CHAPTER 3
Shoulder Musculoskeletal Disorders: Evidence for Work-Relatedness

SUMMARY

There are over 20 epidemiologic studies that have examined workplace factors and their relationship to shoulder musculoskeletal disorders (MSDs). These studies generally compared workers in jobs with higher levels of exposure to workers with lower levels of exposure, following observation or measurement of job characteristics. 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 **evidence** for a positive association between highly repetitive work and shoulder MSDs. The evidence has important limitations. Only three studies specifically address the health outcome of shoulder tendinitis and these studies involve combined exposure to repetition with awkward shoulder postures or static shoulder loads. The other six studies with significant positive associations dealt primarily with symptoms. There is **insufficient evidence** for a positive association between force and shoulder MSDs based on currently available epidemiologic studies. There is **evidence** for a relationship between repeated or sustained shoulder postures with greater than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for specific shoulder postures is strongest where there is combined exposure to several physical factors like holding a tool while working overhead. The association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a constellation of symptoms and physical findings consistent with tendinitis, as the health outcome. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and symptoms or a specific shoulder disorder. This is consistent with the evidence that is found in the biomechanical, physiological, and psychosocial literature.

There is **insufficient evidence** for a positive association between vibration and shoulder MSDs based on currently available epidemiologic studies.

INTRODUCTION

Shoulder MSDs and their relationship to work risk factors have been reviewed by several authors [Hagberg and Wegman 1987; Kuorinka and Forcier 1995; Sommerich et al. 1993; Winkel and Westgaard 1992]. Hagberg and Wegman [1987] attributed a majority of shoulder problems occurring in a variety of occupations to workplace exposure. Kuorinka and Forcier [1995] looked specifically at shoulder tendinitis and stated that the epidemiologic literature is "most convincing" regarding work-relatedness, especially showing an increased risk for overhead and repetitive work.

The focus of this review is to assess evidence for a relationship between shoulder tendinitis and workplace exposures to the following: awkward postures, forceful exertions, repetitive exertions, and segmental vibration. Also included are studies relevant to shoulder disorders—as defined by a combination of symptoms and physical examination findings or by symptoms alone, but not specifically defined as tendinitis—and those studies for which the health outcome combined neck and shoulder disorders, but where the exposure was likely to have been specific to the shoulder. Chapter 2 discusses studies involving neck-shoulder disorders where assessment of exposure was likely specific to the neck region.

Pertinent information about the 39 reviewed studies is presented in several ways. Detailed descriptions of the studies are provided in Table 3-5. The text of this section on shoulders is organized by exposure risk factor. The discussion within each risk factor is organized according to criteria presented on Pages 1-1 to 1-10 of the Introduction. Conclusions are presented with respect to the specific MSD of concern, shoulder tendinitis.

REPETITION

Definition of Repetition for Shoulder MSDs

Studies that addressed the physical factor of repetition and its relation to shoulder MSDs were included in this review. Studies usually defined repetition, or repetitive work, for the shoulder as work activities that involved cyclical flexion, extension, abduction, or rotation of the shoulder joint. Repetitiveness was defined in four different ways in the reviewed studies: (1) the observed frequency of movements past pre-defined angles of shoulder flexion or abduction, (2) the number of pieces handled per time unit, (3) short cycle time/repeated tasks within cycle, and (4) a descriptive characterization of repetitive work or repetitive arm movements. Some of the studies that examined repetition as a risk factor for shoulder MSDs had several concurrent or interacting physical work load factors. Therefore, repetitive work should not be considered the primary exposure factor, particularly independent of posture. Some studies indirectly inferred shoulder repetition by characterizing hand, wrist, and forearm movements.

Studies Reporting on the Association of Repetition and Shoulder MSDs

Three of the reviewed studies reported results on the association between repetition and shoulder tendinitis [English et al. 1995; Ohlsson et al. 1994, 1995]. For all three studies, some or all of the results were for associations with a combined exposure to repetition and awkward posture. Six additional studies reported results on the association between repetition and non-specific shoulder disorders [Sakakibara et al. 1995], non-specific shoulder symptoms [Andersen and Gaardboe 1993a; Ohlsson et al. 1989], combined neck-shoulder disorders [Bjelle et al. 1981; Chiang et al. 1993] or combined neck-shoulder symptoms [Kilbom et al. 1986; Kilbom and Persson 1987].

Studies Meeting the Four Evaluation Criteria

Four studies met all four of the criteria [Chiang et al. 1993; Kilbom et al. 1986; Ohlsson et al. 1994, 1995] (Table 3-1, Figure 3-1). Chiang et al. [1993] studied workers in the fish processing industry in Taiwan. The health outcome of "shoulder girdle pain" was defined as self-assessed symptoms of pain in the neck, shoulder or upper arms, and signs of muscle tender points or palpable hardenings upon physical examination. Pain referred from a nerve root or other spinal source was included in the case definition. The force requirements of the jobs were estimated by surface electromyographs (EMGs) in the forearm flexor muscles. This is not a direct measure of shoulder muscle activity. There may be no relationship between the level of activity in the forearm and shoulder girdle muscles. Three categories, based on both force and repetitiveness, were used as the exposure outcome: Group I (low force, low repetitiveness), Group II (high force or high repetitiveness), and Group III (high force and high repetitiveness). Force was also evaluated independently in multivariate analyses.

Kilbom et al. [1986] performed a prospective study in which female employees in the electronics manufacturing industry were observed for a 2-year period. The health outcome in the neck, shoulder, or arm regions was based on symptoms and physical findings. Symptom severity was coded on the basis of its character, frequency, and/or duration. Changes in severity status at follow-up evaluations were used as the dependent variables in multiple regression analyses. Neck, shoulder, and upper arm posture was determined by VIRA. Although the health outcome combined symptoms from different body regions, knowledge of biomechanical theory can be used to identify significant predictors related to the shoulder symptom severity.

For the two Ohlsson et al. [1994, 1995] studies, the authors reported that the examiners could not be completely blinded to exposed versus referent status, but that a standard protocol was followed and observer bias was likely to have been minimal. As examiners were blinded to objective exposure measures, analyses testing associations between neck-shoulder disorders and specific postures would not have been biased [Ohlsson et al. 1995].

In the first of the Ohlsson et al. studies, a cross-sectional study, women in the fish industry were compared to a control population of women employed in municipal workplaces in the same towns [Ohlsson et al. 1994]. Diagnoses of shoulder disorders (e.g., tendinitis, acromioclavicular syndrome, frozen shoulder) were made on the basis of symptoms determined by interview and a physical exam. Exposure evaluation of each work task held by the fish industry population was evaluated with ergonomic workplace analysis (EWA). Ten different factors were rated on a scale from 1 to 5 and the combined ratings were used as a profile of the work task. Based on this profile, the authors reported that fish industry work was found to be “highly repetitive” and to include “poor work postures.”

Ohlsson et al. [1995] compared a group of women who performed industrial assembly work to a referent group of women from a nearby town who were employed in jobs characterized as having varied and mobile work tasks. One examiner assessed signs and symptoms. The examiner was blinded to specific exposure information, but not completely blinded to factory worker versus referent group status. Shoulder tendinitis included supraspinatus, infraspinatus, and bicipital tendinitis. Another health outcome combined neck and shoulder disorders (tension neck, cervical syndrome, thoracic outlet syndrome, frozen shoulder, tendinitis, acromioclavicular syndrome). In a descriptive assessment, it was reported that the work tasks in the study group involved repetitive arm movements with static muscular work of the neck and shoulder muscles. The percentage of time spent in specific upper arm postures was determined from videotaped observation of 74 (out of 82) workers. The average result from two independent videotape analyses was used. Posture category demarcations included 0, 30, and 60 degrees for arm elevation, and 30, 60, and 90 degrees for arm abduction.

Studies Not Meeting the Four Evaluation Criteria

Bjelle et al. [1981] compared cases with acute, non-traumatic shoulder-neck pain to age- and sex-matched, paired controls. To determine exposure, each case and control was filmed and a biomechanical analysis was performed to determine the frequency and duration of shoulder abduction or forward flexion > than 60 degrees.

