1998–2000.

presence of direct and indirect tenderness at the lateral humeral epicondyle provoked by resisted extension of the wrist or third finger on physical examination. The test was performed by the general practitioner on an extended and pronated elbow. Only new cases diagnosed on their first contact with elbow pain were eligible for inclusion in the study. Patients with a history of elbow pain for more than one year on first contact with the GP, a previous elbow operation, or known rheumatic disorder were excluded. GPs recorded the gender, age, and profession of cases excluded or not accepting participation. A total of 360 eligible cases were identified and invited to participate. Informed written consent was obtained from 289 cases, of which 267 participated in the study by completing a questionnaire (see fig 1).

Referents
Every three months for every new case, two referents, matched by gender and age, were randomly selected from the study base via the registry of the public health insurance office. A total of 289 cases were included, but only 546 referents received a questionnaire (identification of 12 cases was temporarily misplaced, three addresses were protected, and five referents did not receive the questionnaire). A total of 388 referents responded (71.1%) (see fig 1).

A reminder was posted to non-responders after two weeks, and a telephone call was made after four weeks. Questionnaires returned blank were accepted without further contact.

Questionnaire
We enquired about age, gender, height, weight, educational background, health status, and possible risk factors. Cases and referents used identical questionnaires. Respondents indicated the presence of musculoskeletal pain within the past three months in 10 body regions as shown on a body figure. Table 1 shows the distribution of background characteristics by gender and case-referent group.

Physical exposure at work
Physical exposures at work were assessed via factual questions, which did not require evaluation on the part of participants: position held (profession) and duration of the present or latest employment. Based on these and the number of average working hours per week, work related exposure was assessed. The profession to which the participants belonged was classified as strenuous or non-strenuous with respect to the upper extremities. The classification was based on the authors' judgement from occupational health experience and the general impressions of the working conditions in the county as revealed by previous visits at worksites, and thus did not involve a specific ergonomic assessment by visiting the companies involved. Classification was carried out by the two authors before performing analyses as consensus. For example, work as a carpenter, woodworker, farmer, or cleaner was classified as being a strenuous profession, while work as a nurse, teacher, office assistant, or typist was classified as non-strenuous. Likewise, employment in farming or the metal or wood industries was classified as strenuous, while employment in the health sector, shops, or offices was classified as non-strenuous. Vingård *et al*, in a study of disability pensions due to musculoskeletal disorders among men in heavy occupations, identified 20 occupational groups as entailing the greatest load for the neck and shoulders.[17] The average load

Table 1 Background characteristics by case-referent group and gender for 483 participants in case-referent study of risk factors for tennis elbow

Variables	Case group (n=209)				Reference group (n=274)				p value*
	Female		Male		Female		Male		
	n	%	n	%	n	%	n	%	
Gender	109	52.2	100	47.8	156	56.9	118	43.1	0.52
Age (y)									0.30
18–35	30	14.4	25	12.0	31	11.3	29	10.6	
36–45	44	21.1	42	20.1	76	27.7	46	16.8	
46–66	35	16.7	33	15.8	49	17.9	43	15.7	
Body mass index (kg/m^2)									0.09
<20	15	7.2	4	1.9	17	6.2	2	0.7	
20–25	45	21.5	36	17.2	79	28.8	55	20.1	
>25	48	23.0	49	23.4	59	21.5	61	22.3	
Highest obtained level of school education									<0.001
7th–10th grade	88	42.1	85	40.7	95	35.5	91	33.2	
College (gymnasium)	19	9.1	15	7.2	60	21.9	27	9.9	
Musculoskeletal pain (indication of pain in 10 body regions within past three months)									
Headache	66	31.6	43	20.6	102	37.2	57	20.8	0.20
Neck	65	31.1	53	25.4	107	39.1	60	21.9	0.32
Upper back	54	25.8	37	17.7	72	26.3	33	12.0	0.25
Shoulders	81	38.8	58	27.8	72	26.3	44	16.1	<0.001
Elbows	107	51.2	96	45.9	26	9.5	21	7.7	<0.001
Forearms and hands	99	47.4	78	37.3	43	15.7	25	9.1	<0.001
Lower back	54	25.8	60	28.7	82	29.9	56	20.4	0.36
Hips	16	7.7	10	4.8	25	9.1	13	4.7	0.65
Knees	30	14.4	36	17.2	54	19.7	35	12.8	0.83
Ankles and feet	24	11.5	22	10.5	25	9.1	19	6.9	0.10

