CHAPTER 4

Elbow Musculoskeletal Disorders (Epicondylitis): Evidence for Work-Relatedness

SUMMARY

Over 20 epidemiologic studies have examined physical workplace factors and their relationship to epicondylitis. The majority of studies involved study populations exposed to some combination of work factors, but among these studies were also those that assessed specific work factors. Each of the studies examined (those with negative, positive, or equivocal findings) contributed to the overall pool of data to make our decision on the strength of work-relatedness. Using epidemiologic criteria to examine these studies, and taking into account issues of confounding, bias, and strengths and limitations of the studies, we conclude the following:

There is **insufficient evidence** for support of an association between repetitive work and elbow musculoskeletal disorders (MSDs) based on currently available epidemiologic data. No studies having repetitive work as the dominant exposure factor met the four epidemiologic criteria.

There is **evidence** for the association with forceful work and epicondylitis. Studies that base exposure assessment on quantitative or semiquantitative data tended to show a stronger relationship for epicondylitis and force. Eight studies fulfilling at least one criteria showed statistically significant relationships.

There is **insufficient evidence** to draw conclusions about the relationship of postural factors alone and epicondylitis at this time.

There is **strong evidence** for a relationship between exposure to a combination of risk factors (e.g., force and repetition, force and posture) and epicondylitis. Based on the epidemiologic studies reviewed above, especially those with some quantitative evaluation of the risk factors, the evidence is clear that an exposure to a combination of exposures, especially at higher exposure levels (as can be seen in, for example, meatpacking or construction work) increases risk for epicondylitis. The one prospective study which had a combination of exposure factors had a particularly high incidence rate (IR=6.7), and illustrated a temporal relationship between physical exposure factors and epicondylitis.

The strong evidence for a combination of factors is consistent with evidence found in the sports and biomechanical literature. Studies outside the field of epidemiology also suggest that forceful and repetitive contraction of the elbow flexors or extensors (which can be caused by flexion and extension of the wrist) increases the risk of epicondylitis.

Epidemiologic surveillance data, both nationally and internationally, have consistently reported that the highest incidence of epicondylitis occurs in occupations and job tasks which are manually intensive and require high work demands in dynamic environments—for example, in mechanics, butchers, construction workers, and boilermakers.

Epicondylar tenderness has also been found to be associated with a combination of higher levels of forceful exertions, repetition, and extreme postures of the elbow. This distinction may not be a true demarcation of different disease processes, but part of a continuum. Some data indicate that a high

percentage of individuals with severe elbow pain are not able to do their jobs, and they have a higher rate of sick leave than individuals with other upper extremity disorders.

INTRODUCTION

Epicondylitis is an uncommon disorder, with the overall prevalence in the general population reported to be from 1% to 5% [Allender 1974]. There are fewer epidemiologic studies addressing workplace risk factors for elbow MSDs than for other MSDs. Most of these studies compare the prevalence of epicondylitis in workers in jobs known to have highly repetitive, forceful tasks (such as meat processing) to workers in less repetitive, forceful work (such as office jobs); the majority of these studies were not designed to identify individual workplace risk factors.

The text of this section on epicondylitis is organized by work-related exposure factor. The discussion within each factor is organized according to the criteria for evaluating evidence for work-relatedness in epidemiologic studies using the strength of association, the consistency of association, temporal relationships, exposure-response relationship, and coherence of evidence. Conclusions are presented with respect to epicondylitis for each exposure factor. Summary information relevant to the criteria used to evaluate study quality is presented in Tables 4-1 to 4-4. A more extensive summary (Table 4-5) includes information on health outcomes, covariates, and exposure measures. All tables are presented at the end of this chapter. Not all the articles summarized in the tables are referenced in this narrative, but they have been reviewed and evaluated and are included for information.

There are 19 studies referenced in Tables 4-1 through 4-4, 18 cross-sectional studies and one cohort. Those studies using symptom and physical examination findings to define epicondylitis used consistent criteria—almost all studies using physical examination for diagnosis required pain with palpation of the epicondylar area and pain at the elbow with resisted movement of the wrist. However, studies using a definition based on symptom data alone used various criteria, some based on frequency and duration of symptoms [Burt et al.1990; Hoekstra et al. 1994; Fishbein et al. 1988] others based on elbow symptoms preventing work activities [Ohlsson et al. 1989].

REPETITION

Definition of Repetition for Elbow MSDs

For our review, we chose studies that addressed the physical factor of repetition and its relation to elbow MSDs, especially those studies that focused on epicondylitis. Studies usually defined repetition, or repetitive work, for the elbow as work activities that involved (1) cyclical flexion and extension of the elbow or (2) cyclical pronation, supination, extension, and flexion of the wrist that generates loads to the elbow/forearm region. Most of the studies that examined repetition as a risk factor for epicondylitis had several concurrent or interacting physical work load factors. We attempted to select those studies in which repetition was either the single risk factor or the dominant risk factor based on our review of the study and our knowledge of the occupation. This method eliminated those studies in which a combination of high levels of repetition and high levels of force exist, or those studies which selected their exposure groups based on highly repetitive, forceful work.

Studies Reporting on the Association of Repetition and Epicondylitis

Seven studies reported results on the association between repetition and adverse elbow health outcomes including epicondylitis. The epidemiologic studies that address repetitive work and epicondylitis compare working groups by classifying them into categories based on some estimation of repetitive work, such as percent of time typing [Burt et al. 1990], number of items per hour [Ohlsson et al. 1989], or number of hand manipulations per hour [Baron et al. 1991]. Those studies which may have measured repetitive work but have exposure to higher levels of force will be discussed in the "Force" section.

Studies Meeting the Four Evaluation Criteria

None of the studies (see Table 4-1 and Figure 4-1) reviewed for the elbow summary section met all four evaluation criteria outlined in the Introduction Section.

Studies Meeting at Least One of the Criteria

The studies will be summarized in alphabetical order as they appear in
Table 4-1.

Andersen and Gaardboe [1993a] used a cross-sectional design to compare sewing machine operators with a random sample of women from the general population of the same region. Elbow pain, not epicondylitis, was the MSD of interest in this study. A case of elbow pain was based on self-reported symptoms lasting more than 1 month since starting career, or pain for more than 30 days. Exposure was based on the authors' experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. Analysis dealt with exposure as "duration of exposure as a sewing machine operator". Statistical modeling controlled for age, having children, not doing leisure exercise, smoking, and socioeconomic status. For this study, the exposure classification scheme does not allow separation of the effects of repetition from those of force, although repetition may be a more obvious exposure.

Baron et al. [1991] explored epicondylitis among grocery store workers, comparing the prevalence among grocery store cashiers to that among non-cashiers and identified work risk factors while controlling for covariates. Detailed ergonomic assessment of grocery checking and cashiering was completed using both on-site observational techniques and videotaped analyses. The majority of cashiers were categorized as having "medium" levels of repetition for the hand (defined in this study as making 1250 to 2500 hand movements per hour). Repetitive movements were not recorded directly for the elbow; however, the number of hand movements serve as an approximation for elbow repetitions. Age, hobbies, second jobs, systemic disease, and height were considered as covariates in the multivariate analyses. The diagnosis of epicondylitis required standard physical examination techniques of palpation and resisted extension and flexion of the elbow.

Burt et al. [1990] studied 834 employees using computers at a metropolitan newspaper, using a self-administered questionnaire for case ascertainment. Exposure assessment was based on self-reported typing time and observation of employees' job tasks, then categorization by job title. A separate job analysis using a checklist and observational techniques was carried out for validating questionnaire exposure data. Workers fulfilling the case definition for elbow/forearm pain were compared to those who did not fulfill the case definition. Prevalence of cases was associated with percent of time typing and typing speed. Logistic regression controlled for age, gender, metabolic disorders, and job satisfaction.

Automobile assembly line workers were compared to a randomly selected group from the general population in the study by Byström et al. [1995]. A case of epicondylitis required symptoms and physical examination. "Job title" was used as a surrogate for exposure in the analysis. No assessment of repetition or repetitive work was completed specifically for the elbow.

McCormack et al. [1990] had a randomly selected population of 2,261 textile workers from over 8,000 eligible workers. Workers were analyzed by job category, after observation of jobs. Epicondylitis case ascertainment was by clinical exam. Of the 37 cases of epicondylitis identified, 13 were categorized as mild, 22 were moderate, and 2 were severe. Eleven examiners may have introduced an interexaminer reliability problem. Age, gender, race, and years of employment were analyzed as confounders.

Ohlsson et al. [1989] studied electrical equipment and automobile assemblers, former assembly workers and compared these two groups to a random sample from the general population. A case of elbow pain was based on questionnaire responses; exposure was based on job categorization as well as questionnaire responses. Repetitive exposure was based on a self-reported frequency of task items completed per hour (work pace). Results showed no association with work pace and elbow symptoms, and no association between length of employment and elbow symptoms.

Punnett et al. [1985] compared neck/shoulder MSDs based on symptom reporting alone in 162 women garment workers and 76 women hospital workers such as nurses, laboratory technicians, and laundry workers. There was a low participation rate among the hospital workers. Eighty-six percent of the garment workers were sewing machine operators and finishers (sewing and trimming by hand). The sewing machine operators were described as using highly repetitive, low force wrist and finger motions, while the finishers had shoulder and elbow motions as well. The exposed garment workers likely had more repetitive jobs than most of the hospital workers.

Strength of Association—Repetition and Elbow MSDs

No studies met the four criteria to discuss strength of association.

Strength of Association—Studies Not Meeting the Four Criteria

For the other studies not fulfilling all the criteria, the odds ratio (OR) reported in the

Baron et al. [1991] study for epicondylitis overall was 2.3, but this was not statistically significant.

Anderson and Gaardboe [1993a] used years employed as a sewing machine operator as a surrogate for exposure and found no significant association with epicondylitis.
None of the other studies that looked at epicondylitis among working groups carried out independent exposure assessment of workers or representative workers that focused on the elbow.

Burt et al. [1990] found a statistically significant OR of 2.8 for elbow/forearm symptoms in newspaper employees who reported typing 80%–100% of their working day compared to those typing 0%–20%. (Typing hours has been used as a surrogate of both repetition and duration of exposure.)

Likewise, Punnett et al. [1985] found a significant prevalence rate ratio (PRR=2.4) of persistent elbow symptoms among garment workers performing repetitive, forceful work compared to hospital workers. Analysis by job title showed that underpressers, whose jobs consisted of ironing by hand, had a PRR of 6.0. Among stitchers (sewing machine operators), the significant PRR for the task of setting linings was 7.7. When standardized to the age distribution of the hospital workers, the rate ratio did not change.

McCormack et al. [1990] and Ohlsson et al. [1989] based exposure on job title and found no association between repetitive work and epicondylitis, with non-significant ORs between 0.5 and 2.8.

Temporal Relationship—Repetition and Epicondylitis

There were no prospective studies which addressed repetition as a physical factor alone; all the studies were cross-sectional, so a temporal relationship cannot be established. However, some cross-sectional studies allow us to infer causality by use of restrictive case definitions. Studies by the National Institute for Occupational Safety and Health (NIOSH) investigators [Burt et al. 1990; Baron et al. 1991] excluded from analysis those workers who reported symptoms experienced prior to their present job and those with acute injury to the elbow not related to the job.

Consistency in Association for Repetition and Epicondylitis

The studies were not consistent in showing an association between repetitive work and epicondylitis. In terms of strength of association, there were no studies that had statistically significant ORs greater than 3.0, four studies had ORs between 1.0 and 3.0, that were statistically significant; and two studies had nonsignificant ORs less than 1.0.

Coherence of Evidence for Repetition

The evidence for epicondylitis in the biomechanical and sports literature does not address repetition alone, but has consistent evidence with a combination of forceful exertion, awkward or extreme postures, and repetitive movements. Please refer to the discussion under Coherence of Evidence for Force.