In the study by English et al. [1995], cases were determined by medical diagnosis and controls were selected from patients evaluated at specified orthopedic clinics. For statistical analyses, all diagnoses were grouped by anatomical site. The diagnoses for shoulder cases were rotator cuff injury, rupture of long head of biceps, shoulder capsulitis, and symptomatic acromioclavicular arthritis. It is assumed that shoulder tendinitis is included in this group. Exposure measures were determined by a standardized interview conducted by an interviewer who was "unaware of the case-control status of the individual wherever this was possible."

In a study by Sakakibara et al. [1995], the health status of a group of women farm workers was assessed during the performance of two different tasks, with a 1-month interval between the tasks. The health outcome was defined by self-assessed symptoms of shoulder stiffness and pain and a physical examination for muscle tenderness and joint pain on movement. Whether the examining physician was aware of the prior hypothesis regarding differing exposures between the two tasks (bagging pears versus bagging apples) was not stated. Exposure was based on self-report of the number of hours per day spent bagging, the number of pears or apples bagged per day, and the total number of days spent bagging each fruit. One worker was observed for 3 hours while performing each bagging job, with repeated goniometric measures of shoulder forward flexion angles done each minute. While there was no difference in the total number of days or number of hours per day spent bagging each fruit, significantly more pears than apples were bagged per day. The proportion of time spent with the angle of shoulder forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%).

One study did not meet any of the criteria. In a cross-sectional study by Ohlsson et al. [1989], the exposed population was factory employees who produced and assembled plastic components. Work exposure was characterized as "repetitive arm and hand movements in constrained work postures." The referent population was composed of women randomly sampled from the general population in a nearby area. The health outcome was determined by self-reported symptoms of shoulder pain during the previous seven days. The exposure measure was the self-reported number of items completed per hour. The range was from less than 100 items completed per hour (slow category) to more than 700 items per hour (very fast category). Self-reporting was believed to be accurate because workers were paid by the piece.

Strength of Association: Repetition and Shoulder MSDs

Using the data presented in the study by Ohlsson et al. [1994], for supraspinatus, infraspinatus, or bicipital tendinitis the odds ratio (OR) for working in the fish industry (repetitive work, poor posture) was calculated as 3.03 (95% CI 2.5–7.2). For shoulder tendinitis alone, the PRR was calculated as 3.5 (95% CI 2.0–5.9). For clinical diagnoses of the neck and shoulder, the OR for working in the fish industry versus the referent population was 3.2 (95% CI 2.0–5.3).

Using data presented in the study by Ohlsson et al. [1995] for supraspinatus, infraspinatus, or bicipital tendinitis, the OR for being an assembly worker (repetitive arm movements with static load on shoulders) versus the referent population was 4.2 (95% CI 1.35–13.2). For neck-shoulder disorders, the OR for being an assembly worker versus the referent group was 5.0 (95% CI 2.2–11.0).

Using multiple logistic regression analysis with age, gender, and force as covariates, Chiang et al. [1993] found that highly repetitive upper extremity movements were associated with shoulder girdle pain (OR 1.6, 95% CI 1.1–2.5). When tested in the same model with force and repetition, the interaction term for force and repetition was also significant (OR 1.4, 95% CI 1.0–2.0). Several factors could have resulted in an underestimation of the strength of association: no requirement that symptoms had begun on current job means that some symptomatic workers may have transferred to lower risk jobs. Relative to shoulder MSDs, the major limitation of this study was that the exposure assessment was not specific to movement at the shoulder joint and may therefore have either over- or underestimated repetition at the shoulder. In some cases the exposure assessment may have been a measure of repetitive upper arm movements, but it may also have been a measure of repetitive hand and distal upper extremity activity occurring in the context of a static load on the shoulder muscles.

For the shoulder diagnoses used to form their group of cases, English et al. [1995] found an association with repeated shoulder rotation with an elevated arm (OR 2.30, $p < 0.05$). They also found what appeared to be a protective effect associated with elbow flexion (OR 0.4, 95% CI 0.2–0.8). This effect was greatest at low amounts of daily cumulative exposure to elbow flexion; the protective effect decreased (RR increased) as the number of hours of total daily elbow flexion increased. In a laboratory study of shoulder muscle activity in relation to different combinations of shoulder and elbow joint postures (a total of 21 different postures), Herberts et al. [1984] found that humeral rotation and elbow flexion had insignificant effects on shoulder muscle activity. However, the postures tested by that study were stationary, whereas the associations reported by English et al. [1995] appear to be related to repetitive movements.

For symptoms of shoulder pain within the previous 7 days, the OR for assembly workers versus the referent group was 3.4 (95% CI 1.6–7.1) [Ohlsson et al. 1989]. A significantly higher proportion of the farm workers studied by Sakakibara et al. [1995]

had signs of shoulder muscle tenderness while bagging pears than while bagging apples. There was no way to analyze the relative contribution to risk of repetitive shoulder exertions (increased number of pears picked per day) and awkward posture (greater portion of each day spent with extreme forward flexion when picking pears).

Consistency of Association

Repetitiveness was defined in four different ways in the reviewed studies: (1) the observed frequency of movements past pre-defined angles of shoulder flexion or abduction, (2) the number of pieces handled per time unit, (3) short cycle time/repeated tasks within cycle, and (4) a descriptive characterization of repetitive work or repetitive arm movements.

Repetition Characterized as Frequency of Movements Past Pre-Defined Shoulder Angles

Bjelle et al. [1981] and Ohlsson et al. [1995] found a significant positive association between the prevalence of neck-shoulder disorders and the frequency of upper arm movements past 60 degrees of flexion or abduction. English et al. [1995] found a significant association between diagnosed cases of shoulder disorders and repeated shoulder rotation with an elevated arm posture.

Repetition Characterized as the Number of Pieces Handled per Time Unit

A significant positive association was found between both nonspecific shoulder symptoms [Ohlsson et al. 1989] and nonspecific shoulder disorders [Sakakibara et al. 1995] and the number of pieces handled per hour or per day.

Repetition Characterized as Short Cycle Time

Chiang et al. [1993] found a significant association between a very short or repetitive cycle (<30 seconds or >50% spent repeating same task) and shoulder girdle pain.

Repetition Characterized Descriptively

Three studies by Ohlsson et al. found a significantly higher proportion of shoulder MSDs in exposed populations with work characterized as involving repetitive arm and hand movements than in referent populations [Ohlsson et al. 1989, 1994, 1995].

Repetition Combined with Static Shoulder Load

Except for the study by Sakakibara et al. [1995], in which the increased number of pears bagged per day was associated with an increased proportion of the work day spent with extreme shoulder flexion, the studies using measures of piece work or repetitive arm movements as the exposure outcome did not specify which joints or body regions participated in the repetitive action. Ohlsson et al. [1995] described the assembly work performed by the exposed population as combining repetitive arm movements with a static shoulder load. It is possible that the association between piece work, short cycles, or repetitive hand-arm movements and shoulder disorders reported by the other authors is related to a sustained, static load on the shoulder muscles as the upper arm is stabilized in a posture of mild to severe flexion or abduction, while repetitive movements are performed by the hand-wrist-forearm.

Temporal Relationship

In the prospective study by Kilbom et al. 1986; Kilbom and Persson 1987; and Jonsson et al. 1988 the number of shoulder elevations per hour was a strong predictor for a change to severe status at the 1- and 2-year follow-up evaluations. Although the change in status included problems in the neck and arm, as well as the shoulder, it is reasonable to assume that repetitive shoulder elevations would have had the greatest effect on disorders of the shoulder.

Several studies with a cross-sectional design used techniques to determine whether the health outcome of interest had occurred since, or was present during, exposure to hypothesized risk factor(s) of interest. Case definitions which required a positive physical examination finding [Chiang et al. 1993; Ohlsson et al. 1994, 1995] or where symptoms had occurred within the recent past [Chiang et al. 1993; Ohlsson et al. 1989, 1994] were designed to focus on disorders most likely to have been caused or aggravated by current work exposures.