*χ^2 test for difference in distribution between case group and reference group.

was scored greater than 3.4 on a scale from 1 to 4. Seventeen of the 20 occupational groups classified by Vingård *et al* appeared in our study, and they had all been classified as being exposed (strenuous work with respect to the upper extremities).

Physical work related factors—posture of arms and hands (two items), repetitive movements of arms and hands (two items), static load (precision demanding movements) (one item), and vibration from using handheld vibrating tools (one item)—were elucidated by questions of the type: Does your work involve ... working with your arms lifted in front of the body? Responses were given by marking the best fitting alternative among five possibilities: never/almost never, approximately one quarter of the time, approximately half the time, approximately three quarters of the time, and almost all the time. As a proxy for force requirements we asked five questions about use of tools with different weights: "How much of your working time is normally spent using tools weighing less than 100 grams, 100 grams to 1 kg, 1–7 kg, 8–15 kg, and more than 15 kg?" with the same five aforementioned answer categories. Monotonous repetitive work (MRW) was recorded by asking about the proportion of time with MRW within the past 12 months.

Psychosocial workplace factors

The questionnaire contained 21 items from the Karasek and Theorell job content questionnaire: job demands (three items), job control (14 items), and social support (four items).[18] Each question had four response categories: often, sometimes, seldom, and almost never/never. Job satisfaction was assessed by eight questions of the type "How satisfied are you ...?", each with four possible responses: very satisfied, satisfied, unsatisfied, and very unsatisfied.

Physical leisure activity and sports

Self reported physical leisure activity or general physical activity was reported in four categories: (1) almost physically inactive or light physical activity <2 hours per week; (2) light physical activity for 2–4 hours per week; (3) light physical activity >4 hours, or strenuous physical activity (for example, quick walking, heavy work in the garden) for 2–4 hours per week; and (4) strenuous physical activity for >4 hours per week (for example, regular heavy physical training or competition several times per week). Sports were elucidated by indicating number of weekly hours (0, 1, 2, 3, 4, 5, or more) performing one of nine categories of sports, of which we considered racket sports, handball, volleyball/basketball, swimming, and weight training as being potentially harmful for the upper extremities.

Analysis

Odds ratios (ORs) with 95% confidence intervals (CI) were calculated using logistic regression analyses with tennis elbow status (case versus non-case) as the dependent variable. In all analyses adjustments for age and body mass index (BMI) (kg/m^2) were performed. Separate analyses were performed for males and females, or gender was included in the models. In previous studies, 4–6 point scales have shown poorer agreement with direct measurement and observation, so fewer points were advocated. Factors measured on a five point scale resulted in strata with small numbers of cases. The five response categories for questions concerning physical strain were therefore recoded into three categories: never/almost never, approximately ¼ to ½ of the working time, and approximately ¾ or almost all the working time. Whenever in subsequent analyses the scales were dichotomised, at least 25% of the subjects were in the highest group.