Exposure-Response Relationship for Repetition

In Baron et al.'s [1991] study, there was a dose-response relationship for the elbow for the number of hours per week working as a checker, with ORs up to around 3.0, but not for the duration of employment (the average length of employment was 8 years).

Conclusions Regarding Repetition

There is insufficient evidence for support of an association between repetitive work and elbow MSDs based on currently available epidemiologic data. There were no studies that met the four criteria. Of the 7 studies examining repetitive work, no studies found ORs above 3.0, 5 studies found ORs from 1–3, and 2 studies found an OR less than one.

FORCE

Definition of Force for Elbow MSDs

For our review, we included studies that examined force or forceful work or heavy loads to the elbow, or described exposure as strenuous work involving the forearm extensors or flexors, which could generate loads to the elbow/forearm region. Most of the studies that examined force or forceful work as a risk factor for epicondylitis had several concurrent or interacting physical workload factors.

Studies Reporting on the Association of Force and Epicondylitis

Thirteen studies reported results on the association between force and adverse elbow health outcomes, including epicondylitis. The epidemiologic studies that addressed forceful work and epicondylitis compared working groups by classifying them into broad categories based on an estimated amount of resistance or force of exertion and a combination of estimated rate of repetition (e.g., Viikari-Juntura et al. [1991b]; Kurppa et al. [1991]; Chiang et al. [1993]) or in terms of overall elbow stress [Dimberg 1987; Ritz 1995].

Studies Meeting the Four Evaluation Criteria

Of the studies examining epicondylitis and forceful exertion, three studies [Chiang et al. 1993; Luopajärvi et al. 1979; Moore and Garg 1994] fulfilled all four criteria. Most of these studies used combinations of risk factors in their analysis, of which forceful exertion was one.

Chiang et al. [1993] assessed exposure though observational methods, recording of tasks and biomechanical movements of representative workers. With these methods, they categorized fish processing workers into three exposure groups according to the ergonomic risks to the shoulders and upper limbs: (1) those with low force and low repetition (the comparison group), (2) those with high force or high repetition, and (3) those with both high force and high repetition. The diagnosis of epicondylitis included standard physical examination techniques of palpation and resisted extension and flexion of the elbow. Examination-defined cases were about one-half the number of cases defined by symptom alone. The analysis was stratified by gender, and those with metabolic diseases associated with MSDs were excluded. There was no significant difference in age between the comparison groups. Multivariate analysis was not carried out for the elbow in this study.

Luopajärvi et al. [1979] determined MSDs differences between female assembly line workers and shop assistants in a department store (cashiers were excluded from the comparison group). Exposure assessment involved on-site observation, video analysis and interviews. The assembly work was found to be repetitive, with up to 25,000 cycles per workday involving hand and finger motions. Specific cycles were not recorded for elbow motions; however, motions involving the hands and fingers involve tendons and muscles from the flexors and extensors that have their origin at the elbow. Static muscle loading of the forearm muscles, deviations of the wrist, and lifting were also found. The diagnosis of epicondylitis included standard physical examination techniques of palpation and resisted extension and flexion of the elbow. Subjects with previous trauma, arthritis, and other pathologies associated with MSDs were excluded. All participants were female. Covariates considered in the analysis included age, social background, hobbies, and the amount of housework performed. Duration of employment was not an issue because the factory had only been open a short time.

Moore and Garg [1994] carried out a medical records review using an epicondylitis case definition based on symptoms and physical examination and a semi-quantitative ergonomic assessment of 32 jobs at a meatpacking plant. The authors used their “Strain Index” to categorize jobs as “hazardous” or “safe” based on a number of factors: observation, video analysis, and judgements based on force, repetition, posture, and grasp. Force was estimated as percent of maximal strength by comparing the reported weight of the pertinent object with estimated average maximal strength of the worker for different types of pinches and grasps, then categorized into five levels.

These values were derived from population-based data stratified according to age, gender, and hand dominance. Repetition was recorded as cycle-time and exertions per minute. The exposure assessment in this study gave more weight to the factor of “force” than to repetition or posture (the force variable could increase to a higher categorization level if the job was repetitive, involved jerky motions, or extreme postures). Work histories, demographics, and pre-existing morbidity data were not collected on each participant. The diagnosis of epicondylitis extracted from the medical records included standard physical examination techniques of palpation and resisted extension and flexion of the elbow. Analyses were based on “full-time equivalents” for jobs, not individual workers. This analysis did not control for potential confounders; there was a slight preponderance of morbidity of all MSDs among females.

Studies Meeting at Least One Criteria

The Andersen and Gaardboe study [1993a], which did not carry out ergonomic assessment pertaining to the elbow, found a non-significant association between repetitive, forceful work and symptoms or physical findings consistent with epicondylitis. In the Andersen and Gaardboe study [1993a], the exposed group consisted of sewing machine operators.

Baron et al.’s [1991] measure of force was based on estimated assessment of exertion by experienced ergonomists through observation of tasks and video analysis, as well as weight of scanned items. Average forces for the grocery checkers were categorized as “low” and peak forces “medium” on a three-tiered scale (“low, medium, and high”).

Byström et al.’s [1995] study of automobile assembly workers is reviewed in the Repetition section.

Dimberg’s studies [1987] fulfilled three of the criteria but did not mention if examiners were blinded to exposure status. In the 1987 study, exposure was assessed by observational methods, jobs were categorized according to the amount of elbow stress in a particular job, but no individual measurements were made. Numerical results from the logistic regression model were not given in the paper, although employee category (blue collar versus white collar), gender, and degree of elbow stress were said not to be significant predictors of having any one of the three types of epicondylitis. The author classified epicondylitis into three types: leisure-related, no known cause, and work-related groups based on history. When the author specifically looked at “work-related” epicondylitis (criteria for such designation was not given) with respect to elbow stress, he found a significant trend with increasing levels of elbow stress.

The exposure assessment approach was different for the 1989 study by Dimberg et al. In the 1987 study by Dimberg, the exposure classification scheme was focused principally on the elbow and identified jobs with heavy elbow-straining work. In the 1989 study, the author focused on multiple health outcomes in the upper extremity and used an exposure classification scheme that was more broadly focused on the stress to the hand/wrist, elbow, and shoulder areas.

One study by Kurppa et al. [1991] was prospective. Here, workers in meat processing were categorized into strenuous and nonstrenuous jobs based on repetitive and forceful work. The strenuous tasks for the meatcutters consisted of cutting approximately 1,200 kg of veal or 3,000 kg of pork per day; the nonstrenuous tasks consisted primarily of office work. Workers had to have a physician visit and diagnosis in order to be considered a case—a restrictive definition requiring significant enough symptoms to seek out medical care.

Twenty-five percent of cases were diagnosed by physicians outside the plant, so examination techniques may not have been the same as those for the other 75%. The nonstrenuous group was similar to the strenuous group with regards to age, gender, and duration of employment, except for the small number of male sausage makers and male meatpackers—these were excluded from calculation of individual IRs.

Punnett et al.’s [1985] study of garment workers is reviewed in the Repetition section.

Ritz [1995] did not mention the participation rate in their study of welders and pipefitters but fulfilled the other three criteria. Workers studied were likely to be a representative sample, however, since all male employees who were taking their annual examinations during a three month period were enrolled in the study. The multiple logistic model analysis considered age and a variety of confounding factors. Among these public gas and water work employees, the welders and pipefitters who installed and repaired pipes were considered to have high exposure.

Roto and Kivi [1984] based their exposure on job title alone, but fulfilled the other three criteria. They compared meatcutters who had forceful, repetitive work to construction workers who had more varied tasks. The authors stratified the analysis by age and found the majority of cases in the older age groups. They also found that the meatcutters with epicondylitis had been exposed, on the average, five years longer than the other meatcutters. All the meatcutters had more than 15 years in their current occupation, which the authors attributed to support of the work-relatedness of the condition, although increasing age may have been a confounder or effect modifier.

Viikari-Juntura et al. [1991b] studied subjects at the same meat processing plant as Kurppa et al. [1991] using 3 cross-sectional examinations covering a period of 31 months. The same exposure assessment scheme used in the Kurppa et al. [1991] study mentioned above was used comparing workers in strenuous and nonstrenuous work. This study compared the prevalence of all cases of epicondylitis; cases due to injury or known non-occupational causes were not excluded. The diagnosis of epicondylitis included standard physical examination techniques of palpation and resisted extension and flexion of the elbow; the authors stated that palpation pressure increased on the second of the three cross-sectional examinations and may have influenced results. The investigators stated the comparison group was selected similar to the study group in gender, age, and duration of employment.

In conclusion, for the studies with less than our four criteria, four are supportive [Kurppa et al. 1991; Ritz 1995; Dimberg 1987; and Roto and Kivi 1984], two are non-supportive [Dimberg et al. 1989; Byström et al. 1995], and one is not very informative [Andersen and Gaardboe 1993a]. The results from the positive studies are unlikely to be due to confounding or selection bias. Overall, these studies provide limited support for the association of forceful repetitive work and epicondylitis.

Strength of Association—Force and Epicondylitis

Chiang et al. [1993] did not find an association between hand-intensive work (categorized based on forceful exertion and repetition) and epicondylitis when analyzing all workers at six fish processing plants. However, in examining the highest level of exposure (we calculated the odd ratios for men and women separately, which was not done in the article), we found a significant difference between males in the highest exposed group (Group III) and males in the lowest exposed group (Group I) (OR= 6.75) and a non-significant OR of 1.44 for women. Exposure in Group III was based on a combination of high-force exertion and high repetition; analysis of working techniques by gender was not performed, so the reason for the difference in the groups by gender is not known. The Chiang et al. [1993] study provides limited support for the association between high levels of forceful repetitive elbow work and epicondylitis.

Luopajärvi et al. [1979] found a non-significant difference overall in the prevalence of epicondylitis and pronator teres syndrome (3 versus 11 cases, OR 3.35 [95% confidence interval (CI) 0.86–19.1]); for lateral epicondylitis only, an OR of 2.73 (95% CI 0.66–15.94). There were five cases of medial epicondylitis in the assembly workers and none in the shop assistants. The increase in medial epicondylitis (an indeterminate OR because of "zero" cases in the shop assistants) was attributed to the difficult grasping movements involved in the assembly line work. They found that their female assembly workers tended to have physically light work, but this work required highly repetitive movements of the wrists and fingers and static muscle loading of the forearm muscles.

Using the Strain Index, Moore and Garg [1994] found a significant relationship between hazardous jobs (of which force was a major component) and upper extremity MSDs (of which epicondylitis was an important component). The results found a significant OR of 5.5 for a case of epicondylitis to occur in a hazardous job. When approximating the classification scheme for low and high force used by Silverstein et al. [1987] and then by Kurppa et al. [1991], Viikari-Juntura et al. [1991b], and Chiang et al. [1993], the association between forcefulness and the overall upper extremity morbidity in the study was again statistically significant ($p<0.02$).

The overall conclusion from the three studies that met our four criteria is that there is evidence for association between force and epicondylitis based on strength of association.

Strength of Association—Studies Not Meeting the Four Criteria: Force and Elbow MSDs

Baron et al. [1991] found an OR of 2.3 for the combination of factors, but this was not statistically significant. The authors mention that ergonomic analysis of the non-checkers showed that they also performed work requiring repetitive motions and awkward postures; therefore, the comparison probably resulted in a lower OR than had the referent group been truly unexposed to the ergonomic stressors.

Kurppa et al. [1991] found a strong significant relationship between strenuous jobs and epicondylitis (IR= 6.7), while Viikari-Juntura et al. [1991b] did not (OR=0.88, nonsignificant). These results may have been influenced by allowing "cases" who had recurrence in the same elbow to be counted as new cases (12 out of 57 employees with epicondylitis had more than one episode, and were counted twice). There was a median of 184 days between the episodes. In examining this study, it is important to see if the odds of having epicondylitis would be elevated if these workers with recurrences were only counted once. We recalculated the OR using only "persons" and not "single episodes of epicondylitis" in order to obtain a more conservative estimate. We counted, only once, the employees with recurrence, as well as the four employees mentioned with simultaneous occurrence in both elbows and subtracted these from the strenuous job cases. This gave a total of 44 cases of epicondylitis among the strenuous group.