Exposure-Response Relationship

Chiang et al. [1993] found a significant increasing trend in the prevalence of shoulder girdle pain from Group I (low force, low repetitiveness) to Group III (high force, high repetitiveness). However, the health outcome was not specific to shoulder disorders, and the exposure categories combine increasing repetitiveness—as defined by either less than a 30-second cycle time or a repeated task within the job cycle—and increasing forearm flexor muscle activity. Ohlsson et al. [1995] found that neck and shoulder disorders among assembly workers were significantly associated ($p<0.05$) with both the number of arm elevation movements from less than to greater than 60 degrees and the number of arm abduction movements from less than to greater than 60 degrees. Bjelle et al. [1981] found that the frequency of shoulder abduction or forward flexion (past 60 degrees) was significantly greater ($p<0.005$) for cases with neck-shoulder disorders than for controls.

In the study of assembly workers by Ohlsson et al. [1989], the number of pieces completed per hour was categorized as follows: slow: <100, medium: 100–299, fast: 300–699, very fast: >700. In this study, the ORs are shown in a figure, rather than reported in the text. Compared with the slow-paced group, the odds for symptoms of shoulder pain is approximately seven times that for those workers in the medium-paced group and approximately nine times that for those in the fast-June 26, 1997 pace group. While adjusting for age and length of employment, the OR for shoulder pain was significantly higher for the medium- and fast-paced groups than for the slow-paced group ($p=0.0006$). The OR for the very fast-paced group compared to the slow-paced group was between 1.0 and 2.0 and was not significantly different from the slow-paced group. The authors hypothesized that symptomatic workers may have self-selected out of the very fast paced jobs or that other unknown factors may have mitigated the effects of work pace.

When comparing fish industry workers to the reference population, Ohlsson et al. [1994] found that among those workers younger than age 45, the ORs for disorders of the neck and shoulders were significantly elevated and increased with duration of employment [0–5 years, OR 3.2 (95% CI 1.5–7.0); >5 years, OR 10 (95% CI 4.5–24)]. In their study of assembly workers, Ohlsson et al. [1989] found a statistically significant increase in the odds for pain in the shoulder with duration of employment (p=0.03) which was dependent on age. The increase with duration of employment had a steeper slope for younger (<35 years) assembly workers than for the older subgroup (i.e., among those workers employed for short durations, older women had more symptoms, and among those workers employed for long durations, younger women had more symptoms). This was thought to be a reflection of both survivor bias as well as the possibility that older new hires may have experienced a relatively more rapid onset of symptomatic problems than do younger women.

Coherence of Evidence

Repetitive movements of the upper extremity involving flexion or abduction of the glenohumeral joint would increase the frequency of effects such as fatigue and tendon circulation disruption hypothesized to occur as a result of such postures. These effects could be magnified by the addition of a hand-held load. Repetition may also be solely related to the development of tendinitis. In a laboratory study, Hagberg [1981] induced acute shoulder tendinitis in female subjects performing repetitive shoulder elevations for one hour. Six female students, ages 18–29, all developed shoulder tenderness (two with tendinitis) when exposed to 15 shoulder flexions (from 0 to 90 degrees) per minute for 60 minutes while holding up to 3.1 kg (6.4 lb) of weight.

Some of the significant associations reported may have been related to exposure to repetitive work in the distal upper extremity while the shoulder and upper arm were maintained in a static posture [Chiang et al. 1993; Ohlsson et al. 1989, 1994, 1995]. Winkel and Westgaard [1992] have pointed out that, “It is not possible to use the arm/hand without stabilizing the rotator cuff girdle and the glenohumeral joint. Therefore, work tasks with a demand of continuous arm movements generate load patterns with a static load component.”

The finding that the supra- and infraspinatus muscles were particularly prone to fatigue when subjects performed overhead work led Herberts et al. [1984] to hypothesize that the rotator cuff muscles may develop high intramuscular pressures at relatively low contraction levels. These high intramuscular pressures could lead to an impairment of intramuscular circulation, which could contribute to the early onset of fatigue. Intramuscular pressure increases with the muscle contraction level, and impaired circulation has been demonstrated at levels of contraction as low as 10–20 percent of maximal voluntary contraction (MVC). [Hagberg 1984].

The increased pressure in rotator cuff muscles and increased pressure on the supraspinatus tendon may trigger two different events that are both related to impaired microcirculation. The impaired microcirculation in the tendon may also result from tension within the tendon produced by forceful muscle contractions [Rathburn and Macnab 1970]. An inflammatory infiltrate with increased vascularity and edema within the rotator cuff tendons, especially the supraspinatus tendon may be a result of or a contributor to the process. If the inflammation process is sufficiently intense, then shoulder tendinitis may occur. If the process is less intense, and more chronic, then it may contribute to a degenerative process in the tendons of the rotator cuff. In the muscles of the rotator cuff, the impaired microcirculation may lead to small areas of cell death. A reasonable hypothesis is that repeated or sustained episodes of muscle ischemia result in localized cell death and persistent inflammation.

Neither of these proposed models for shoulder muscle pain or tendinitis suggest that all muscle activity is potentially harmful. Both muscles and tendons are strengthened by repeated activity if there is sufficient recovery time. However, the models present plausible mechanisms by which work tasks with substantial shoulder abduction could contribute both to shoulder pain and tendinitis.

There is evidence of a relationship between shoulder tendinitis and highly repetitive work. However, there are several limitations to the evidence. In the three studies for which the health outcome was shoulder tendinitis, the exposure combined repetition with awkward shoulder posture and/or a static shoulder load [English et al. 1995; Ohlsson et al. 1994, 1995]. Five out of the eight studies reviewed used either nonspecific shoulder disorders, nonspecific shoulder symptoms or combined neck-shoulder disorders as the health outcome.

Despite the limitations of the evidence, significant and positive relationships between repetitiveness, regardless of the measurement method, and shoulder MSDs or symptoms were found in all studies. Of the eight studies in which the effect of repetition was examined, three studies found ORs above 3.0 [Ohlsson et al. 1989, 1994, 1995] and three studies found ORs from 1.0 to 3.0 [Chiang et al. 1993; English et al. 1995; Sakakibara et al. 1995]. The remaining studies were prospective studies [Jonsson et al. 1988; Kilbom and Persson 1987] or studies that reported risk indicators other than OR [Bjelle et al. 1981].

In none of these studies is it likely that age, the most important personal characteristic associated with shoulder tendinitis and other shoulder disorders, or nonoccupational factors such as sports activities, caring for young children, or hobbies explained these associations. There is evidence of a relationship between shoulder tendinitis and highly repetitive work.

FORCE

Definition of Force for Shoulder MSDs

Studies that examined force or forceful work or heavy loads to the shoulder, or described exposure as strenuous work involving the shoulder abduction, flexion, extension, or rotation that could generate loads to the shoulder region were also included. Most of the studies that examined force or forceful work as a risk factor for shoulder symptoms or tendinitis had several concurrent or interacting physical work load factors. However, there is still a need to summarize present knowledge about the relationships between forceful work and shoulder MSDs. This section summarizes that knowledge, while acknowledging that other factors can modify the response.

Neck-shoulder disorders are discussed in Chapter 2.

Studies Reporting on the Association of Force and Shoulder Tendinitis

There are five studies which reported results on the association between force and adverse shoulder health outcomes (Table 3–2, Figure 3–2). The epidemiologic studies that addressed forceful work and shoulder MSDs tended to compare 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 [Andersen and Gaardboe 1993a; Chiang et al. 1993] or in terms of overall load [Herberts et al. 1984; Stenlund et al. 1992; Wells et al. 1983].

Studies Meeting the Four Evaluation Criteria

Chiang et al. [1993] studied workers in the fish processing industry. (This study was described in detail in the section on shoulder MSDs and repetition.) Chiang et al. [1993] did not report an exposure specific to the shoulder.