Working with one of three categories of heavy tools weighing more than 1 kg for at least one quarter of the work time was considered forceful (force F). An index for force was established based on the use of heavy tools (force F), and the use of lighter tools weighing 100 g to 1 kg by adding the two items (scale 0, 1, 2). The physical factors "posture" and "repetition" were first formed as three level (0, 1, 2) ordinal variables by adding two dichotomised answers, describing each of them as indicated in table 2. Posture, repetition, and force were found to be correlated. These are the factors most often discussed in relation to tennis elbow in the literature. We thereby established a physical strain index by adding the dichotomised factors posture (P), repetition (R), and force (F)

Table 2 Physical risk factors among 483 employees and odds ratios (OR) with 95% confidence intervals (CI) for having tennis elbow

Question (item) and category of answer	Women						Men					
	Model I*			Model II†			Model I*			Model II†		
	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI
Working posture												
Arms lifted in front of body												
Never or almost never	113	1.0		106	1.0		78	1.0		75	1.0	
1/4 to 1/2 of the time	78	2.1	1.1 to 4.0	72	2.0	1.0 to 3.9	73	2.6	1.3 to 5.1	68	2.7	1.3 to 5.5
3/4 to almost all the time	71	4.4	2.3 to 8.3	66	4.0	2.0 to 8.3	62	2.1	1.1 to 4.3	54	1.9	0.9 to 4.3
Hands bent or twisted												
Never or almost never	150	1.0		137	1.0		111	1.0		103	1.0	
1/4 to 1/2 of the time	73	2.9	1.6 to 5.2	69	2.8	1.4 to 5.4	63	1.9	1.0 to 3.6	59	1.6	0.8 to 3.3
3/4 to almost all the time	39	10.0	4.1 to 22.4	38	7.4	2.9 to 18.7	39	3.2	1.5 to 6.9	35	3.2	1.3 to 7.9
Repetitive movements												
Same movements of fingers or hands												
Never or almost never	102	1.0		93	1.0		89	1.0		85	1.0	
1/4 to 1/2 of the time	98	1.5	0.8 to 2.7	95	1.3	0.7 to 2.5	84	1.5	0.8 to 2.9	77	1.7	0.9 to 3.3
3/4 to almost all the time	62	2.8	1.4 to 5.4	56	1.9	0.9 to 4.0	40	2.2	1.0 to 4.8	35	2.2	0.9 to 5.3
Same movements of arms												
Never or almost never	166	1.0		153	1.0		117	1.0		106	1.0	
1/4 to 1/2 of the time	48	1.8	0.9 to 3.4	47	1.5	0.7 to 3.1	54	1.9	1.0 to 3.7	54	1.8	0.9 to 3.6
3/4 to almost all the time	48	4.8	2.4 to 9.8	44	3.7	1.7 to 8.3	42	2.5	1.2 to 5.2	37	1.9	0.8 to 4.6
Precision												
Work demands precision movements												
Never or almost never	218	1.0		202	1.0		155	1.0		143	1.0	
1/4 to 1/2 of the time	23	1.7	0.9 to 4.2	22	1.5	0.6 to 3.9	38	1.0	0.5 to 2.2	37	1.0	0.5 to 2.2
3/4 to almost all the time	21	1.1	0.4 to 2.8	20	0.9	0.3 to 2.5	20	5.4	1.7 to 17.1	17	5.2	1.5 to 17.9
Vibration												
Work with hand held vibrating tools												
Never or almost never	245	1.0		227	1.0		165	1.0		152	1.0	
1/4 to 1/2 of the time	10	3.5	0.9 to 13.9	10	3.5	0.9 to 14.5	36	2.8	1.3 to 5.9	35	2.9	1.3 to 6.3
3/4 to almost all the time	7	2.0	0.4 to 9.5	7	0.9	0.2 to 5.3	12	1.6	0.5 to 5.2	10	1.4	0.4 to 5.3
Force F												
Use of heavy tools weighing ⩾1 kg												
No force full work	191	1.0		177	1.0		123	1.0		114	1.0	
Force full work	72	2.8	1.6 to 5.0	68	3.0	1.6 to 5.5	94	2.2	1.3 to 3.9	85	2.1	1.1 to 3.8
Force index												
Use of tools weighing 100 g to 1 kg and/or use of heavy tools ⩾1 kg												
No force full work (0)	153	1.0		143	1.0		90	1.0		83	1.0	
Force full work level 1 (1)	63	2.9	1.6 to 5.5	58	2.6	1.3 to 5.3	71	2.0	1.0 to 3.8	66	2.0	1.0 to 4.1
Force full work level 2 (2)	40	4.0	1.9 to 8.4	39	4.6	2.1 to 10.3	53	3.8	1.8 to 8.9	48	3.5	1.6 to 7.7

*Adjusted for age and body mass index.
†Adjusted for age, body mass index, and psychosocial factors: demands, low control, and low social support at work.

giving the strain scale: 0 = no strain, 1 = low strain, 2 = medium strain, 3 = high strain.