Using this estimate, more restrictive than that found in the article, gives an OR of 5.5 (2.4, 12.7) for epicondylitis among the workers with strenuous jobs versus those with nonstrenuous jobs. The Kurppa et al. [1991] prospective study also found the IR of epicondylitis in nonstrenuous jobs to be similar to Allender's [1974] population background prevalence rate (1%) for epicondylitis.

Ritz [1995] found a significant OR for 10 years of high exposure to elbow straining work: 1.7 for currently held jobs and 2.2 for formerly held jobs. The significant OR for moderate exposure in the current job was 1.4 for 10 years of exposure. This study provides support for the association of forceful work with epicondylitis.

We calculated odd ratios from data in Dimberg's [1987] study and found an OR for moderate stress versus none or light elbow stress of 2.9, and for heavy versus none or light stress of 7.4. Heavy stress in the elbows was assigned to job titles like blaster, driller, or grinder. The major limitation of this analysis of the work-related cases is that it did not consider age, a likely confounder. Overall, this study provides support for the association between forceful work and epicondylitis, particularly in older workers.

The 1989 Dimberg et al. study was not supportive of an association between lateral epicondylitis and forceful repetitive work, but was positive for "mental stress at work" at the onset of symptoms for lateral epicondylitis ($p<0.001$). As a result of the specific elbow exposure assessment, we believe that with regards to stressful or forceful elbow exertions that the 1987 study is more informative.

The study conducted by Roto and Kivi [1984] found an OR of 6.4 (95% CI 0.99–40.9) using an exposure assessment based on job title alone (meatcutters were assumed to have more forceful jobs than construction workers). Only one referent had epicondylitis.

In the paper by Viikari-Juntura et al. [1991b], the cases of epicondylitis not listed as insidious all involved forceful, repetitive tasks (although some of these tasks were not related to work). Prevalences of "epicondylar pain" and "sick leave due to epicondylar pain" were significantly different between the two groups (OR 1.9 and 2.1). There was no significant difference in the prevalence of epicondylitis (combined work and non-work related) between workers in strenuous versus nonstrenuous jobs (OR=0.88). In 95 women sausage makers, there were four cases with insidious onset, while among 160 women referents there were two cases, one with insidious onset, the other related to an "exceptional task of cutting cheese." The resulting OR was 6.9 (95% CI 0.74–171). This study also found that rates of "epicondylar pain" and "sick leave due to epicondylar pain" differed significantly between the two groups (OR 1.9 and 2.1, respectively). Rates of medically diagnosed cases of epicondylitis were not statistically different between the two groups, but the results for epicondylar pain (causing sick leave in the two groups), and the fact that the majority of cases in both groups were due to events involving strenuous, repetitive tasks, give some support to forceful, repetitive work as a cause.

Byström et al. [1995] noted that the low frequency could not be attributed to selected subjects being absent, as all persons on leave participated in the investigation. The authors also stated that “exposure to repetitiveness and force in automobile assembly line work may be less than in other investigated work situations.” Because the authors did not give quantitative or qualitative information on the forcefulness or repetitiveness of jobs included in the study group, it is difficult to know whether these jobs were appropriate to use to study epicondylitis.

Temporal Relationship: Force and Epicondylitis

See temporal relationship above in Repetition and Epicondylitis.

Consistency of Association

The studies that met the four criteria were fairly consistent in their strength of association between force and epicondylitis, with most ORs between 2.5 and 7.0. Focusing on those studies that compared workers exposed to force that was documented to be at a high level, to those exposed to a low level, all studies [Chiang et al. 1993; Kurppa et al. 1991; Moore and Garg 1994] were consistent.

Of those 10 studies that examined force but did not fulfill the four criteria, two studies had a significant OR greater than 3.0, three studies had significant ORs between 1.0 and 3.0, one had a nonsignificant OR between 1.0 and 3.0, and two had an OR less than 1.0. Two had statistically significant findings but did not report ORs. Most of these studies examined workers in repetitive, forceful job tasks and did not separate out

the independent effect of repetition through any analytic method.

Viikari-Juntura et al.’s [1991b] study did not exclude workers with elbow symptoms or physical findings that were due to acute injury not related to the job, which may account for the contrasting result. In fact, in that study, four workers with acute non-work-related epicondylitis in the nonstrenuous group were noted in the journal article. Another consideration for inconsistency is due to grouping of studies, which may all fulfill good epidemiologic criteria, may all examine the same risk factor, but may compare groups that do not have similar contrasting levels of exposure. For example, the Chiang et al. [1993] study found statistically significant results in men when comparing high force/high repetition jobs to low force/low repetition jobs. Baron et al. [1991], on the other hand, compared checkers in low force, medium repetition jobs to noncheckers in low force, low repetition jobs.

Two factors explain the difficulty in determining the reasons for the apparent inconsistencies among the studies on forceful and repetitive work. First, very few of the exposure assessments were quantitative—this is due to existing limitations in directly measuring exposure in detail in most field studies. As a result, there is likely to be frequent non-differential misclassification of exposure. Second, most of the studies completed have been cross-sectional, and therefore subject to survivor bias.

As an example, Chiang et al. [1993] found that epicondylitis was significantly associated with increasing repetitiveness and

forcefulness among fish processors employed less than 12 months. For those working for 12 to 60 months, a similar trend was found, but a reverse trend was found in those workers employed for over 60 months. The authors stated that because most of the workers were semi-skilled, they were likely to leave their job if they felt frequent muscle pain because of it. They went further to say that the selection mechanism may explain the lack of significant associations between the disorders and the duration of employment. There was no indication that the authors pursued this hypothesis by trying to identify former workers who may have left. Turnover rate was not discussed. This example highlights two important factors concerning the cross-sectional studies examining work-related epicondylitis: there is some evidence that older workers may be at higher risk of epicondylitis [Dimberg 1987; Ritz 1995], and there is also a "survivor" effect, which results in the loss to the study of affected workers. These two factors make the interpretation of duration of disease relationships complex and may affect the estimate of the risk of disease.

There were studies that used more accurate exposure assessment or had comparison groups with marked differences in levels of exposure to forceful and repetitive work that were positive, such as the Kurppa et al. [1991] study of meatcutters, sausage makers, and packers, Moore and Garg's [1994] study of pork processors; Dimberg's [1987] study of blasters, drillers, grinders, and others in an engineering industry; Ritz's [1995] study of pipefitters and welders in a public utility; and Roto and Kivi's [1984] study of meatcutters. There were studies with these characteristics that were negative, such as the Viikari-Juntura et al. [1991b] study of meatcutters, sausage makers, and packers; and the study by Dimberg et al. [1989] of blue- and white-collar workers in the automobile industry. In both of these studies, those cases of epicondylitis listed in the comparison groups were due to highly repetitive, forceful activities. The lack of a significant difference in the prevalence of the disorder between the two groups may be because the referent, "low" exposure groups had a higher incidence of non-work-related lateral epicondylitis.

Coherence of Evidence

The epidemiologic results of finding the majority of cases occurring in highly repetitive, forceful work [Moore and Garg 1994; Chiang et al. 1993; Kurppa et al. 1991; Kopf et al.1988] are consistent with the evidence from biomechanical and physiologic findings, as well as from sports medicine literature and older medical clinical case series. In cases of lateral epicondylitis occurring in workplaces as well as in sports, the forearm extensors are repetitively contracted and produce a force that is transmitted via the muscles to their origin on the lateral epicondyle. These repetitive contractions produce chronic overload of the bone-tendon junction, which in turn leads to changes at this junction. The most common hypothesis is that microruptures occur at the attachment of the muscle to bone (usually at the origin of the extensor carpi radialis brevis muscle), which causes inflammation. Peƒina et al. [1991] did not agree with the microrupture theory; they theorized that overuse leads to avascularization of the affected muscle origin, which leads to overstimulation of the free nerve endings and results in aseptic inflammation. Further repetition of the offending movements causes angiofibroblastic hyperplasia of the origin. Nirschl [1975] stated that the degree of angiofibroblastic hyperplasia is correlated to the duration and severity of symptoms. On histologic analysis of severe cases of epicondylitis, one can see the characteristic invasion of fibroblasts and vascular tissue, the typical picture of angiofibroblastic hyperplasia.

Prior to many of the epidemiologic studies, there were numerous reports in the medical literature of clinical case series that suggest a relationship between epicondylitis and repetitive, forceful work. For example, as early as 1936 Cyriax reported that with regard to patients with lateral epicondylitis, "those patients who remember no special overexertion will be found to be working at screwing, lifting, hammering, ironing, etc., or to be violinists, surgeons, masseurs, etc." Cyriax had designated a "Chronic Occupational" variety of tennis elbow, in which he stated that "often no history of an injury is obtainable, but the patient's occupation at once provides the clue." He cited "work which entails repeated pronation and supination movements with elbow almost fully extended" to be responsible for epicondylitis [Cyriax 1936]. Feldman et al. [1987] reported that occupations with work tasks requiring repeated pronation and internal/external rotation of the forearm are at high risk of pronator teres syndrome (compression of the median nerve as it courses through the pronator teres muscle in the forearm). A number of case series have reported similar findings [Hartz et al. 1981; Morris and Peters 1976].

Sinclair [1965] reported 2 case series of patients with tennis elbow (lateral epicondylitis), 44 patients treated between 1959-1961 and 38 patients treated between 1961-1963. In the first group of 267, the 130 (48%) whose onset occurred spontaneously had occupations that included gripping tools with consequent forearm extensor muscle contraction and repetitive supination/ pronation of the forearm. In the second group of 26, the 23 (88%) who had spontaneous onset worked in jobs with constant gripping or repetitive movements.

Many case studies of professional athletes have documented that forceful, repeated dorsiflexion, pronation, and supination movements with the elbow extended can cause epicondylitis. [Ollivierre et al. 1995; Priest et al. 1977; King et al. 1969]. Most cases have occurred in baseball pitchers and tennis players. Occupations involving movements described above have also been found to have increases in rates of elbow MSDs. This literature has also referred to increased occurrence in occupations requiring force, awkward postures, and repetitive use of the elbow and forearm [Lapidus and Guidotti 1970; Mintz and Fraga 1973; Berkeley 1985]. These reports, though mainly case series, have lead to further studies that examined the links between exposure and epicondylitis.

An example of an early occupational study is one by Mintz and Fraga [1973], who found that foundry workers (with an average of 14 years of employment) who used tongs requiring twisting and bending of the elbows/forearms for eight hours per day had decreased elbow flexion and extension and

pain on physical examination, as well as severe radiographically documented osteoarthritis localized to the elbows. In the studies that are reviewed in Tables 4-1

through 4-4, the occupations with the highest rates of epicondylitis, such as drillers, packers, meatcutters, and pipefitters, are consistent with the force-repetition model of the causation of epicondylitis. The development of epicondylitis in these workers is consistent with proposed biological mechanisms and is plausible.

The lack of elbow MSDs and work factors in some of the studies with occupations like sewing workers [McCormack et al. 1990] or automobile assembly line workers [Byström et al. 1995], most likely reflects the interplay of two factors. The movement of affected workers out of high exposure jobs limits the ability of cross-sectional studies to accurately determine associations between work factors and epicondylitis. Our ability to accurately identify working conditions with an elevated risk for epicondylitis may require an exposure assessment of each job to a degree that has been beyond the limits of current epidemiological methods. As a result, misclassification of exposure may be common. Overall, the majority of the epidemiologic studies are supportive of the hypothesis of an increase risk of epicondylitis for occupations that involve forceful and repetitive work, frequent extension, flexion, supination, and pronation of the hand and the forearm. The surveillance data are also supportive of this hypothesis [Roto and Kivi 1984; Washington State Department of Labor and Industry 1996]. The highest relative risks for epicondylitis in Finland were with mechanics, butchers, food industry workers, and packers; the highest industries in Washington State for 1987-1995 [Silverstein et al. *In Press*] were construction workers, meat dealers, and foundry workers—all occupations with repetitive, forceful work involving the arms and hands and requiring pronation and supination.