Studies Not Meeting the Four Evaluation Criteria

Andersen and Gaardboe [1993a] performed a cross-sectional study in which a cohort of sewing machine operators was compared to a random sample of women in the general population of the same region. Chronic shoulder pain was defined as a having experienced a continuous pain episode lasting more than 1 month and either daily pain or pain lasting more than 30 days in the same location within the previous year (per self-administered questionnaire). In order to compare the current exposure of sewing machine operators and those in the control group, the authors' experience and knowledge of the jobs were used to assign job titles to exposure categories based on crude assessments of force and repetitiveness. High exposure was characterized as a combination of high repetitiveness (activity repeated several times per minute) and low or high force, or medium repetitiveness (activity repeated many times per hour) and high force. Medium exposure was characterized as medium repetitiveness and low force, or low repetitiveness (jobs with more variation) and high force. Those in teaching, academic, self-employed, or nursing professions were classified as low exposure. The exposure classification scheme in this study does not allow separation of the effects of force from those of repetition. More sewing machine operators than referents were considered to have high exposure (41% versus 15%), but more in the referent population were considered to be in the medium exposure group (44% versus 22%). Because the outcome of interest was duration of historical exposure, current exposure was included as an independent variable in multivariate regression analyses.

Herberts et al. [1984] added to the 1981 study by comparing the prevalence of supraspinatus tendinitis between plate-workers and office clerks. Tendinitis in welders was determined by a combination of self-reported symptoms and positive physical examination findings. The only information given regarding plate-work is that it is dynamic in character. It is presumed that plate-workers handled heavy loads more frequently than office clerks.

In a cross-sectional study, the prevalence of osteoarthrosis in the acromioclavicular joint, as determined by radiography, was compared among three groups of workers in the construction industry [Stenlund et al. 1992]. The three groups were bricklayers, rock blasters, and construction foremen. The foremen did not perform manual work currently, or in the past, and were considered the control population. A standardized interview was used to determine exposure factors, including job title and the sum of loads lifted during all working years (expressed in tonnes). Analyses were performed separately for right and left sides.

In a study of letter carriers, Wells et al. [1983] evaluated the effect of a load carried on the shoulder. Letter carriers, who carry a load and walk, were compared to gas meter readers (who walk without carrying a load) and postal clerks. Utilizing information from telephone interviews, points were assigned to symptom characteristics such as frequency, length of episodes, and interference with work ability. Case definition required a report of recurrent shoulder pain with greater than 20 points. A subset of letter carriers had experienced an increased load during the previous year. (The Postal Service had increased maximum weight carried from 25 to 35 pounds, but not all locations had implemented this change.)

Strength of Association—Force and Shoulder MSDs

The studies are presented in alphabetical order in Table 3-2. Results of studies where ORs, or other measures of association, were specifically associated with a measure of exposure, are presented in the section on Exposure-Response Relationship.

Andersen and Gaardboe [1993a] found that current work as a sewing machine operator was associated with chronic shoulder pain (OR 1.72, 95% CI 1.17–2.55). Using multiple logistic regression analysis with age, gender, and repetitiveness as covariates, Chiang et al. [1993] found that high force exertions measured in the forearm were associated with shoulder girdle pain (OR 1.8, 95% CI 1.2–2.5). When tested in the same model with force and repetition, the interaction term for force times repetition was also significant (OR 1.4, 95% CI 1.0–2.0). Two factors could have resulted in an underestimation of the strength of association: (1) no requirement that symptoms have started on current job meant that some symptomatic workers may have transferred to lower risk jobs, and (2) no matching of health status and exposure status by side (left, right, or both) may have caused non-differential misclassification. For supraspinatus tendinitis, Herberts et al. [1984] calculated a prevalence rate ratio (PRR) for plate-workers versus office clerks of 16.2 (90% CI 10.9–21.5) "under the assumption that missing data had the same characteristics as those considered." The absence of specific exposure information was a major limitation of this study.

The age-adjusted OR associated with osteoarthritis of the acromioclavicular joint was 2.16 (95% CI 1.14–4.09) (right side) and 2.56 (95% CI 1.33–4.93) (left side) for manual construction workers versus foremen [Stenlund et al. 1992]. Because there was a lower participation rate among bricklayers and blasters, self-selection into the study because of having symptoms could have resulted in overestimation of the strength of association. While some of the items handled required a bilateral lift (e.g., jackhammer), other loads may have been specific to the right or left hand. Because the exposure measure did not separate load by sides, non-differential misclassification may have caused underestimation of the strength of association.

Consistency of Association: Force and Shoulder MSDs

Despite different outcome and exposure measures, all of the studies had positive associations. Each study used a different case definition, ranging from relatively mild symptoms to radiographic evidence of osteoarthritis, and a different measure of exposure. Chiang et al. [1993] used EMG measures of forearm flexor muscle activity. Wells et al. [1983] evaluated the effect of a direct load on the shoulder. Stenlund et al. [1992] used an estimate of the cumulative, lifetime load carried. Andersen and Gaardboe [1993a] compared sewing machine operators to a referent population. However, positive and significant associations were found, regardless of the measure of health outcome or exposure.

Temporal Relationship: Force and Shoulder MSDs

All of the studies of forceful exertions used a cross-sectional study design. To increase the likelihood that shoulder symptoms were caused or aggravated by current exposure, Chiang et al. [1993] required that symptoms had occurred within the previous 30 days.

Wells et al. [1983] used several analytical methods to increase confidence in a relationship between carrying the increased load and having shoulder disorders. The use of age, the number of years on the job, and previous heavy work experience as covariates when performing analysis of covariance helped ensure that the difference in the proportion of shoulder disorders between letter carriers with and without the increased load was related to current exposure rather than past peak exposures or cumulative duration. Although baseline symptom status in the group with the increased load could not be obtained, there was no significant difference in the prevalence of shoulder problems between the two groups when results were adjusted for the amount of weight currently carried. Therefore, the difference in symptom prevalence was likely related to the load increase rather than prior differences in symptom status. The cross-sectional studies are consistent with exposure occurring before the onset of the shoulder MSDs.

Exposure-Response Relationship

When sewing machine operators were compared with an external control population, there was a trend of increasing ORs for chronic shoulder pain with increasing duration of work as a sewing machine operator [Andersen and Gaardboe 1993a]. The OR for 0–7 years was 1.38 (95% CI 0.86–2.39), for 8–15 years it was 3.86 (95% CI 2.29–6.50), and for >15 years it was 10.25 (95% CI 5.85–17.94), while controlling for other factors including age and current exposure.

Chiang et al. [1993] found a significant increasing trend in the prevalence of shoulder girdle pain from Group I (low force, low repetitiveness) to Group III (high force, high repetitiveness). However, the health outcome is not specific for shoulder tendinitis and the exposure categories combine increasing force, as measured in the forearm flexor muscles, and increasing repetitiveness.

In the study of bricklayers and blasters, and acromioclavicular osteoarthritis, Stenlund et al. [1992] found that for the left side, ORs increased with the level of lifetime load lifted. For a lifetime load of 710–24,999 tonnes versus less than 710 tonnes, the left side OR was 7.29 (95% CI 2.49–21.34), and for greater than 25,000 tonnes versus less than 710 tonnes, the left side OR was 10.34 (95% CI 3.10–34.46).

For severe, but not disabling, shoulder pain, the OR for letter carriers versus postal clerks was 3.6 (95% CI 1.8–7.8) [Wells et al. 1983]. For those letter carriers who had experienced a weightload increase within the previous year, versus postal clerks, the OR was 5.7 (95% CI 2.1–17.8). Furthermore, letter carriers who had experienced the weightload increase had significantly more shoulder problems than those whose bag weight had not been increased. If letter carriers tend to keep the mail-bag strap on one shoulder, the fact that the side of the load was not matched with the side of the shoulder problem could have resulted in non-differential misclassification and an underestimation of the strength of association. However, some of the health effects may have been related to activation of contralateral muscles involved in stabilizing the shoulder girdle [Winkel and Westgaard 1992].

Coherence of Evidence

High shoulder muscle force requirements can cause increased muscle contraction activity, which may lead to an increase in both muscle fatigue and tendon tension, and may possibly impair microcirculation as well.

Force may also be related to a static load on shoulder muscles. Sjøgaard et al. [1988] found that muscular fatigue will occur at EMG levels as low as 5% of maximal voluntary contraction (MVC) if sustained for 1 hour. Other studies have demonstrated that when the period of muscle contraction is extended to more than an hour, the endurance limit of force may be as low as 8% MVC [Jonsson 1988]. Workers performing repetitive work with the hands and wrists, while maintaining static upper arm elevation may experience fatigue even at low load levels. Jonsson [1988] reported that many constrained work situations are characterized by static load levels near or exceeding 5% MVC, even when characterized by a fairly low mean muscular load.