The items from Karasek and Theorell's job content questionnaire were dichotomised between the response categories "sometimes" and "seldom", except for the three demand items, which were dichotomised between "often" and "sometimes". Items on job satisfaction were dichotomised between "satisfied" and "unsatisfied". Indexes for the psychosocial factors were constructed by summing the dichotomised items (job demands 0–3, job control 0–14, social support 0–4, and job satisfaction 0–8). These four dimensions were subsequently dichotomised. In the analysis, the main effects of demands, control, and social support were tested, because these three items are usually considered together in studies of the psychosocial work environment. All odds ratios (OR) are adjusted for these three variables unless otherwise stated. No association was found between living in predominantly rural versus urban areas and being a case of tennis elbow, and there is no clustering of particular industries or professions within the study area. Thus, area has not been included in the models presented.

RESULTS

Among 209 cases, 129 (61.7%) had tennis elbow on the right side, 69 (33.0%) on the left side, and 11 (5.3%) on both sides. A total of 189 (90.4%) were right handed, 15 (7.2%) were left handed, and five (2.4%) indicated using both hands equally well. Sixty six right handed cases and four left handed cases had tennis elbow contralaterally. A total of 89.5% of cases of tennis elbow reported the presence of pain in the shoulders, the forearms, or the hands within the previous three months.

When asked about what they thought might be the cause of their elbow pain, 61% of female cases and 66% of male cases answered that they considered work being the most likely cause of their elbow pain; 24% of females and 20% of males were not sure of the cause. Analyses showed tennis elbow to be associated with holding a profession classified as strenuous among both women and men: OR 3.4 (CI 1.7 to 6.8) and 2.8 (CI 1.4 to 5.8) respectively, and altogether OR 3.1(CI 1.9 to 5.1).

Having had monotonous repetitive work tasks during at least half of the working time within the past year was associated with tennis elbow among women (OR 2.6, CI 1.4 to 4.7), but not among men (OR 1.0, CI 0.5 to 2.0). Most of the physical job characteristics were associated with tennis elbow. Among women, the risk of tennis elbow increased with increasing daily exposure time to work with the arms lifted in front of the body (to OR 4.0, CI 2.0 to 8.3), working with the hands bent or twisted (to OR 7.4, CI 2.9 to 18.7), and working with the same movements of the arms (to OR 3.7, 1.7, 8.3) (table 2, model II). When working with repetitive movements ("the same movements of the fingers or hands") the ORs increased, but neither the OR nor the increase was significantly different from 1.0. Work involving precision demanding movements was not

Table 3 Psychosocial workplace factors among 483 employees and odds ratios (OR) with 95% confidence intervals (CI) for tennis elbow

	Model I*			Model II†					
				Female			Male		
	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI
Demands (3 items)									
Low (0–1)	224	1.0		112	1.0		97	1.0	
High (2–3)	249	0.9	0.6 to 1.4	133	1.0	0.6 to 1.7	102	0.7	0.4 to 1.2
Control (14 items)									
High (0–5)	294	1.0		161	1.0		131	1.0	
Low (6–14)	157	2.2	1.4 to 3.2	84	2.0	1.1 to 3.7	71	1.7	0.9 to 3.0
Social support (4 items)									
High (0–1)	338	1.0		188	1.0		134	1.0	
Low (2–4)	132	1.8	1.2 to 2.7	57	3.0	1.5 to 5.9	65	1.0	0.5 to 1.8

*Adjusted for age, gender, and body mass index.
†Mutual adjustment for age, gender, body mass index, and the items shown in the column.