Evidence of a Dose-Response

Relationship for Force

The Baron et al. [1991] study is mentioned above in the Repetition Section as showing a dose-response relationship for number of hours of work per week. Chiang et al. [1993] found that among men the prevalence of epicondylitis increased with increasing force and repetition in fish processors. In several studies, only dichotomous divisions were made, so conclusions concerning an exposure-response relationship cannot be drawn. However, we can see significantly contrasting rates of elbow MSDs between high- and low-exposure groups. Moore and Garg [1994] found a higher risk in workers with high-strain jobs compared to those with low-strain jobs. Kurppa et al. [1991] found higher risk in workers with strenuous jobs compared to those with nonstrenuous jobs, and that female sausage makers had an increase in epicondylar tenderness with increasing duration of employment. While Dimberg [1987] found no difference in epicondylitis between blue- and white-collar workers, he found that workers with elbow pain severe enough to require a physician consult were significantly more often in those jobs identified independently as having high elbow stress. Dimberg also found a statistically significant correlation coefficient for lateral epicondylitis and time spent in the present job. Luopajärvi et al. [1979] found a higher rate of epicondylitis and pronator teres syndromes in a high-exposure group of assembly line packers compared to the referent group of shop assistants. Overall, these studies provide considerable evidence for a difference in level of risk for epicondylitis when there are marked differences in the level of exposure to forceful and repetitive tasks.

Ritz [1995] reported a positive dose-response relationship between duration of exposure to gas and waterworks jobs regarded as moderately and highly stressful to the elbow and epicondylitis. Roto and Kivi [1984] reported that all workers with epicondylitis in their meat-packing facility worked for more than 15 years in the strenuous job category and had been exposed an average of 5 years longer than non-diseased workers. Kopf et al. [1988] reported that in their study of brick layers, with increasing levels of job demands (defined as either heavy physical work, awkward working postures, repetitive movements, or restriction in standing position), the OR increased from 1.8 to 3.4. These studies, with less clear contrasts in exposure, provide support for the exposure-response relationship between epicondylitis and forceful, repetitive work.

POSTURE

Definition of Postures for Elbow MSDs

We chose to include those studies that addressed posture or examined workers in those activities or occupations that require repeated pronation and supination, flexion/ extension of the wrist, either singly or in combination with extension and flexion of the elbow.

Studies Reporting on the Association of Posture and Epicondylitis

The six studies in Table 4-3 addressed posture variables. Of these, only the studies by Moore and Garg [1994] and Luopajärvi et al. [1979] fulfilled all four criteria. The details of these studies are discussed in the Repetition and Force sections.

Strength of Association—Posture and Epicondylitis

Studies Meeting the Four Evaluation Criteria

The Moore and Garg [1994] study (also discussed above) recorded wrist posture using a classification similar to Armstrong et al. [1982] and Stetson et al. [1991]. Pinch grasp was also noted to be present or absent. In this study, posture was not found to be significantly associated with "hazardous" jobs. This may be due to the heavier weighting given the force rating system than the posture or repetition scale. For example, if a job required extreme posture, the authors increased the force rating instead of the posture rating. If a combination of extreme posture and high-speed movement was required, then the force rating was raised by two levels, but not the posture rating. Data that would allow analysis of the incidence of epicondylitis and the exposure to extreme posture were not presented.

Luopajärvi et al.'s [1979] assessment was focused on the extreme work position of the hands but not the elbow; it included extension, flexion and deviation of the wrists. Although there was a non-significant association between assembly line work and the presence of either epicondylitis or pronator teres syndrome in shop assistants (11 cases versus 3), there were 5 cases of medial epicondylitis and 2 cases of pronator teres syndrome in the assembly workers and none in the shop assistants. The greater prevalence of medial epicondylitis in assembly workers was attributed to the difficult grasping movements involved in the assembly line work. The authors stated that the overall prevalence may have been "connected with the constant overstrain of flexors in work."

Studies Not Meeting the Four Evaluation Criteria

The Dimberg [1987] study stated that over-exertion of the extensor muscles of the wrist due to gripping and twisting movements prior to the onset of symptoms was verified in 28 of the 40 (70%) of the cases, of which 14 were considered to be caused by work. In the study by Dimberg et al. [1989], the guidelines for classification include repeated rotation of the forearms and wrists in Group 1, large and frequent rotations in extreme positions in Group 2, but fail to include work involving frequent rotations in the highest exposed group, Group 3. The difference in exposure classification scheme may explain why there was no relationship between prevalence of epicondylitis and increasing work strain.

Hughes and Silverstein [1997] found a strong, statistically significant association (OR 37) between elbow/forearm disorders and "the number of years of forearm twisting" in their study of aluminum workers. However, this study had an overall low participation rate (55%), which limits the interpretation of its result.

The other study that may be interpreted as related to a posture variable is the one by Hoekstra et al. [1994]. This study evaluated video display terminal users at two work sites differing only in whether adjustable office equipment was present. By self-reported symptoms and exposure

observations, the Hoekstra et al. [1994] study found that having a "non-optimally adjusted" chair was associated with elbow MSDs. This improper chair adjustment was thought to increase shoulder and elbow flexion, as well as wrist deviation, thus producing more symptoms. These conclusions should be considered to be hypothesis generating and not definitive.

Temporal Relationship

There are no prospective studies that address posture and epicondylitis. The one prospective study concerning epicondylitis did not address posture.

Consistency in Association

There are too few occupational epidemiologic studies that address posture and epicondylitis to meaningfully discuss consistency of association.

Coherence of Evidence

Please refer to the "Repetition Section and Coherence of Evidence" for a discussion of the sports literature, and the combination of factors, including extreme postures that have been documented concerning epicondylitis.

Exposure-Response Relationship

There is little evidence on which to base a discussion exposure response relationship in the epidemiologic studies. Once again, the reader is referred to the biomechanical sports literature.

EPICONDYLITIS AND THE ROLE OF CONFOUNDERS

The model for epicondylitis clearly implies that both occupational and non-occupational activities can cause the disorder. Several studies [Ritz 1995; Andersen and Gaardboe 1993a; Dimberg 1987] directly address the issue of work-related versus non-work-related exposures by assessing both. Two of the most important potential confounders or effect modifiers are age and duration of employment. In Dimberg's [1987] and Ritz's [1995] studies, older workers had high rates of epicondylitis. Nevertheless, in both studies the increase in the risk for epicondylitis in the high-exposure group does not seem related primarily to age, independent of intensity and duration of exposure. Furthermore, the incidence of elbow MSDs unlike most MSDs, has been found to decrease after retirement age, after peaking during the fourth and fifth decades.

Many of the studies controlled for several possible confounders in their analyses. In general, for epicondylitis, psychosocial factors or gender do not appear to be important confounders in occupational studies.

CONCLUSIONS

The epidemiologic studies reviewed in this section focused principally on the risk of epicondylitis in workers performing repetitive job tasks requiring forceful movements. These forceful movements included, but were not limited to, repeated dorsiflexion, flexion, pronation, and supination, sometimes with the arm extended. Clinical case series of occupationally-related epicondylitis and studies of epicondylitis among athletes had suggested that repeated forceful dorsiflexion, flexion, pronation, and supination, especially with the arm extended, increased the risk of epicondylitis. In general, the epidemiologic studies have not quantitatively measured the fraction of forceful hand motions most likely to contribute to epicondylitis; rather, they have used as a surrogate qualitative estimation the presence or absence of these types of hand movements [Viikari-Juntura et al. 1991b]. Although we recognize this limitation of the epidemiologic studies, there is value in assessing where we are in regards to the epidemiologic evidence of causal inference.

There is epidemiologic evidence for the relationship between forceful work and epicondylitis. Those studies that base their exposure assessment on quantitative or semiquantitative data have shown a solid relationship. We conclude that there is insufficient evidence for the association of repetitive work and epicondylitis. For extreme posture in the workplace, the epidemiologic evidence thus far is also insufficient, and we turn to the sports medicine literature to assist us in evaluating the risk of the single factors of repetition and posture. The strongest evidence by far when examining the relationship between work factors and epicondylitis is the combination of factors, especially at higher levels of exposure. This is consistent with the evidence that is found in the biomechanical and sports literature.

Most of the relevant occupational studies were cross-sectional; the current estimates of the level of exposure were used to estimate past and current exposure. Despite the cross-sectional nature of the studies, it is likely, in our opinion, that the exposures predated the onset of disorders in most cases.

When we examine all of the studies, a majority of studies are positive. The association between forceful and repetitive work involving dorsiflexion, flexion, supination, and pronation of the hand is definitely biologically plausible. These motions can cause the contraction of the muscle-tendon units that attach in the area of the medial and lateral epicondyles of the elbow.

The evidence for a qualitative exposure-response relationship overall was considerable for the combination of exposures, with studies examining differences in levels of exposure for the elbow, and corresponding evidence for greater risk in the highly exposed group. In contrast, we found one study with clear differences in exposure and no evidence of an increase in risk [Viikari-Juntura et al. 1991b].

In summary, the combination of the biological plausibility, the studies with more quantitative evaluation of exposure factors finding strong associations, and the considerable evidence for the occurrence with combinations of factors at higher levels of exposure provide evidence for the association between repetitive, forceful work and epicondylitis. There are several important qualifications to this conclusion. Forceful and repetitive work is most likely a surrogate for repetitive, forceful hand motions that cause contractions of the muscles whose tendons insert in the area of the lateral and medial epicondyles of the elbow. While the studies do not identify the number or intensity of forceful contractions needed to increase the risk of epicondylitis, the levels are likely to be substantial. Future studies should focus on the types of forceful and repetitive hand motions such as forceful dorsiflexion, pronation, and supination that result in forceful contractions of the muscle tendon units that insert in the area of the lateral and medial epicondyles. Common non-occupational activities, such as sport activities, which cause epicondylitis should be considered. Older workers may be at some increased risk. Finally, even though the epidemiologic literature shows that many affected workers continue to work with definite symptoms and physical findings of epicondylitis, survivor bias should be addressed.

Table 4-1. Epidemiologic criteria used to examine studies of elbow MSDs associated with repetition

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing elbow exposure to repetition
Met at least one criterion:					
Andersen 1993a	1.7	Yes	No	Yes	Job titles or self-reports
Baron 1991	2.3	No	Yes	Yes	Observation or measurements
Burt 1990	2.8†	Yes	No	Yes	Job titles or self-reports
Byström 1995	0.74	Yes	Yes	No	Job titles or self-reports
McCormack 1990	0.5–1.2	Yes	Yes	NR‡	Job titles or self-reports
Met none of the criteria:					
Ohlsson 1989	1.5–2.8	NR	No	NR	Job titles or self-reports
Punnett 1985	2.4†	No	No	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance.

‡Not reported.