Because the five studies reviewed had a considerable diversity of exposure assessment approaches and health outcomes, there is insufficient epidemiologic evidence to conclude that forceful exertions are associated with rotator cuff or bicipital tendinitis. The one study that used shoulder tendinitis as the health outcome reported a strong association related to job category (OR for plate-workers versus clerks: 16.2 (95% CI 10.9–21.5), but did not describe or measure specific exposure risk factors [Herberts et al. 1984]. One of the reviewed studies did present evidence for an association between acromioclavicular osteoarthrosis and cumulative, lifetime load on the shoulder muscles [Stenlund et al. 1992]. Another study reported a significant association between severe shoulder pain and a direct shoulder load [Wells et al. 1983].

POSTURE

Definition of Awkward Posture for Shoulder MSDs

For the shoulder, a relaxed, neutral posture is one in which the arm hangs straight down by the side of the torso. As the arm is flexed, abducted, or extended, the included angle between the torso and the upper arm increases. In one study, postures in which the included angle was equal to or greater than 45 degrees required substantial supraspinatus muscle activity, while deltoid muscle activity underwent a pronounced increase as the angle of shoulder flexion or abduction increased from 45 to 90 degrees [Herberts et al. 1984]. As the arm is elevated, the space between the humeral head and the acromion narrows such that mechanical pressure on the supraspinatus tendon is greatest between 60 and 120 degrees of arm elevation [Levitz and Iannotti 1995]. While there is a continuum of severity from an included angle of 30 degrees to a maximally abducted arm, postures with shoulder abduction or flexion past 60 degrees are considered awkward.

Studies Reporting on the Association of Awkward Postures and Shoulder MSDs

Six of the reviewed studies reported results on the association between awkward postures and shoulder tendinitis [Baron et al. 1991; Bjelle et al. 1979; English et al. 1995; Herberts et al. 1981; Ohlsson et al. 1994, 1995] (Table 3-3, Figure 3-3). Seven additional studies reported results on the association between awkward postures and non-specific shoulder disorders [Sakakibara et al. 1995], non-specific shoulder symptoms [Hoekstra et al. 1994; Milerad and Ekenvall 1990; Schibye et al. 1995] combined neck-shoulder disorders [Bjelle et al. 1981; Jonsson et al. 1988; Ohlsson et al. 1995] or combined neck-shoulder symptoms [Kilbom and Persson 1987].

Studies Meeting the Four Evaluation Criteria

Four studies met all four of the evaluation criteria.

Using a prospective study design, Jonsson et al. [1988] assessed the health and exposure status of 69 electronics manufacturing plant employees at the beginning of the study and after one and two years. Employees who dropped out before completion of the study were compared to those who fully participated; there was no significant difference in medical status, working technique, or work history. Employees who had upper extremity disorders resulting in a physician visit or sick leave were excluded from the initial study group. The dependent variables related to health status were of two types: a change in symptom severity and being symptom free. Symptom status was assessed by interview and a physical examination by a physiotherapist. The symptoms severity index compiled data from the five body regions combined and was not specific for the shoulder region. Because the exposure was determined by direct observation for each individual, and clearly separated ergonomic risk factors by body region, it was still possible to evaluate associations likely to specifically involve the shoulder.

Kilbom and Persson [1987] and Kilbom et al. [1986] performed a study in which female employees in the electronics manufacturing industry were observed for a 2-year period. The health outcome of fatigue, ache, or pain in the neck, shoulder, or arm regions was based on symptoms information. Symptom severity was coded on the basis of its character, frequency, and/or duration. Changes in severity status at follow-up evaluations were used as the dependent variables in multiple regression analyses. Neck, shoulder, and upper arm posture was determined by computerized analysis (VIRA) of videotapes of individuals. Although the health outcome combined symptoms from different body regions, knowledge of biomechanical theory can be used to identify significant predictors related to the shoulder symptom severity.

Two of the reviewed studies in which tendinitis was the health outcome are Ohlsson et al. [1994, 1995]. For both studies, the authors reported that the examiners could not be completely blinded to exposed versus referent status, but that a standard protocol was followed and observer bias was likely to have been minimal. Because examiners were blinded to objective exposure measures, analyses testing associations between neck-shoulder disorders and specific postures would not have been biased [Ohlsson et al. 1995].

In a cross-sectional study, women in the fish industry were compared to a control population of women employed in municipal workplaces in the same towns [Ohlsson et al. 1994]. Diagnoses of shoulder disorders (e.g., tendinitis, acromioclavicular syndrome, frozen shoulder) were made on the basis of symptoms determined by interview and a physical exam. Exposure evaluation of each work task held by the fish industry population was evaluated with ergonomic workplace analysis (EWA). Ten different factors were rated on a scale from 1 to 5 and the combined ratings were used as a profile of the work task. Based on this profile, the authors reported that fish industry work was found to be "highly repetitive" and include "poor work postures."

Ohlsson et al. [1995] compared a group of women who performed industrial assembly work to a referent group of women from a nearby town who were employed in jobs characterized as having varied and mobile work tasks. One examiner assessed signs and symptoms. The examiner was blinded to specific exposure information, but not completely blinded to factory worker versus referent group status. Shoulder tendinitis included supraspinatus, infraspinatus, and bicipital tendinitis. Another health outcome combined neck and shoulder disorders (tension neck, cervical syndrome, thoracic outlet syndrome, frozen shoulder, tendinitis, and acromioclavicular syndrome). In a descriptive assessment, it was reported that the work tasks in the study group involved repetitive arm movements with static muscular work of the neck and shoulder muscles. The percentage of time spent in specific upper arm postures was determined from videotaped observations of 74 (out of 82) workers. The average result from two independent videotape analyses was used. Posture category demarcations included 0, 30, and 60 degrees for arm elevation, and 30, 60, and 90 degrees for arm abduction.

Studies Not Meeting the Four Evaluation Criteria

Summaries of studies that specifically evaluated associations with shoulder tendinitis are presented next [Baron et al. 1991; Bjelle et al. 1979, 1981;

English et al. 1995; Herberts et al. 1981]. Summaries of other studies are presented in alphabetical order.

In the study by Baron et al. [1991], grocery store workers who performed the job of checker were compared to a non-checker group that performed a variety of other jobs (e.g., general stocking, working in the produce section, the bakery, salad bar, pharmacy, and courtesy counter). There was a low participation rate among non-checkers (55%), which could have resulted in an underestimation of the OR for checkers if symptomatic non-checkers were more likely to participate than those non-checkers without symptoms. The authors evaluated this possibility by performing a sufficient number of telephone interviews with non-participants to raise the non-checker participation rate for interviews to 85%. The OR for shoulder symptoms among the full participant population was similar to the OR for the full participant plus telephone interview population. The case definition was shoulder symptoms lasting at least one week or occurring at least once per month during the previous year that began while the worker was performing her current job and positive physical examination findings consistent with a shoulder tendinitis. Detailed descriptions of the checker jobs were presented based on both on-site and videotape analyses of a few representative workers per workstation. No videotaping of non-checkers was performed. Shoulder flexion and/or abduction ($90 degrees) was observed during a variety of different tasks performed by the checkers. The exposure measures used in statistical analyses were: (1) checker versus non-checker and, (2) for exposure-response assessment among checkers, the total number of months and the number of hours per week working as a checker.

Bjelle et al. [1979] compared cases with persistent shoulder pain to controls employed as manual workers. After an extensive medical evaluation, a diagnosis of bicipital and/or supraspinate tendinitis was made for a majority (12/17) of the cases. Physical workload was categorized in relation to sitting or standing posture, weight lifting, and carrying. The work height of the hands was categorized based on position relative to the acromion height, per individual. Placement of workers into exposure categories was determined by the combined efforts of each study participant and a physician.