Table 4 Combined physical strain with adjusted odds ratios (OR) with 95% confidence intervals (CI) for tennis elbow among 483 employees

	Model I*			Model II†			Model II†					
							Female			Male		
Strain	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI
Repetition (R) and force (F)												
Low repetition and low force	111	1.0		102	1.0		61	1.0		41	1.0	
Low repetition and high force	48	1.7	0.9 to 3.5	45	1.5	0.7 to 3.2	22	0.8	0.3 to 2.6	23	2.3	0.8 to 7.1
High repetition and low force	200	1.4	0.9 to 2.3	187	1.1	0.6 to 1.9	115	0.5	0.2 to 1.2	72	2.0	0.8 to 4.8
High repetition and high force	116	3.9	2.2 to 6.9	107	2.5	1.3 to 4.9	46	1.8	0.7 to 5.0	61	3.5	1.3 to 9.1
Extreme position (P)	–	–	–	225	1.6	1.0 to 2.7	120	2.9	1.4 to 6.0	105	1.0	0.5 to 2.0
Repetition (R) and posture (P)												
Low repetition and neutral posture	119	1.0		110	1.0		66	1.0		44	1.0	
Low repetition and extreme posture	40	2.3	1.1 to 4.8	37	1.6	0.7 to 3.7	17	4.4	1.2 to 15.9	20	0.8	0.3 to 2.8
High repetition and neutral posture	112	1.1	0.6 to 2.0	106	1.3	0.7 to 2.3	58	1.1	0.5 to 2.6	48	1.6	0.6 to 3.8
High repetition and extreme posture	204	3.0	1.9 to 4.9	188	2.1	1.2 to 2.6	103	2.4	1.1 to 5.3	85	1.7	0.7 to 4.0
High force (F)	–	–	–	152	2.0	1.3 to 3.2	68	2.0	1.0 to 4.0	84	1.9	1.0 to 3.6
Force (F) and posture (P)												
Low force and neutral posture	190	1.0		177	1.0		108	1.0		69	1.0	
Low force and extreme posture	121	2.2	1.4 to 3.6	112	1.6	0.9 to 2.8	68	1.8	0.8 to 4.0	44	1.5	0.6 to 3.6
High force and neutral posture	41	1.8	0.9 to 3.7	39	1.9	0.9 to 4.0	16	0.6	0.1 to 2.3	23	3.3	1.2 to 9.3
High force and extreme posture	123	4.3	2.6 to 7.0	113	3.3	1.9 to 5.8	52	6.5	2.8 to 14.7	61	2.0	0.9 to 4.5
High repetition (R)	–	–	–	294	1.3	0.8 to 2.0	161	0.8	0.4 to 1.7	133	1.8	0.9 to 3.6

n, number of persons in the exposed group.
*Adjusted for age, gender, and body mass index.
†Mutual adjustment and adjusted for age, gender, body mass index, social support, job demands, and job control.

related to tennis elbow among women. Only 7% of the women in the analysis indicated using vibrating tools for one quarter or more of the work time, and results were therefore inconclusive for women. Among women, poor social support generally remained a significant factor (figures not shown). For men, findings were different (table 2). Only working with the hands bent or twisted and doing work involving precision demanding movements led to significantly increased risks with increasing exposure. Work involving the same movements of fingers or hands showed an increased OR at the highest exposure levels, but it was not significant. When working with hand held vibrating tools at least a quarter to a half of working time, the OR for tennis elbow was 2.9 (CI 1.3 to 6.3), but in the highest level, the OR was not significantly increased. When working with the arms lifted in front of the body ¼ to ½ of the working time, the OR was 2.7 (CI 1.3 to 5.5), but here also the OR was not significantly increased for those with greatest exposure. Among men, work with the same movements of the arms was not related to tennis elbow, but work demanding precision movements was associated with tennis elbow (OR 5.2, CI 1.5 to 17.9). For men, poor social support was generally not related to tennis elbow (figures not shown).