Figure 4-1. **Risk Indicator for "Repetition" and Elbow Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)

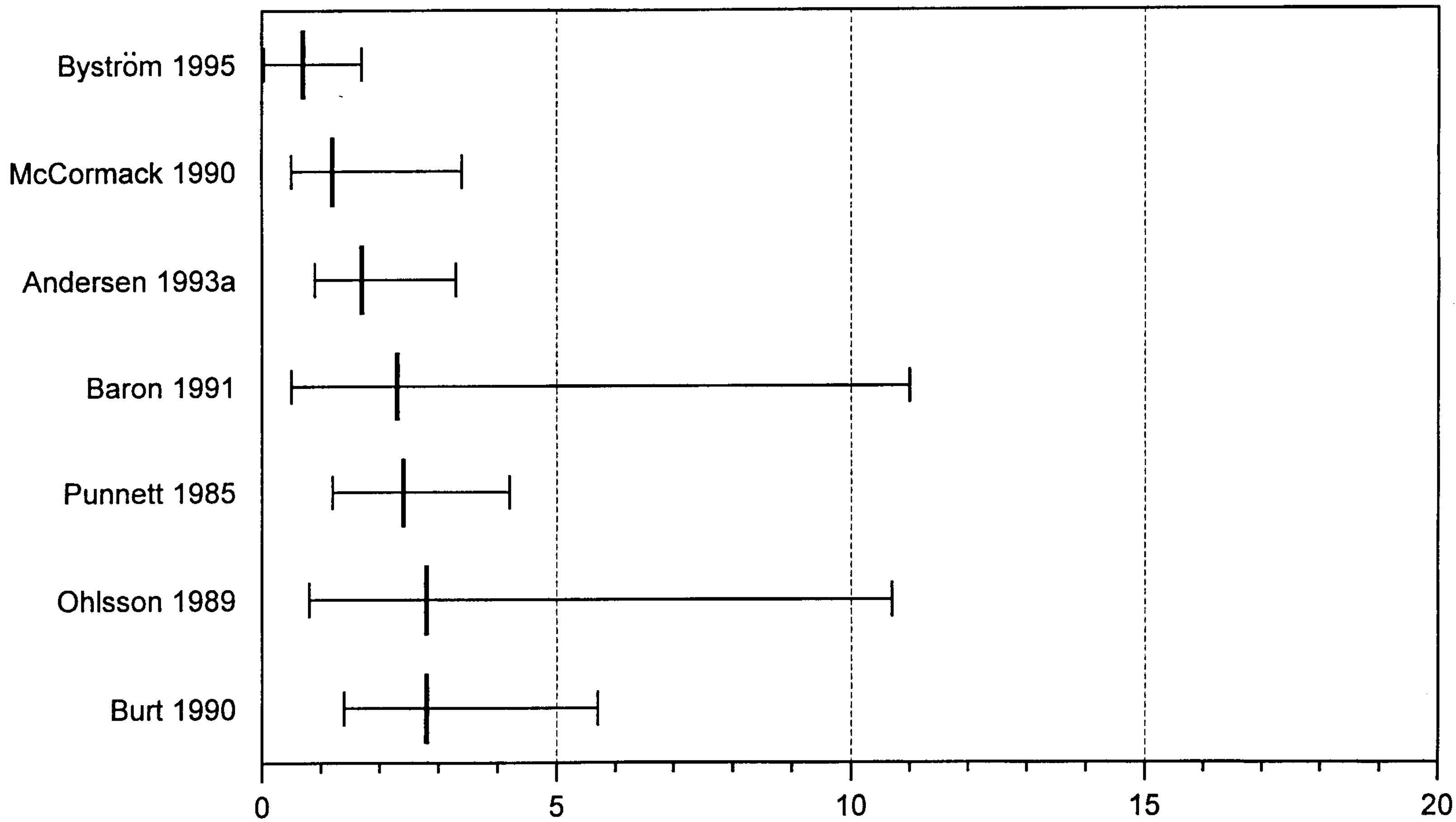


Table 4-2. Epidemiologic criteria used to examine studies of elbow MSDs associated with force

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing elbow exposure to force
Met all four criteria:					
Chiang 1993	6.75† (males) 1.44 (females)	Yes	Yes	Yes	Observation or measurements
Luopajärvi 1979	2.7	Yes	Yes	Yes	Observation or measurements
Moore 1994	5.5†	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Andersen 1993a	1.7	Yes	No	Yes	Job titles or self-reports
Baron 1991	2.3	No	Yes	Yes	Observation or measurements
Byström 1995	0.74	Yes	Yes	No	Job titles or self-reports
Dimberg 1987	NR†,‡	Yes	Yes	NR	Observation or measurements
Dimberg 1989	NR	Yes	Yes	NR	Observation or measurements
Kurppa 1991	6.7†	Yes	Yes	NR	Observation or measurements
Punnett 1985	2.4†	Yes	No	NR	Job titles or self-reports
Ritz 1995	1.4–1.7†	NR	Yes	Yes	Observation or measurements
Roto 1984	6.4†	Yes	Yes	Yes	Job titles or self-reports
Viikari-Juntura 1991b	0.88	Yes	Yes	NR	Observation or measurements

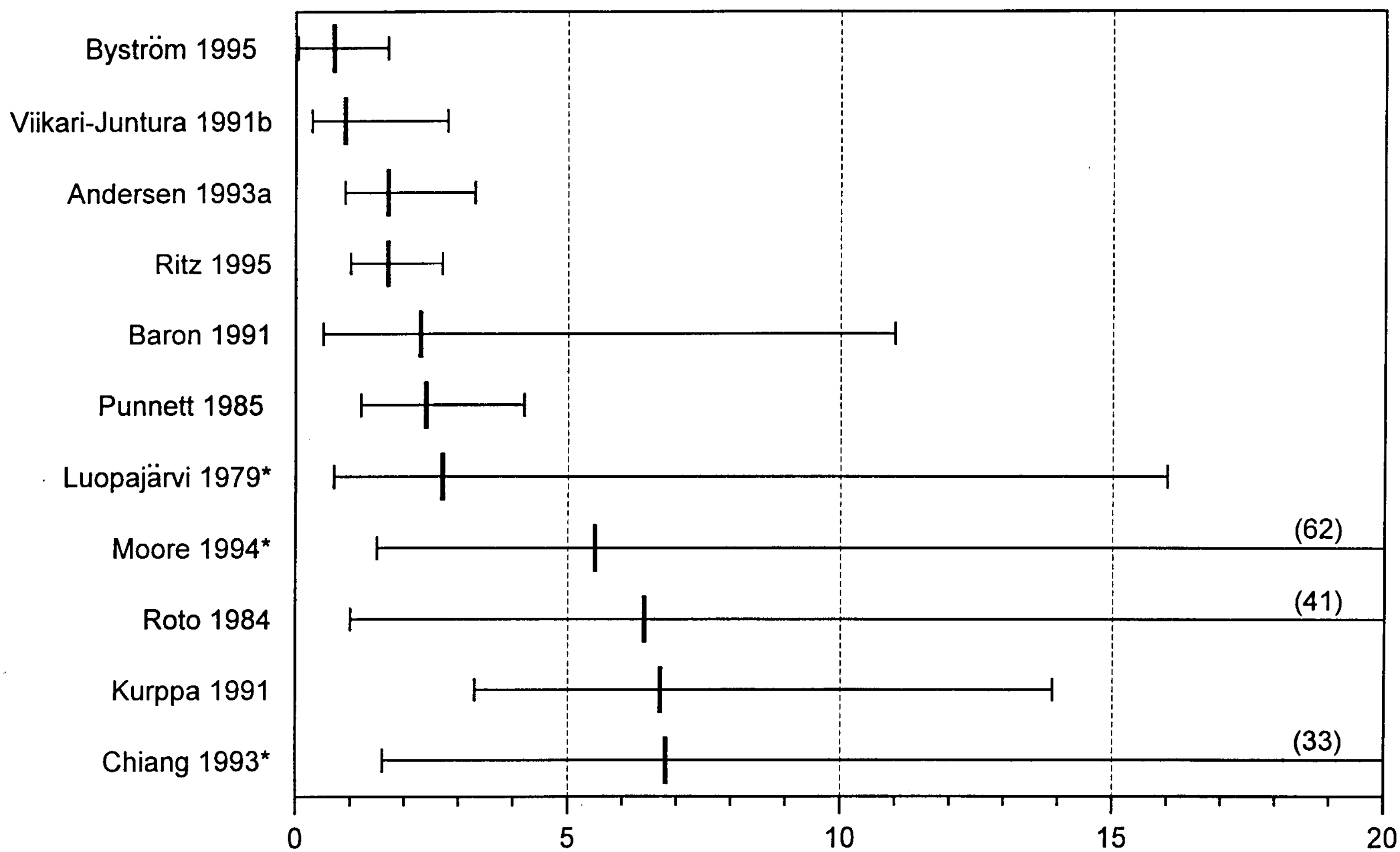
*Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

Figure 4-2. **Risk Indicator for "Force" and Elbow Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 4-2.

Table 4-3. Epidemiologic criteria used to examine studies of elbow MSDs associated with posture

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination or medical records	Investigator blinded to case and/or exposure status	Basis for assessing elbow exposure to posture
Met all four criteria:					
Luopajärvi 1979	2.7	Yes	Yes	Yes	Observation or measurements
Moore 1994	NR‡	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Dimberg 1987	NR†	Yes	Yes	NR	Observation or measurements
Dimberg 1989	NR	Yes	Yes	NR	Observation or measurements
Hoekstra 1994	4.0†	Yes	No	Yes	Job titles or self-reports
Hughes 1997	37.0†	No	Yes	NR	Observation or measurements

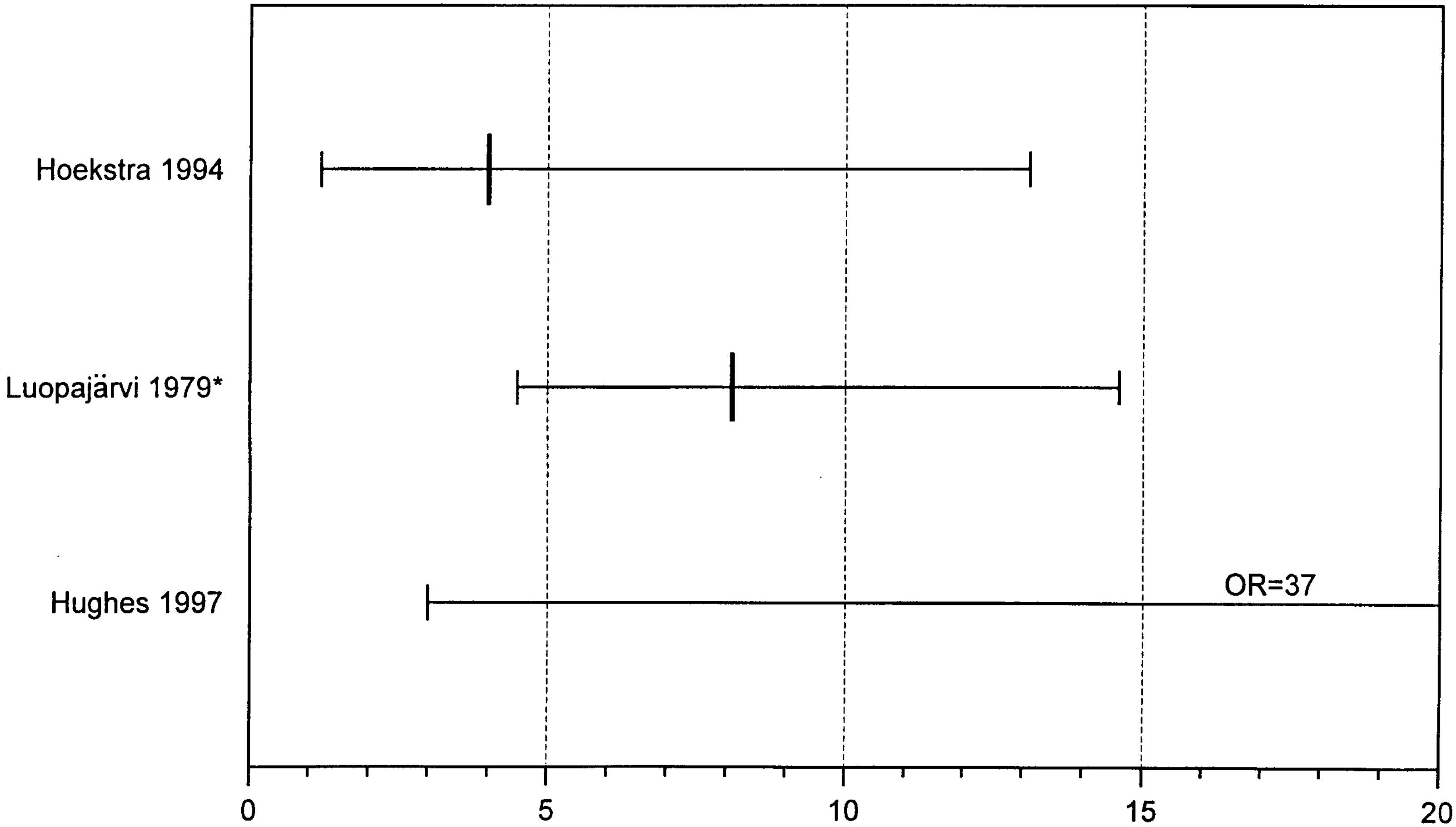
*Some risk indicators are based on a combination of risk indicators—not on posture alone (e.g., posture plus repetition, force, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

Figure 4-3. **Risk Indicator for "Posture" and Elbow Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

Note: Some studies indicate a statistical significant association without a risk indicator. See Table 4-1.