Bjelle et al. [1981] compared cases with acute, non-traumatic shoulder-neck pain to age- and sex-matched, paired controls. An extensive physical examination was performed and workers with inflammatory rheumatoid diseases were excluded. To determine exposure, each case and control was filmed and a biomechanical analysis was performed to determine the duration and frequency of shoulder abduction or forward flexion greater than 60 degrees.

In a study by English et al. [1995], cases determined by medical diagnosis, and controls were selected from patients evaluated at specified orthopedic clinics. For statistical analyses, all diagnoses were grouped by anatomical site. The diagnoses for shoulder cases included rotator cuff injury, rupture of the long head of the biceps, shoulder capsulitis, and symptomatic acromioclavicular arthritis. It is assumed that shoulder tendinitis was included in this group. Exposure measures were determined by a standardized interview conducted by an interviewer who was, "unaware of the case-control status of the individual wherever this was possible."

In a study by Herberts et al. [1981], the prevalence of supraspinatus tendinitis was compared between welders and office workers. Tendinitis cases were based on a combination of symptoms reported on a nurse-administered questionnaire and a positive physical examination done by a physiotherapist. For welders, an "experienced physiotherapist" rated work-load on the shoulder as low, high, or very high; no description of the classification scheme was given.

Hoekstra et al. [1994] evaluated government office workers at two locations. The case definition for shoulder symptoms was symptoms that began after starting current job, lasting greater than one week, or occurring at least once per month during the past year with an intensity greater than two on a five point scale, and no preceding acute, non-occupational injury. A self-administered questionnaire was used to determine exposure to factors such as "perceived adequacy of adjustment of video display terminal (VDT)." Walk-through ergonomic evaluations of factors such as workstation surface height and furniture adjustability were used to provide descriptive differences between the two office locations.

Milerad and Ekenvall [1990] compared the prevalence of self-reported, non-specific shoulder symptoms between dentists and pharmacists. Dentistry, as a profession, was described as work "with the arms abducted and unsupported" whereas, pharmacists had "physically light and varied work."

In a prospective study by Sakakibara et al. [1995], the health status of a group of women farm workers was assessed during the performance of two different tasks, with a 1-month interval between the tasks. The health outcome was defined by self-assessed symptoms of shoulder stiffness and pain and a physical examination for muscle tenderness and joint pain on movement. Whether the examining physician was aware of the prior hypothesis regarding differing exposures between the two tasks (bagging pears versus bagging apples) was not stated. Exposure was based on self-report of the number of hours per day spent bagging, the number of pears or apples bagged per day, and the total number of days spent bagging each fruit. One worker was observed for 3 hours while performing each bagging job, with repeated goniometer measures of shoulder forward flexion angles done each minute. While there was no difference in the total number of days or number of hours per day spent bagging each fruit, significantly more pears than apples were bagged per day. The proportion of time spent with the angle of shoulder forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%).

Schibye et al. [1995] performed a prospective study of a population of sewing machine operators in which the change in self-reported shoulder symptom status was compared with those sewing machine operators who continued to work and those operators that moved into other occupations (e.g., shop assistant, health care worker, and fishing industry worker).

Strength of Association—Awkward Posture and Shoulder MSDs

Results are presented in the section on Exposure-Response Relationship (Table 3-3, Figure 3-3) for studies where ORs, or other measures of association, were specifically associated with a measure of exposure.

Using data presented in the study by Ohlsson et al. [1994], for supraspinatus, infraspinatus, or bicipital tendinitis, the PRR for working in the fish industry (repetitive work, poor posture) versus the referent population was calculated as 3.03 (95% CI 2.0–4.6). For shoulder tendinitis alone, the PRR was calculated as 3.5 (95% CI 2.0–5.9). In the same study, the authors also interviewed a large group of former fish industry employees and found that a quarter of those workers who left employment had done so because of problems with their neck or upper limbs. This proportion increased with age and also occurred after a shorter duration of employment among the oldest workers. This evidence of a survivor bias highlights the importance of controlling for age. Higher risks were found for the workers less than 45 years old and these risks may be a more accurate assessment of the true risk.

Using data presented in the study by Ohlsson et al. [1995], for supraspinatus, infraspinatus, or bicipital tendinitis, the OR for being an assembly worker (repetitive arm movements with static load on shoulders) versus the referent population was 4.2 (95% CI 1.35–13.2). For neck-shoulder disorders, the OR for being an assembly worker versus the referent group was 5.0 (95% CI 2.2–11.0).

For shoulder disorders consistent with tendinitis, Baron et al. [1991] found that the OR for being a checker versus a non-checker was 3.9 (95% CI 1.4–11.0). Because non-checkers also performed work requiring awkward postures, the reported OR may underestimate the risk for checkers. Short stature (# 5'2") was associated with an elevated, but not statistically significant, OR for shoulder disorders (2.1, 95% CI 0.7–6.9). Because work-station height was fixed, it is likely that short stature workers experienced more frequent and/or more severe episodes of shoulder flexion and/or abduction.

The OR for work performed at or above acromion height (i.e., hands above the shoulder) versus work performed below acromion height was 10.6 (95% CI 2.3–54.9) [Bjelle et al. 1979]. In this study, all cases were patients who had been examined by the same physician. Placement of cases and controls into exposure categories was performed by each subject in collaboration with a physician who "had personal knowledge of the work involved in each case." Whether or not the physician who performed the clinical examinations is the same person as the physician involved in exposure classification is not stated. If this was the same person, a potential bias towards assigning cases to higher exposure categories could have resulted in overestimation of the strength of association. However, two other factors could have resulted in an underestimation of the strength of association. The exposure outcome was based on current work load without any stated restriction that cases' symptoms had started on their current job. If some of the cases, defined as having problems non-responsive to therapy lasting longer than 3 months, had transferred to a lower risk job, the strength of association may have been underestimated. Location of the disorder and exposure were not matched by side (left, right, or both) and this would have caused non-differential misclassification, resulting in some underestimation of the strength of association.

English et al. [1995] found that the risk of having a medically diagnosed shoulder condition was increased by repeated shoulder rotation with an elevated arm (OR 2.30, $p<0.05$). Non-differential misclassification due to a combination of complicated exposure definitions using a questionnaire, and the fact that analyses did not relate health outcomes and exposure on a temporal basis, or by left/right side, may have caused an under-estimate of the strength of association.

For supraspinatus tendinitis, Herberts et al. [1981] found that the PRR for welders (characterized as using awkward postures to perform overhead work) versus clerks was 18.3. However, in determining this PRR, the authors performed extrapolation based on an assumption that, “the drop-out group does not deviate from the examined group,” without any data to support this assumption. To determine a more reliable indicator of risk, unextrapolated data presented in the study were used to calculate a crude OR=8.3 (95% CI 0.63–432). The office clerks were older than the welders, so that confounding by age may have caused an under-estimation of the strength of association.

In a study of teleservice employees, there was an association between reporting shoulder symptoms and working at one location versus another location; the OR was 4.0 (95% CI 1.2–13.1) [Hoekstra et al. 1994]. Descriptive differences between workstation design at the two locations provided a plausible explanation for this finding. At the higher risk location, the workstation surface was too high to serve as a keyboard support, there were nonadjustable chairs, and it was observed that “nonadjustable furniture universally promoted undesirable postures (i.e. elevated arms, hunched shoulders).” Having shoulder symptoms was also positively associated with using a non-optimally adjusted desk height (OR 5.1, 95% CI 1.7–15.5) and a non-optimally adjusted VDT screen (OR 3.9, 95% CI 1.4–11.5). Because exposure was self-reported without any indication of whether or not study participants had received education regarding good VDT workstation design, the phrase, “non-optimally adjusted,” may have had various meanings to the study participants. This could have caused non-differential misclassification of exposure and an under-estimation of the strength of association. On the other hand, a possible reporting bias related to self assessment of both symptoms and exposure could have resulted in an overestimation of the strength of the association. A plausible explanation for the association between shoulder symptoms and these workstation design factors is that the non-optimally adjusted workstation components forced the employees to abduct the upper arms and/or hunch the shoulders.