High job demands was not related to tennis elbow (OR 0.9, CI 0.6 to 1.4) (table 3, model I). Tennis elbow was related to low job control (OR 2.2, CI 1.4 to 3.2), lack of social support at work (OR 1.8, CI 1.2 to 2.7), and low levels of job satisfaction (OR 1.9, CI 1.3 to 2.8) (figures not shown). On separate analyses for women and men with mutual adjustment, none of the three factors (high demands, low control, and low social support) was associated with tennis elbow among men (model II in table 3), but for women, both low control and low social support remained significant.

None of the sports activities was associated with tennis elbow. Pooling of weekly activities in racket sports, handball, volleyball or basketball, and muscle conditioning did not reveal an association with tennis elbow. General physical activity in leisure time was not related to tennis elbow (figures not shown).

Analysis of men and women together showed an association between combined physical workplace factors (high repetition and high force, high repetition and extreme posture, high force and extreme posture) and the occurrence of tennis elbow (table 4, model I). On mutual adjustment with the third physical factor and psychosocial workplace factors, only simultaneous

Table 5 Psychosocial and physical workplace factors as physical strain index among 483 employees and odds ratios (OR) with 95% confidence intervals (CI) for tennis elbow

	Model I*			Model II†					
				Female			Male		
	n	OR	95% CI	n	OR	95% CI	n	OR	95% CI
Demands (3 items)									
Low (0–1)	207	1.0		111	1.0		96	1.0	
High (2–3)	234	0.8	0.6 to 1.3	133	0.9	0.5 to 1.6	101	0.7	0.4 to 1.3
Control (14 items)									
High (0–5)	288	1.0		160	1.0		128	1.0	
Low (6–14)	153	1.5	0.9 to 2.3	84	1.5	0.8 to 2.9	69	1.4	0.7 to 2.6
Social support (4 items)									
High (0–1)	319	1.0		187	1.0		132	1.0	
Low (2–4)	122	1.5	0.9 to 2.4	57	2.4	1.3 to 4.6	65	0.9	0.5 to 1.8
Physical strain‡									
None	87	1.0		55	1.0		32	1.0	
Low	128	1.4	0.8 to 2.7	70	0.8	0.3 to 1.8	58	3.0	1.1 to 8.3
Medium	135	2.0	1.1 to 3.7	78	1.6	0.7 to 3.7	57	2.6	0.9 to 7.3
High	91	4.4	2.3 to 8.7	41	5.3	2.0 to 13.7	50	4.7	1.6 to 13.4

*Mutual adjustment for age, body mass index, and the items shown in the column.
†Mutual adjustment for age, body mass index, and the items shown in the column.
‡Physical strain levels established as index from force, repetition, and posture.

exposure to two physical factors remained significant, and high repetition alone was not associated with tennis elbow (table 4, model II). Separate analyses for men and women showed that extreme posture was no longer associated with tennis elbow among men. For men, only a combination of high repetition and high force remained significant (OR 3.5, CI 1.3 to 9.1), while for women the opposite appeared: high repetition and high force combined gave an OR of 1.8 (CI 0.7 to 5.0), while high repetition and extreme posture showed more than twofold increased risk (OR 2.4, CI 1.1 to 5.3), and high force and extreme posture had an OR of 6.5 (CI 2.8 to 14.7). Social support remained in the models with OR values significantly above 1 for women, but not for men (figures not shown).

The physical strain index based on force, posture, and repetition was associated with tennis elbow, and an exposure-response relation was revealed (table 5). At low, medium, and high physical strain levels, ORs for tennis elbow were 1.4 (CI 0.8 to 2.7), 2.0 (CI 1.1 to 3.7), and 4.4 (CI 2.3 to 8.7). In addition, separate analyses for men and women revealed a difference: for women only, social support remained significant (OR 2.4, CI 1.3 to 4.6).