Table 4-4. Epidemiologic criteria used to examine studies of elbow MSDs associated with vibration

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination or medical records	Investigator blinded to case and/or exposure status	Basis of assessing elbow exposure to vibration
Met at least one criterion:					
Bovenzi 1991	4.9†	NR‡	Yes	Yes	Observation or measurements

*Some risk indicators are based on a combination of risk indicators—not on vibration alone (e.g., vibration plus repetition, force, or posture). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

† Indicates statistical significance.

‡ Not reported.

Table 4–5. Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Andersen and Gaardboe 1993a	Cross-sectional	424 female sewing machine operators, compared to 781 females from the general population of the region and an internal referent group of 89 females from the garment industry.	Outcome: Questionnaire: continuous pain lasting > 1 month since starting career; pain for > 30 days. Exposure: Job categorization based on "authors' experiences" as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. Jobs involving high repetitiveness (several times/min) and low or high force, and jobs with medium repetitiveness (many times/hr) combined with high force were classified as high exposed jobs; jobs with medium repetitiveness and low force and jobs with more variation and high force were classified as medium exposed. Job titles such as teachers, self-employed, trained nurses, and the academic professions were "low exposed." Exposure also measured as years as sewing machine operator.	4.5%	2.6%	1.7	0.9-3.3	Participation rate: 78.2%. Examiners blinded to control/subject status. Adjusted for age, number of children, exercising, smoking, socioeconomic status.

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Baron et al. 1991	Cross-sectional; case-referent	Grocery checkers using laser scanners (n=124, 119 females, 5 males) compared to other grocery store workers (n=157, 56 females, 101 males); excluded 18 workers in meat, fish, and deli departments, workers under 18, and pregnant workers.	Outcome: Self-administered questionnaire and physical exam. Case defined as the presence of pain, numbness, tingling, aching, stiffness or burning in the elbow region as previous non-occupational injury; symptoms must have begun after employment at the supermarket of employment and in the current job, and last >1 week or occurred once a month within the past year. Physical Exam: Tenderness at the lateral/medial epicondyle and pain with palpation and resisted motion. Exposure: Based on job category, estimates of repetitiveness, average and peak forces based on observed and videotaped postures, weight of scanned items, and subjective assessment of exertion. The majority of cashiers were categorized as having “medium” levels of repetition for the hand (defined in this study as making 1250 to 2500 hand movements/hr).	8% among checkers	õ	2.3	0.5-11	Participation rate: 85% checkers; 55% non-checkers in field study. Following telephone survey 91% checkers and 85% non-checkers. Examiners blinded to worker’s job and health status. Age, hobbies, second jobs, systemic disease and height were considered as covariates in the multivariate analyses. Total repetitions/hr ranged from 1,432 to 1,782 for right hand and 882 to 1,260 for left hand. Average forces were low and peak forces medium. No statistical significance associated between duration of employment as a checker and elbow MSDs. Multiple awkward postures of all upper extremities recorded but not analyzed in models. Statistically significant increase in elbow MSD with increase in hr/week “checking.”

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bovenzi et al. 1991	Cross-sectional	Vibration-exposed forestry operators using chain-saws (n=65) and maintenance workers (n=31, control group).	Outcome: Epicondylitis syndrome: Pain at the epicondyle either during rest or motion, local tenderness at the lateral or medial epicondyle; pain during resisted flexion/extension of the fingers and wrist with the elbow flexed, palpated local tenderness at the lateral/medial epicondyle. Exposure: Direct observation of awkward postures, manual forces and repetitiveness evaluated via checklist. Vibration measured from two chain saws.	29.3	6.4%	For vibration exposed group >7.5 m/s^2: OR=4.9 (adjusted) OR=5.99 (unadjusted)	1.27-56	Participation rate: Not reported. Analysis controlled for age and ponderal index. Controls found to have several risk factors for MSDs at work-static arm and hand overload, overhead work, stressful postures, non-vibrating hand tool use. Controls actually had a greater proportion of the time in work cycles shorter than 30 sec than forestry workers.

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	95% CI	Comments
Burt et al. 1990	Cross-sectional	Newspaper employees (n=836, females=55%). Workers fulfilling case definitions compared to those who did not fulfill case definition.	Outcome: Self administered questionnaire. Case defined as the presence of pain, numbness, tingling, aching, stiffness, or burning in the elbow region as previous non-occupational injury. Symptoms began after starting the job, last > 1 week or occurred once a month within the past year; reported as "moderate" (3) or greater on a 5-point scale. Exposure: Based on observation of job tasks, then categorized by job title. A separate job analysis using a checklist and observational techniques was carried out for validating questionnaire exposure data.	Male: 11% Female: 14%	õ	80% to 100% time typing compared to 0% to 19%: OR=2.8 Reporters compared to others: OR=2.5	1.4-5.7 1.5-4.0	Participation rate: 81%. Analysis controlled for age, gender, years on the job. Psychosocial factors dealing with job control and job satisfaction were addressed in questionnaire. Job analysis found significant correlation (0.56) between reported average typing time/day and observed 8 hr period of typing ($p < 0.0001$). Reporters were characterized by high, periodic demands (deadlines), although they had high control and high job satisfaction. Number of workers in some non- typing jobs not reported. Case definition based on symptoms alone.