For shoulder symptoms without concomitant neck symptoms, Milerad and Ekenvall [1990] found that the OR for being a dentist (work with both arms abducted) versus being a pharmacist was 3.8 (95% CI 1.2– 10.3). As with most cross-sectional studies, the survivor bias may have resulted in underreporting of the strength of exposure. Conversely, the exposed group may have had better recall of self-reported symptoms with a resultant overestimation of the OR.

In the study of farm workers by Sakakibara et al. [1995], the point prevalence of muscular tenderness in the shoulder regions (per physical examination) was significantly higher when performing pear bagging (48%) than when performing apple bagging (29%). The proportion of time spent with the shoulder in forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%). Whether or not there was a recovery period between pear and apple bagging is not stated. If there was insufficient recovery after pear bagging, persistent muscle tenderness or increased susceptibility may have caused underestimation of the difference in shoulder disorder prevalence between these two work ta sks.

With the exception of the study by English et al. [1995], in which the strength of association may have been underestimated, for the studies in which the health outcome was shoulder tendinitis [Baron et al. 1991; Bjelle et al. 1979; Herberts et al. 1981; Ohlsson et al. 1994, 1995], the magnitude of association was strong. ORs ranged from 2.0 to 10.6. In none of these studies is it likely that nonoccupational factors such as sports activities or personal characteristics such as age explain these associations.

Consistency of Association

All but one of the reviewed studies relevant to posture and shoulder disorders found a positive association between shoulder disorders or shoulder symptoms and awkward shoulder posture. Awkward postures were consistently described as overhead work, arm elevation, and specific postures relative to degrees of upper arm flexion or abduction. This association was found in cross-sectional, case-control, and prospective studies among a great variety of types of work performed.

Temporal Relationship

It is important to determine whether symptoms or MSDs occur as a consequence of work-related exposures. This can be done most clearly with a prospective study design.

In the study by Jonsson et al. [1988], the percent of the work cycle spent with the shoulder elevated was negatively associated with remaining healthy (symptom free). Because workers with pre-existing shoulder conditions were excluded from study participation, the onset of new symptoms may have been associated with the daily and/or cumulative duration of exposure to elevated shoulder postures. In the study by Kilbom and Persson [1987], three of the work exposure variables that were strong predictors for a change to severe status at the 1- and/or 2-year follow-up evaluations were related to shoulder posture: (1) percent of work cycle time with arm abduction greater than 30 degrees, (2) percent of work cycle time with arm abduction greater than 60 degrees, and (3) percent of work cycle time with arm extension.

A few studies utilized techniques to improve the ability to detect possible relationships despite a cross-sectional study design. The case definition used by Baron et al. [1991] required that symptoms began while the worker was on the currently held job. Bjelle et al. [1979] filmed and analyzed the job held at the time the worker/case became symptomatic. The results of the prospective studies are similar to the cross-sectional studies. There is no evidence that shoulder disorders predicted the onset of exposure.

Exposure-Response Relationship

The level of an exposure can be described in two different ways. It may be related to the amount of exposure over a relatively short time period, such as a day or week, or it may be related to cumulative or life-time exposure over a number of years. Studies that tested associations related to daily or weekly variation in exposure are presented first, followed by studies that evaluated cumulative exposure by using independent variables, such as duration of employment or estimated lifetime exposure.

Four studies have some evidence of exposure-response relationships. Baron et al. [1991] found a significantly larger OR for shoulder disorders among employees working greater than 25 hours/wk as a checker compared to those working less than 20 hours/wk. Bjelle et al. [1981] found that the duration of hours worked per day with the shoulder flexed or abducted >60 degrees was significantly higher ($p<0.025$) for cases with neck-shoulder disorders than for controls. Ohlsson et al. [1995] found that neck and shoulder disorders among assembly workers were significantly associated ($p<0.05$) with the percent of time spent with the shoulder abducted or elevated >60 degrees. Although it is more difficult to detect associations with homogenous exposure, this association was significant despite very little variability in exposure to arm abduction greater than 60 degrees. While the analysis among assembly workers was performed without controlling for age, there is no evidence to suggest that older workers were more likely to be on high exposure jobs, and therefore a substantial bias is unlikely.

When comparing fish industry workers to the reference population, Ohlsson et al. [1994] found that among those workers younger than 45 years, the ORs for disorders of the neck and shoulders were significant and increased with duration of employment (0–5 years, OR 3.2; 95% CI 1.5–7.0) (>5 years, OR 10; 95% CI 4.5–24). Ohlsson et al. [1995] found a decreasing trend when they compared OR after stratifying the factory workers by employment duration (<10 years, OR 9.6; 10–19 years, OR 4.4 and $20 years: 3.8). Given the cross-sectional study design, this finding could be an artifact caused by the survivor bias (i.e., workers with disorders left, while symptom-free ‘survivors’ stayed; see Table 3-5). The assumption of a survivor bias is based on the finding that 28% of a group of former assembly workers reported pain in the musculoskeletal system as their reason for leaving employment at the factory. In the study by Schibye et al. [1995], improvement in shoulder symptoms among those who were no longer sewing machine operators appeared greater at follow-up, but was not significant. The fact that many of those who left sewing jobs moved into industries such as health care and fishing, where awkward postures and high force loads may occur, might explain why a large difference between sewing machine operators and non-sewing machine operators was absent. These four studies provide some support for the relationship between shoulder abduction and shoulder MSDs.

Coherence of Evidence

Discussions of the probable influence of workplace exposure factors in the pathophysiology of localized muscle fatigue, myalgia, and tendinitis have been presented by a number of authors [Bjelle et al. 1981; Hagberg 1984; Herberts and Kadefors 1976; Herberts et al. 1984; Levitz and Iannotti 1995]. Posture is important: when the arm is raised or abducted, the muscle activity in supraspinatus and other muscles increases, and the supraspinatus tendon comes in contact with the undersurface of the acromion. The mechanical pressure on the tendon from the acromion is greatest between 60 and 120 degrees of arm elevation. [Levitz and Iannotti 1995]. The degree of upper arm elevation is also important in the onset and intensity of localized muscle fatigue in the trapezius, deltoid, and rotator cuff muscles. [Hagberg 1981; Herberts and Kadefors 1976; Herberts et al. 1984]. In a laboratory study, EMG signals from these muscles were analyzed. The supraspinatus muscle was found to be highly active at ≥45 degrees of abduction. The deltoid muscle underwent a pronounced increase in activity as shoulder flexion or abduction increased from 45 to 90 degrees [Herberts et al. 1984]. The earlier sections on Coherence of Evidence also discussed the rate of fatigue and role of impaired micro-circulation in shoulder tendinitis.

Overall, there is epidemiologic evidence for a relationship between repeated or sustained shoulder postures with more than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for increased risk of MSDs due to specific shoulder postures is strongest when there is a combination of exposures to several physical factors such as force and repetitive work. An example of this combination would be holding a tool while working overhead. The strength of association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a combination of symptoms and physical findings consistent with tendinitis, as the health outcome [Baron et al. 1991; Bjelle et al. 1979; English et al. 1995; Herberts et al. 1981; Ohlsson et al. 1994, 1995]. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and symptoms or a specific shoulder disorder. However, in this study discontinuing employment as a sewing machine operator was associated with a reduction in neck and shoulder symptoms. While most of the studies that considered specific shoulder postures as an exposure variable were cross-sectional, the two prospective studies found that the percent of work cycle spent with the shoulder elevated [Jonsson et al. 1988] or abducted [Kilbom et al. 1986; Kilbom and Persson 1987] predicted change to more severe neck and shoulder disorders. While there is insufficient evidence to develop a quantitative exposure-disorder relationship, three studies reported a significant association with shoulder flexion or abduction greater than 60 degrees [Bjelle et al. 1981; Kilbom and Persson 1987; Ohlsson et al. 1995]. Among the studies for which shoulder tendinitis was the health outcome, the largest ORs were associated with work above acromion height [Bjelle et al. 1979;

Herberts et al. 1981]. These results are consistent with the current models for the pathophysiology of shoulder tendinitis and stressful shoulder muscle activities. In none of these studies does "age," an important personal characteristic associated with shoulder tendinitis, explain the positive results. Most of the studies controlled for a variety of confounders, such as occupational sports activities in their analyses. In summary, there is evidence that repeated or sustained shoulder abduction or flexion is associated with shoulder tendinitis, and the evidence is stronger for highly repetitive, forceful work.