DISCUSSION

Lateral epicondylitis or tennis elbow was related to physical workplace factors, and among female subjects to low social support at work. The combination of high levels of physical work factors and low social support at work among women revealed a high risk for tennis elbow. Workers belonging to a profession classified as strenuous were at increased risk. Tennis elbow was not found to be associated with physical activity in leisure time or the performance of sports activities.

This study adds evidence to the claim that forceful work, extreme posture, and probably repetitive movements are independent risk factors for tennis elbow. The review from NIOSH found evidence for forceful work as a risk factor,[8] but on review of the literature concerning the work relatedness of tennis elbow, force was not clearly separated from the other physical risk factors in the analyses. In this study, force was studied by a proxy variable—the use of heavy hand held tools. The results support our clinical impression that no single physical factor is involved in developing tennis elbow.

The findings do not in general support the role of psychosocial workplace factors for tennis elbow. However, increased risks among women with high physical strain and poor social support, indicate that there may be an interaction. Recent studies have found significant positive associations between quality of social relations at work and support from colleagues or supervisors, and upper extremity morbidity, including onset of forearm pain.[19 20] The mechanisms are unknown, but low social support from colleagues and supervisors could simply address overall distress or dissatisfaction at the workplace, or it could imply that a workplace with a supportive environment gives the worker better opportunities to cope with everyday aches and pains, thereby preventing more severe pain or amplification of pain. However, we have no explanation for why low social support in this study apparently only affected women. It may partly be explained by differences in how women report on these issues when experiencing pain. In addition, the social and organisational structures may be different for female and male employees in ways that affect health and morbidity.

The widespread presence of pain in the hand, forearm, and shoulders among cases with tennis elbow is an indication that tennis elbow possibly is part of a larger complex of upper extremity morbidity related to a variety of physical and psychosocial risks at work and outside work. Ekberg *et al* found that 27% of cases in the study of disorders of the shoulder and neck area had tennis elbow.[1] A prospective population based study found a higher incidence of pain in the shoulders in persons with forearm pain.[20]

The results may be affected by selection bias due to the recruitment only of cases attending general practice. Patients attending general practice may be those with more severe symptoms or those experiencing the greatest problems in performing their activities of daily living at home, at work, or during leisure time. Thus, the more exposed cases may be recruited to a higher extent than the less exposed through a higher attendance rate. We examined the number of contacts to general practice for all cases and referents. The data were obtained from the public health insurance registry. Women had more contacts than men did, but among both female and male referents we found no difference in mean number of contacts during one year prior to the entering the study for participants with strenuous professions or who reported physical strain at work. Referents in strenuous professions and trades actually tended to have fewer contacts. In the case group, we found a higher number of contacts to GPs, but the difference was not related to exposures. From our examination of cases randomised to intervention in another part of this study, we found that some cases had more than one contact to general practice before confirmation of the diagnosis, and many cases had simultaneous pain in other areas of the upper extremities. This partly explains the excess attendances in the case group. In conclusion, we have good reason to believe that the results are not seriously biased due to differential inclusions related to exposure.

The general practitioners registered and invited 360 new cases eligible for inclusion in the study. However, we do not know the number of eligible cases not included due to deficient participation of the general practitioners. Seventy one patients (19.7%) did not accept the invitation to participate in the study; 38 of these (53.5%) belonged to professions classified as being potentially strenuous, whereas among cases, 57.9% belonged to a strenuous profession. Although registration of new cases attending general practice was incomplete, there is no evidence that refusal to participate among cases was related to exposure.