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Byström et al. 1995	Cross-sectional	Automobile assembly line workers (n=199) compared to a randomly selected group from the general population (n=186). The automobile assembly line workers were randomly selected from a primary group of 700 assembly line workers. These original 700 workers had been randomly selected from the 2,334 assembly workers of a Swedish automobile factory.	Outcome: Epicondylitis was defined as tenderness to palpation of the lateral or medial epicondyle and pain at the same epicondyle or in the forearm extensors or flexors on resisted wrist extension or flexion. Exposure: No evaluation of repetition, force, posture, or vibration occurred in this study to evaluate risk factors for epicondylitis. "Assembly line worker" vs. "Population referent" was used. Hand grip strength was evaluated. Forearm muscular load and wrist angle were evaluated for a subgroup in this population but were not used in this analysis [Hägg et al 1996].	Tender lateral epicondyle: 4.3% Epicondy-litis: 0 cases	Tender lateral epicondyle: 12.4% Epicondy-litis: 1%	PRR for tender lateral epicondyle: 0.74	0.04-1.7	Participation rate: 96%. Comparison group is from the MUSIC study (Hagberg and Hogstedt, 1991). Examiners were blinded to questionnaire responses but not exposure status. Analysis stratified by gender and age <40 years. Psychosocial variables and other potential confounders or effect modifiers were addressed by Fransson-Hall et al. [1995]. Pain-pressure threshold (PTT) was evaluated. PTT was not related to age. It was higher among women with short employment compared to those who had been employed for a long time. No correlation was found between low MCV and subjective or objective signs.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Chiang et al. 1993	Cross-sectional	207 fish processing workers, 67 males and 140 females, divided in 3 groups: (I) low force, low repetition (comparison group, n=61); (II) high force or high repetition (n=118); (III) high force and high repetition (n=28).	Outcome: Prevalence of lateral or medial epicondylitis (local tenderness, pain in resisted extension or flexion of the wrist and fingers, decreased hand grip strength compared to the opposite hand). Exposure: Assessed by observation and recording of tasks and biomechanical movements of three workers, each representing one of 3 study groups. Highly repetitive jobs with cycle time <30 sec or >50% of cycle-time performing the same fundamental cycles. Hand force from EMG recordings of forearm flexor muscles. Classification of workers into 3 groups according to the ergonomic risks of the shoulders and upper limbs: Group I: low rep. and low force; Group II: high repetition or high force; Group III: high repetition and high force.	Group II: 15% Male: 10%; Female: 17% Group III: 21% Male: 33%; Female: 18% Physician observed epicondylitis, all cases: 14.5 %	Group I: 10% Male: 6%; Female: 14%	Crude ORs calculated from data presented: Group II vs. Group I, males: OR=1.7 Group II vs. Group I, females: OR=1.2 Group III vs. Group I, males: OR=6.75 Group III vs. Group I, females: OR=1.44	0.3-9.2 0.4-3.4 1.6-32.7 0.3-5.6	Participation rate: Authors reported: "In order to prvent selective bias all employees in the fatories were observed initially." Workers examined in random sequence to prevent observer bias, examiners blinded to case status. Analysis stratified by gender. No significant age difference in exposure groups. Logistic regression not performed for epicondylitis because of lack of significant trend with increasing exposure. Workers with hypertension, diabetes, history of traumatic injuries to upper limbs, arthritis, or collagen diseases excluded from study group. Physician observed cases had about ½ the prevalence of symptoms of elbow pain (9.8 vs. 18.0; 5.3 vs. 19.5; 35.7 vs. 17.9). No dose-response for elbow pain or physician observed epicondylitis.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Dimberg 1987	Cross-sectional	A questionnaire was distributed to every fifth person in the automobile company's personnel file selected by random numbers. Final sample consisted of 546 workers, 494 males and 52 females. (25 were excluded due to military service, pregnancy, or study away).	Outcome: Only workers reporting elbow problems were examined by the physician. Physical exam: case defined as physical findings of lateral elbow pain and pain with palpation over lateral epicondyle and pain increase with dorsiflexion of wrist with resistance. Exposure: Observation of the work site then categorization of jobs "with respect to elbow stress" by a Physical Work Stress Group composed of a physician, physiotherapist, and safety engineer. Table 2 in the article lists types of jobs with respect to subjects's elbow stress.	Lateral humeral epicondylitis among all subjects: 7.4% Blue collar workers: 5.3% White collar workers: 11% Blue collar: under age 40 years: 4.6% Blue collar: over age 40 years: 8.9% White collar: under age 40 years: 6.1% White collar: over age 40 years: 13.9%	õ	Epicondylitis, blue vs. white collar workers: 0.7 Distribution of epicondylitis cases by type of work stress: Leisure related epicondylitis: low work stress: 85%; medium work stress: 15%; high work stress: 0% No-known-cause group: epicondylitis: low work stress: 75%; medium work stress: 25%; high work stress: 0% Work-related epicondylitis: low work stress: 14%; medium work stress: 36%; high work stress: 50%	0.3-1.2	Participation rate: 98.9%. Physician blinded to exposure status: not reported. Results age stratified. Physician-consulted elbow pain significantly greater in jobs with increased elbow stress. Work considered to be the cause in 35%. Authors found that work-related group had work defined by high stress (categorized by low, moderate, and high) compared to leisure-related epicondylitis and epicondylitis of no-known-cause. Authors reported that proportion of workers who consulted a physician for their elbow problems was significantly greater with increasing elbow stress ($p < 0.05$). Multiple regression analyses included gender, employee category, age, and degree of stress as independent variables—only age significantly related to prevalence. Overexertion of the extensor muscles of the wrist due to gripping and twisting movements prior to onset was verified in 28 (70%) of those with epicondylitis. Tennis players among "sufferers": 15% total population: 12%. All racquet sports: 20% among sufferers, 15% among total population.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Dimberg et al. 1989	Cross-sectional	2,814 automotive workers, both blue- and white-collar workers: 2,423 males, 382 females.	Outcome: Questionnaire results of elbow trouble (pain, ache, discomfort) preventing normal work in last 12 months. Physical exam performed on 615 of 641 symptomatic workers. Epicondylitis: tenderness at the lateral/medial epicondyle and pain with resistance. Exposure: Observation of jobs, then classification into 3 Physical Work Stress Groups by physician, physiotherapist, and safety engineer. Guidelines for classification with respect to the strain on the subject's neck and upper extremities listed for light, moderately heavy, and heavy work included in article.	Blue collar	White collar	Univariate Results: $p<0.001$: higher age; longer time in present job; ponderal index, more symptoms; more mental stress at the onset of symptoms. $p<0.05$: salaried staff vs. others; heavy weight; less racquet sports, more symptoms. $p<0.01$: vibrating hand tools, more symptoms; time in present job, more symptoms. $p>0.05$: gender; strain group; full time; hrs/week; piece-work; fixed pay; smoking, house-owner.		Participation rate: 96%. Not stated whether examiner blinded to exposure status. Multivariate analysis performed, although the confounders controlled for were not stated by authors, nor were ORs presented. Vibrating tools, ponderal index, and mental stress at work listed as significant. Guidelines for classification of jobs as listed in the article do not seem to reflect increasing elbow stress. Group 1 includes "repeated rotation of the forearms and wrists occurs sporadically"; Group 2 includes less specifically "large and frequent rotations in extreme positions"; Group 3 does not include any reference to repeated rotation or extreme position of the forearms or wrists. The classification used seems unlikely to pick up increased elbow stress that would reflect higher strain and risk of epicondylitis. Increased ponderal index correlated with elbow symptoms in multivariate analysis. Mental stress at work with the onset of symptoms correlated with right-sided lateral epicondylitis. Mental stress variables not uniformly collected, so this may impact interpretation.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	95% CI	Comments
Fishbein et al. 1988	Cross-sectional (mailed survey)	2212 musicians performing on a regular basis with one or more of the International Conference of Symphony and Opera Musicians (ICSOM). Total population of the membership was 4,025 musicians in 48 ICSOM orchestras. One orchestra did not participate.	Outcome: Outcome based on self-reported responses from survey. Self-reported elbow pain, with severity defined in terms of the effect of the problem on the musician's performance. Exposure: Questionnaire responses to orchestral instrument, age they began playing, age they joined the orchestra, number of weeks each year spent playing professionally.	10% right elbow: 6 % severe 8% left elbow: 4% severe	õ	Severe medical problem and its affect on performance, females vs. males: OR=2.04	1.6-2.6	Participation rate: 55%. Low response rate due to the fact that many orchestras were not in season at the time of the survey. Statistical weighting performed; "severe" pain was defined as pain that affects performance. Health habits, such as extent of exercise, use of cigarettes, alcohol, beta blockers, and other drugs. Average age beginning playing instrument is 10 years. Average age joining a professional orchestra is 23 years. Average age: male musicians–43 years, female musicians–40 years. Severe problems were more likely in ages under 35 than over 45 years. Authors speculated that musicians with severe problems leave the orchestra. Low participation rate limits interpretation.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hales et al. 1994	Cross-sectional	518 telecommunication workers (416 females and 117 males). Workers fulfilling outcome definition compared to those not fulfilling outcome definition.	Outcome: Pain, aching, stiffness, burning, numbness, or tingling >1 week or >12 times a year; occurring after employment on current job within the last year and positive physical examination (PE): Moderate to worst pain experienced with medial or lateral epicondyle palpation. Exposure: Assessed by questionnaire. Questions addressed number of overtime hr, co-worker use of same workstation, task rotation, hr spent at the (VDT) workstation, hr spent typing, number and types of work breaks, length of time sitting, frequency of arising from a chair, number of keystrokes estimated for each directory assistance operator.	7%	õ	Fear of being replaced by computers: OR=2.9 Lack of decision-making opportunities: OR=2.8 Surges in workload: OR=2.4 Race (non-white) OR=2.4	1.4-6.1 1.4-5.7 1.2-5.0 1.2-5.0	Participation rate: 93%. ORs for psychosocial represent risk at scores one standard deviation (SD) above the mean compared to risk at scores one SD below mean. May be a problem with non-normal distribution. Analysis controlled for age, gender, individual factors, and number of keystrokes/day. Physician examiners blinded to case and exposure status. Although keystrokes/day was not significant–workers only typed average of 8 words/min over 8-hr period. 97% of workers "used" VDTs $ 6 hr/day–not enough variance to adequately evaluate hr typing. Number of hr on hobbies and recreation not significant. Over 70 variables analyzed in models–may have multiple comparison problem.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hoekstra et al. 1994	Cross-sectional	108 of 114 teleservice representatives working at 2 government administration centers: A and B.	Outcome: Self administered questionnaire. Case defined as the presence of pain, numbness, tingling, aching, stiffness, or burning in the elbow region as previous non-occupational injury; symptoms began after starting the job, last > 1 week or occurred once a month within the past year; reported as “moderate” (3) or greater on a 5-point scale. Exposure: Measurement and evaluation of work station; observation of postures to provide descriptive differences between the two locations.	Center A Center B	19% 21%	"Non-optimally" adjusted chair: 4.0	õ 1.2-13.1	Participation rate: 95%. Analysis controlled for gender. Interactions evaluated. Variables considered in logistic model included location, age, seniority, hr spent typing at VDT, hr on the phone, 3 chair variables: (1) Perceived adequacy of chair adjustment, VDT screen, (2) Perceived adequacy of keyboard adjustment, VDT screen, (3) Perceived adequacy of desk adjustment, job control, workload variability. Linear regression also performed on psychosocial variables in separate models for job dissatisfaction and exhaustion. Center B generally had nonadjustable chairs and work stations. Authors noted elevated arms, hunched shoulders and other "undesirable" postures. Did not include non-work-related variables in analyses.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	95% CI	Comments
Hughes and Silverstein 1997	Cross-sectional	104 male aluminum smelter workers: 62 carbon setters, 36 crane operators, 9 carbon plant workers. There were 14 workers who were not from selected jobs and were excluded.	Outcome: Symptoms occurring in the elbow/forearm > once/month or lasting longer than one week in the previous year, no acute or traumatic onset; occurrence since working at the plant, no systemic disease. Physical examination: Active, passive, and resisted motions, pinch and grip strength, 128 Hz vibration sensitivity, two-point discrimination. Psychosocial scales from questionnaire based on Theorell and Karasek Job Stress Questionnaire, and on Work Apgar Questionnaire. Exposure: For carbon setters and crane operators (non-repetitive jobs) a modified job-surveillance checklist method was used. Job task analysis used a formula based on the relative frequency of occurrence of postures during (a) task(s).	11.6% with positive symptoms and physical exam 24% had symptoms in the elbow/forearm in the previous week	õ	Model based on MSD defined by symptoms and physical exam Age: OR=0.96 Low decision latitude: OR=3.5 Years of forearm twist: OR=37 Model based on MSD defined by symptoms Age: OR=0.96 Years of ulnar deviation: OR=0.005 Years forearm twist: OR=4	 0.9-1.2 0.6-19 3.0-470 0.9-1.2 0.0-16 0.18- 4	Participation rate: Carbon setters: 65%; crane operators: 56%; carbon plant: 33%. Examiners blinded to exposure and health status: not stated. Analysis controlled for age, smoking status, sports, and/or hobbies. Psychosocial data collected individually; physical factors based on estimates of each job. Job risk factors entered into the model for hand/wrist included: (1) the number of years handling > 2.7 kg/hand, (2) push/pull, (3) lift/carry, (4) pinching, (5) wrist flexion/extension, (6) ulnar deviation, and (7) forearm twisting. Health interview included information about metabolic diseases, acute traumatic injuries, smoking, hobbies. Low participation rate limits interpretation.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kopf et al. 1988	Cross-sectional	Bricklayers (n=163) compared to other manual workers (n=144) employed by state agencies in Hamburg, Germany.	Outcome: Questionnaire based, self-reported symptoms. Self-reported pain in the elbow. Exposure: Based on job categories, bricklayer vs. other manual laborers. Physical stress of bricklayers described as lifting and carrying bricks weighing 5 to 24 kg up to 100 times/hr with the left hand and handling the bricklayer's trowel with the right hand.	Not reported	Not reported	Painful left elbow, bricklayers vs. other manual workers: OR=2.8	Not reported	Participation rate: bricklayers: 65%, manual workers: 69%. Controlled for confounders: age, job satisfaction, job security, vibration, moistness, Scheuerman's disease. Karasek's model of job latitude and job demands were included in the questionnaire. Physically demanding previous tasks, medical disposition for MSD, being a member of a trade union included in analysis. 64% attributable risk proportion of elbow pain is explained by being a bricklayer. For increasing levels of job demands (heavy physical work, awkward working positions, repetitive movements, and restriction in standing position), OR increased from 1.8 to 3.4.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kurppa et al. 1991	Cohort; 31 month follow-up	Sausage makers (107 females) compared to nonstrenuous jobs (197 females). Meatcutters (102 males) compared to nonstrenuous jobs (n=141). Packers (118 females) compared to nonstrenuous jobs (197 females).	Outcome: Tenderness to palpation of the epicondyle and epicondylar pain provoked by resisted extension or flexion of the wrist and fingers with the elbow extended. Incidence based on visits to doctor during 31 month visit. Disease considered "new" episode if new sick leave with same diagnosis occurred at same anatomic site within 60 days after end of former sick leave. Exposure: Data obtained from “previous published literature” and walkthrough. “Cutting of veal (appx. 1,200 kg/day) or pork (appx. 3,000 kg/day) (meatcutters); spraying the sausages and hanging them on bars (sausage makers); peeling sausages, inserting them into slicing machine, setting the slices into packages, setting packages on a conveyor belt, collecting finished packages into bags; room temperature 8E to 10E (packers); nonstrenuous tasks included primarily office work.”	Sausage makers (females): 11.1 cases/100 person-years Meatcutters (males): 6.4 cases/100 person-years Packers (males): 7.0 cases/100 person-years	Workers in Non-strenuous jobs: 1.1 cases /100 person-years Workers in non-strenuous jobs: 0.9 cases/100 person-years Workers in Nonstrenu-ous jobs: 1.1 cases/100 person-years	IR of males in strenuous jobs vs. nonstrenuous jobs: 5.7 IR of females in strenuous jobs vs. nonstrenuous jobs: 8.1 IR of total number of cases of epicondylitis in strenuous jobs vs. nonstrenuous jobs: 6.7	3.3-13.9	Participation rate: 93% of strenuous workers retained during study; 90% of nonstrenuous workers. Examiners blinded to exposure or past episodes: not reported. Diagnoses made by different physicians at different locations. Plant physicians agreed to the diagnostic criteria and made 75% of diagnoses. 25% of physicians were not involved in agreement of diagnostic criteria. 13% of epicondylitis diagnosed by consulting specialists at the nearby medical center, 12% elsewhere, usually at municipal health centers. No adjustment for confounders, but referent group selected similar to strenuous group with regards to age, gender, and duration of employment, except for male sausage makers and male packers who were younger than the rest of the study population–these were excluded from calculations of incidence rates. “New" episode of epicondylitis may be recurrence of same disease. 12 employees reafflicted with epicondylitis with median of 184 days between episodes. There were 68 diagnoses of epicondylitis among 57 individuals.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Luopajärvi et al. 1979	Cross-sectional	Female assembly line workers (n=152) compared to female shop assistants in a department store (n=133). Cashiers excluded from comparison group.	Outcome: Epicondylitis diagnosed by interview and physical exam. Symptoms include muscle pain during effort, local swelling, and local ache at rest. Signs include tenderness at the ateral or medial epicondyle on palpation, pain during resisted extension/flexion of the wrist and fingers with the elbow extended. Physiotherapist examined workers, diagnoses were from pre-determined criteria (Waris 1979). In problem cases orthopedic and physiatric teams handled cases. Exposure: Exposure to repetitive work, awkward hand/arm postures, and static work assessed by observation, video analysis and interviews. Video recordings showed repetitive motins of the hands and fingers up to 25,000 cycles/day, static muscle loading of the forearm muscles, and deviations of the wrist, lifting.	5.9%	2.3%	2.7	0.66-15.9	Participation rate: 84%. Workers excluded from participation for previous trauma, arthritis and other pathologies. Examiner blinded to case status: yes, according to the Waris et al. 1979, epidemiologic screening procedure, which was used in study. No association between age and MSDs or length of employment and MSDs. Gender not an issue because study population was all female. Factory opened only short time so no association between duration of employment and MSDs possible. Social background, hobbies, amount of housework not significant.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
McCormack et al. 1990	Cross-sectional	Randomly selected population of 2,261 textile workers from 8,539 eligible workers; 4 groups compared with 468 non-office workers Manufacturing workers: A. Packaging/folding workers (41 males, 238 females). B. Sewing workers (28 males, 534 females). C. Non-office workers (204 males, 264 females). D. Boarding workers (19 males, 277 females).	Outcome: Based on physician administered physical exams. Reproducible tenderness with direct pressure on the lateral epicondyle. Severity graded as mild, moderate, and severe. Exposure: Assessment by observation of jobs. Exposure to repetitive finger, wrist and elbow motions assumed from job title; no objective measurements performed.	Boarding workers: 1.0% Sewing workers: 2.1% Packaging/ folding workers: 2.2% Knitting: 1.4%	Non-office workers: 1.9%	Boarding vs. non-office: OR=0.5 Sewing vs. non-office: OR=1.1 Packaging vs. non-office: OR=1.1 Knitting vs. non-office: OR=1.2	0.09-2.1 0.4-2.9 0.4-3.2 0.5-3.4	Participation rate: 91%. Physician or nurse examiners not blinded to case or exposure status (personal communication). Age, gender, race, and years of employment analyzed. Prevalence higher in workers with < 3 years of employment. Questionnaire asked types of jobs, length of time on job, production rate, nature and type of upper extremity complaint, and general health history. 11 physician examiners; interexaminer reliability potential problem acknowledged by authors. Epicondylitis significantly associated with years of employment, age, race. Job category not related to epicondylitis, however no measurement of force, repetition, posture analysis, etc. Of 37 cases of epicondylitis identified: 13 were categorized as mild, 22 were moderate, and 2 were severe.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Moore and Garg 1994	Cross-sectional	Workers employed in 32 jobs at a pork processing plant (n=230). Workers in jobs classified as "hazardous" compared to those in "safe" jobs.	Outcome: OSHA logs verified by medical records data for 20 months. Epicondylitis: localized elbow pain that increased with tension of muscle-tendon unit and direct palpation. A case required that a physical examination specific to epicondylitis was performed. Exposure: Observation and video analysis, semi-quantitative methods using motion and time methods (MTM), force estimated as % maximal strength (5 levels), wrist posture (3 levels), type of grasp (2 levels), high speed work (yes or no), localized mechanical compression (yes or no), vibration (yes or no), and cold (yes or no). Observed videotaped representative worker in each job. Repetition as cycle-time and exertions/min measures. Jobs classified as "hazardous" or "safe" based on data, experience of authors, and judgements. Work histories, demographic, pre-existing morbidity data not collected on each participant.	Workers in "hazardous jobs": 23%	Workers in "safe jobs": 3%	Odds of epicondylitis in workers in "hazardous jobs" compared to workers in "safe jobs": OR=5.5 (based on personal communi-cation)	1.5-62	Participation rate: Cases identified from medical records. Jobs analyzed from observational methods. Investigators blinded to exposure, case outcome status, and personal identifiers on medical records. Repetitiveness and "type of grasp" were not significant factors between hazardous- and safe-job categories. No pattern of morbidity according to date of clinic visits. Strength demands significantly greater for hazardous job categories compared to safe. IR based on full-time equivalents and not individual workers, may have influenced overall results. Workers had a maximum of 32 months of exposure at plant–duration of employment analysis limited. Duration of exposure not collected on study sample. Average maximal strength derived from population-based data stratified for age, gender, and hand dominance. Using estimates of Silverstein's classification, association between forcefulness, and overall observed morbidity was statistically significant; repetition was not. 31 of 32 jobs were in high repetitive category–no variance to find difference.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	RR, OR, or PRR	95% CI	Comments
Ohlsson et al. 1989	Cross-sectional	Electrical equipment and automobile assemblers (n=148), former female assembly workers who quit within 4 years (n=76) compared to randomly sampled females from general population (n=60).	Outcome: Questionnaire: Any elbow pain, elbow pain affecting work ability, and elbow pain in the last seven days and the last 12 months. Exposure: No exposure measurements; based on job categorization. Work pace divided into 4 classes: (1) Slow <100 items/hr; (2) Medium 100 to 199 items/hr; (3) Fast 200 to 700 items/hr; (4) Very Fast >700 items/hr.	Elbow pain in last 12 months: 21% Elbow pain in last 7 days: 14% Work inability in last 12 months: 10%	Elbow pain in last 12 months: 17% Elbow pain in last 7 days: 11% Work inability in last 12 months: 3%	1.5 1.9 2.8	0.6-3.4 0.7-5.3 0.8-10.7	Participation rate: Not reported. Work pace assessed by questionnaire, the number of items completed/hr. No association between length of employment and elbow symptoms. No statistical significance associated with work pace (data not present). Logistic models evaluated for interaction and controlled for age. Study group consisted of females only.