The collection of information on exposure by questionnaire can introduce an information bias. Cases may judge a given exposure to be more intense or larger than referents. In this study, the prevalence of pain within the past three months within body regions other than the upper extremities was the same within the case group and reference group, which indicates that the cases are not generally over reporting their pain. This is consistent with the findings in other studies, which found no differential misclassification of exposure among subjects seeking and not seeking care for low back pain or neck or shoulder disorders.[21 22] By including only new cases of tennis elbow and by focusing on workplace factors in the present or latest job within the past year, we believe the risk of recall bias is reduced substantially. Regarding validity of questions about physical factors, acceptable intraclass correlation coefficients were obtained for questions on use of vibrating hand tools, performance of repetitive movements of fingers and hands, and precision movements. Self reported information about posture was moderately correlated to information obtained on interview.[23] Responses, especially those concerning work demanding precision and use of hand held vibrating tools, are most likely imprecise to some degree. This especially affects the results for exposures of low prevalence. We have no estimate of the validity of our measure for force. It has been found that self reported lifting of 1–5 kg is moderately correlated to workplace observation.[24] We believe that our choice of tools weighing 1 kg or more for at least a quarter of the working time indicates that the work requires forceful movements of the hands or the arms. The finding that profession, which we can consider as being reported without bias, is related to lateral epicondylitis, supports the above results. The classification of profession has not been evaluated by workplace assessments, but we find it reassuring that comparison of a list of male occupations classified as having a high load for neck and shoulders by Vingård *et al* revealed that all jobs appearing in our study are classified as being strenuous.[17] Socioeconomic factors may affect risk, and we considered including school education in the regression models as a surrogate measure for socioeconomic position. This may well be an over adjustment, because a greater proportion of those with only high school education were manual workers. Nevertheless, we found that adjusting for education attainment did not change the overall results.

In conclusion, this study supports an association between physical workplace factors and tennis elbow. The study emphasises that low social support seems to increase the risk among women. The background for this apparent gender difference needs further consideration and research. The findings call for an effort to modify workplaces, which have combinations of several high loads from physical factors, and at least among women a more accommodating workplace environment.

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Main messages

- Evidence has previously been found that lateral epicondylitis is related to forceful work and the combined factors of force, posture, and repetition.
- Psychososcial factors at work have shown contradictory associations to lateral epicondylitis.
- Cases of lateral epicondylitis often report concomitant symptoms in the shoulders, forearms, and wrists.
- In this study, lateral epicondylitis was related to force and posture, and to the combinations of force, posture, and repetition.
- Among women, self reported low social support at work was related to lateral epicondylitis.

Policy implications

- Work related upper extremity disorders, including lateral epicondylitis, share a body of related physical and probably psychosocial workplace risk factors. Therefore an effort to modify workplaces, especially those that have combinations of several high loads, remains one of the most important issues in the prevention of musculoskeletal disorders.

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ECHO

Oasys-2 outperforms experts in diagnosing occupational asthma

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Diagnosis of occupational asthma should become more reliable, now that a study has shown that computer analysis of respiratory data is much more accurate than "expert" judgement.

Clinicians expert in diagnosing occupational asthma were compared for their interpretation of actual peak expiratory flow (PEF) measurements from 35 patients with suspected occupational asthma and—though they did not know it—their individual performance against computer program Oasys-2 (Occupation Asthma SYStem), a validated diagnostic aid for occupational asthma.

There was good agreement among the experts' overall scores for "occupational effect" and "asthma effect", as judged by median κ score, but wide interquartile range indicated inconsistency. Comparing individual with Oasys-2 scores showed great variation, especially for four scoring categories. The experts underscored compared with Oasys-2 and missed the occupational effect. Their scores were most variable for "intermediate" PEF records.

The clinicians had an hour for the exercise. Each was given plots of peak flows and Oasys-2 summary plots. They scored each work-rest-work period and rest-work-rest period for occupational effect and gave overall scores for occupational and asthma effects (0–100). Scores were later subdivided into two categories (0–50, 51–100%) or four categories (0–25, 26–50,51–75, 76–100%) equivalent to the clinical probability of occupational asthma (negative, possible, probable, positive) according to Oasys-2.

Correct interpretation of serial PEF values is essential to diagnosing occupational asthma. Interpretation is recognised as being difficult and is confined to expert clinicians. Oasys-2 has been designed to help the diagnosis.

▲ *Thorax* 2002;**57**:860–864