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Punnett et al. 1985	Cross-sectional	162 female garment workers, 85% were employed as sewing machine operators and sewing and trimming by hand. Comparison: 76 of 190 full or part-time workers on day shift in a hospital who worked as nurses or aids; lab technicians or therapists; food service workers. Employees typing >4 hr/day excluded from comparison group.	Outcome: Self-administered questionnaire concerning symptoms Cases defined as the presences of persistent elbow pain, numbness or tingling (lasted for most days for one month or more within the past year); were not associated with previous injury; and, began after first employment in garment manufacturing or hospital employment. Key questions based on the arthritis supplement questionnaire of National Health and Nutrition Examination Survey (NHANES). Exposure: Self-administered questionnaire; # of years in the industry, job category, previous work history.	Garment workers: 6.5%	Hospital employees: 2.8%	Elbow Symptoms in Garment workers vs. Hospital employees: OR= 2.4 Persistent elbow pain in finishers vs. hospital employees: OR=5.6 Persistent elbow pain in underpresser vs. hospital employees: OR=5.0	1.2-4.2	Participation rate: 97% (garment workers), 40% (hospital workers). Analysis stratified for number of years employed, decade of age, native language. Health outcome based on symptoms alone for elbow MSDs. Age and length of employment not a predictor of risk of elbow MSDs. Prevalence of pain not associated with years of employment in garment workers. Non-English speakers significantly less likely to report pain (RR 0.6 ; $p<0.05$). Native English speakers significantly older than non-native English speakers ($p<0.03$).

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Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ritz 1995	Cross-sectional	290 males from the public gas and water works of Hamburg, Germany examined during routine medical check-up at the company occupational health center. Employees, excluded if on sick leave, came for medical treatment, pre-employment checkups, or to file a worker's compensation claim.	Outcome: Physician diagnosed; required local tenderness to palpation at the epicondyle and pain during resisted movement of the wrist and fingers (extension or flexion of the wrist or fingers with an extended elbow) AND elbow pain during the lifting of a chair. Epicondylitis was categorized as severe (Grade II and Grade III) if both functional tests were positive and as moderate (Grade I) if only symptom was a severe tenderness to palpation or a moderate pain in the resistance test. Clinical signs of epicondylitis > Grade 0 at one or more of the four anatomical sites was considered sufficient for the diagnosis. Exposure: All current and former job titles evaluated by members of the team according to possible bio-mechanical strain to the elbow and grouped into categories of high, moderate, and non work-related exposure. Exposure categorization was based on company job descriptions, interviews with employees, and workplace observations. Exposure duration was defined for all subjects as the	41 employees: 14% had epicondylitis 11% fulfilled Waris's criteria for epicondylitis (Waris, 1979)		10 years of high exposure to elbow straining work for currently held job: OR=1.7 High exposure to elbow straining work for formerly held job: OR= 2.16 10 years of high exposure to elbow straining work for currently held job using diagnostic criteria for epicondylitis [Waris et al. 1979]: OR=1.89	1.0-2.7 1.1-4.3 1.2-3.1	Participation rate: Not reported. Examiner blinded to exposure status. Logistic regression model controlled for age, age-squared, and an indicator term for "history of cervical spine symptoms" (yes, no). The following variables tested for confounding: having ever played tennis, squash, other racquet sports, rowing, bowling, the duration of having played these sports, injuries involving the elbow joint, ponderal index, handedness, and former surgical treatment for epicondylitis. The variable "time in years since retiring from a job with high or moderate exposure" was retained in the model for workers formerly employed in high exposure jobs when duration of exposure was tricotomized. Mean length of employment was not significantly different between cases and non-cases. Increasing duration of current exposure increased the risk of being diagnosed with epicondylitis.

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Roto and Kivi 1984	Cross-sectional	Meatcutters, (n=90) compared to construction workers (n=72) not exposed to repetitive movements.	Outcome: Defined by physical exam: local tenderness, pain during resisted extension/flexion of the wrist and fingers, and decreased hand grip power in comparison to other hand. Exposure: Based on job title (meatcutter vs. construction worker).	Meatcutters: 8.9%	Construction workers: 1.4%	6.4	0.99-40.9 $p = 0.05$	Participation rate: 100% for meat cutters, 94% for construction workers. Authors state that examiners were blinded to occupation of subjects because part of larger group of meat processing workers examined, but it is unclear whether construction foremen (referents) were examined separately. Serologic testing for rheumatoid arthritis was done to control for potential confounding (none detected). 7 additional meatcutters had local tenderness in epicondylar region. All with epicondylitis had > 15 years of employment. Authors stated that on average, meatcutters with epicondylitis had been exposed five years longer than other meatcutters, supporting the association with meatcutting.

(Continued)

Table 4–5 (Continued). Epidemiologic studies evaluating elbow musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Viikari-Juntura 1991b	Cross-sectional	All permanent workers exposed to repetitive and manually stressful tasks in a meatpacking plant (102 meatcutters, 150 packers, and 125 sausage makers) were compared to 332 workers in nonstrenuous jobs (supervisors, maintenance men, accountants, and office workers).	Outcome: Elbow trouble (pain, ache, discomfort) preventing normal work in last 12 months and physical exam: tenderness at the lateral/medial epicondyle and pain with resistance. Exposure: Based on observation: Meatcutters: High force/high repetition. Sausage makers: High repetition/low force with high force tasks. Packers: High repetition/low force with high force jobs. Nonstrenuous jobs, mainly office jobs. “Cutting of veal (appx. 1,200 kg/day) or pork (appx. 3,000 kg/day) (meatcutters); spraying the sausages and hanging them on bars (sausage makers); peeling sausages, inserting them into slicing machine, setting the slices into packages, setting packages on a conveyor belt, collecting finished packages into bags; room temperature 8E to 10E (packers); nonstrenuous tasks included primarily office work.”	Epicondylitis: 0.8% Lateral: 0.6% Medial: 0.2%	Epicondylitis: 0.8% Lateral: 0.6% Medial: 0.3%	The Odds Ratio of epicondylitis in strenuous jobs vs. non-strenuous jobs: 0.88 Elbow Pain (without the physical exam): Male: 1.8 Female: 1.6	0.27-2.8 1.1-2.8 1.2-2.3	Participation rate: 94%. No adjustment for confounders in analysis. Authors stated that the comparison group was selected similar to the study group to sex, age, and duration of employment. Examiners blinded to case and exposure status. Male packers and male sausage makers younger and length of employment shorter than other groups. Palpation pressure increased on 2nd of cross-sectional examinations–may have influenced results. For female sausage makers, elbow pain for preceding 12 months increased with age and duration of employment. No such associations in other groups. Age and current occupational correlated (r=0.52) for female sausage makers. Cases were not excluded due to direct trauma.