VIBRATION

Three of the studies evaluated exposure to low-frequency vibration found in industrial settings (Table 3-4, Figure 3-4). Because of the small number of studies, the full outline used for the sections on repetition, force, and posture will not be repeated here. The study by Stenlund et al. [1992] is summarized in the section on force. Vibration exposure occurred in one of the three job categories: rock blaster. The exposure outcome, lifetime exposure to vibration expressed in hours, was determined from a weighted summary of the number of self-reported hours using specific tools. However, because the rock blaster job category was also the only one where workers performed heavy lifts several times per day, the authors concluded that, "vibration exposure is indivisible from static load and heavy lifting in the present data." When both cumulative lifting exposure and cumulative vibration exposure were included in the same multivariate model of an association with acromioclavicular osteoarthrosis, the OR for lifting and right- side osteoarthrosis remained significant while the weaker ORs for vibration became non-significant.

In the study by Stenlund et al. [1993], the same population of bricklayers, rock blasters, and foremen described in Stenlund et al. [1992] were evaluated to determine whether signs of tendinitis or muscle attachment inflammation in the shoulders were related to lifetime work load, years of manual work, lifetime exposure to vibration, or job title. The case definition for "signs of shoulder tendinitis" was pronounced (i.e., grade 3 out of 3) pain upon palpation of the muscle attachment or pronounced pain in response to isometric contraction of any of the rotator cuff muscles or the biceps muscle. The case definition of "clinical entity of tendinitis" was "signs of shoulder tendinitis" plus the subject's report of shoulder pain during the past year. Using multivariate models that included age and hours spent in arm intensive sports activities, a significant association with cumulative vibration exposure was found when it was tested in isolation from the other exposure variables. For "clinical entity of tendinitis" the OR for the left side was 1.86 (95% CI 1.00–3.44) and the OR for the right side was 2.49 (95% CI 1.06–5.87). For "signs of shoulder tendinitis" the OR for the left side was 1.66 (95% CI 1.06–2.61) and the OR for the right side was 1.84 (95% CI 1.10–3.07). When cumulative vibration exposure was tested in the same model with cumulative lifting load, significant associations were not found for either variable. Several factors could have resulted in an underestimation of the strength of association: (1) bricklayers or rock blasters with tendinitis may have been more likely to leave their jobs than foremen, (2) subjects may have had difficulty recalling exposure throughout their lifetimes, (3) the inability to separate exposure by left and right sides. These factors may have caused nondifferential misclassification. Most important is the authors' observation that vibration exposure occurred through the used of hand-held, heavy tools (e.g., jack-hammers) and thus is intertwined with exposure to a static load on the shoulders (from stabilizing the upper extremity while using the tool) as well as being associated with the heavy lifting tasks performed by rock blasters.

In a cross-sectional study by Burdorf and Monster [1991], riveters and control subjects in an aircraft company were investigated for vibration exposure and self-reported symptoms of pain or stiffness in the shoulder. Riveters were exposed to hand-arm vibration from working with hand drills, riveting hammers, bucking bars, and grinders. Controls were manual workers selected from the machine shop, maintenance, and welding departments in the same factory. In order to focus on the effect of vibration alone, a walk-through survey was performed to confirm that there were "no striking differences in dynamic and static joint loads during normal working activities." Participation was 76% among riveters and 64% among controls. An analysis of non-respondents revealed that controls with health complaints were more likely to have participated than those without, while riveters with health complaints were less likely to have participated. The health outcome, determined by a self-administered questionnaire, was shoulder pain or stiffness occurring for at least a few hours during the prior year. Only subjects who reported having no symptoms before starting their present work were included in logistic regression analyses. The vibration transmitted by hand-tools was measured and weighted according to International Standards Organization (ISO) standards. Tool vibration profiles and time-work studies of riveters and controls were used to determine daily vibration exposure for each group. For riveters, on the basis of daily tool operating time, the equivalent frequency-weighted acceleration for a period of 4 hours was 2.8 $m\ s^{-2}$. For controls, it was 1.0 $m\ s^{-2}$. Using a multiple logistic regression model that included age, there was a weak association between shoulder symptoms and the number of years riveting (0.05# p<0.10). When the age-adjusted ORs for riveters compared to controls were plotted by the duration (in years, from 0 to 20) of riveting, the slope for shoulder symptoms was very gradual, with ORs ranging from 1.0 to 2.0. While the results of the analysis of non-respondents described above suggest that the strength of association may have been underestimated, the reported associations are weak and it is unlikely that the response bias would have resulted in a large increase in the magnitude of association.

There is insufficient evidence for an association between shoulder tendinitis and exposure to segmental vibration. In four separate evaluations, stratified by "signs of tendinitis" (positive physical examination findings), "clinical entity of tendinitis" (signs plus symptoms), left and right side, Stenlund et al. [1993] found an association between shoulder tendinitis and vibration exposure to segmental vibration; the range of ORs was from (OR for right side 1.66, 95% CI 1.06–2.61) (OR for left side 1.84, 95% CI 1.10–3.07). However, work with vibration exposure also placed a large, static load on shoulder muscles so that the effects of forceful shoulder muscle exertions could not be separated from vibration.

ROLE OF CONFOUNDERS

Shoulder MSDs are multifactorial in origin and may be associated with both occupational and non-occupational factors. The relative contributions of these covariates may be specific to particular disorders. For example, the confounders for non-specific shoulder pain may differ from those for shoulder tendinitis. Two of the most important confounders or effect modifiers for shoulder tendinitis are age and sport activities. Most of the shoulder studies considered the effects of age in their analysis. Some studies considered sport activities [Baron et al. 1991; Stenlund et al. 1993; Jonsson et al. 1988; Kilbom et al. 1986]. Some studies also used multivariate methods to simultaneously adjust for several confounders or effect modifiers. For example, Ohlsson et al. [1995] found that for shoulder/neck diagnoses, repetitive work was the strongest predictor 4.6 (95% CI 1.9–12); age, muscle tension, and stress/worry tendency were also significant predictors. It is unlikely that the majority of the positive associations between physical exposures and shoulder MSDs are due to the effects of non-work confounders.

CONCLUSIONS

There are over 20 epidemiologic studies that have examined workplace factors and their relationship to shoulders (MSDs). These studies generally compared workers in jobs with higher levels of exposure to workers with lower levels of exposure, following observation or measurement of job characteristics. 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 **evidence** for a positive association between highly repetitive work and shoulder MSDs. The evidence has important limitations. Only three studies specifically addressed the health outcome of shoulder tendinitis and these studies investigated combined exposure to repetition with awkward shoulder postures or static shoulder loads. The other six studies with significant positive associations dealt primarily with symptoms. There is **insufficient evidence** for a positive association between force and shoulder MSDs based on currently available epidemiologic studies. There is epidemiologic **evidence** for a relationship between repeated or sustained shoulder postures with greater than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for specific shoulder postures is strongest where there is combined exposure to several physical factors like holding a tool while working overhead. The strength of association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a combination of symptoms and physical findings consistent with tendinitis, as the health outcome. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and a specific shoulder disorder or symptoms of a shoulder disorder.

This is consistent with the evidence that is found in the biomechanical, physiological, and psychosocial literature.

There is **insufficient evidence** for a positive association between vibration and shoulder MSDs based on currently available epidemiologic studies.

Table 3-1. Epidemiologic criteria used to examine studies of shoulder 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 shoulder exposure to repetition
Met all four criteria:					
Chiang 1993	1.6[†]	Yes	Yes	Yes	Observation or measurements
Kilbom 1986, 1987	NR[†,‡]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1994	3.5[†]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	5.0[†]	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Bjelle 1981	NR[†]	NR	Yes	Yes	Observation or measurements
English 1995	2.3[†,§]	Yes	Yes	Yes	Job titles or self-reports
Sakakibara 1995	1.7[†]	Yes	Yes	NR	Job titles or self-reports
Met none of the criteria:					
Ohlsson 1989	3.4[†]	NR	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).

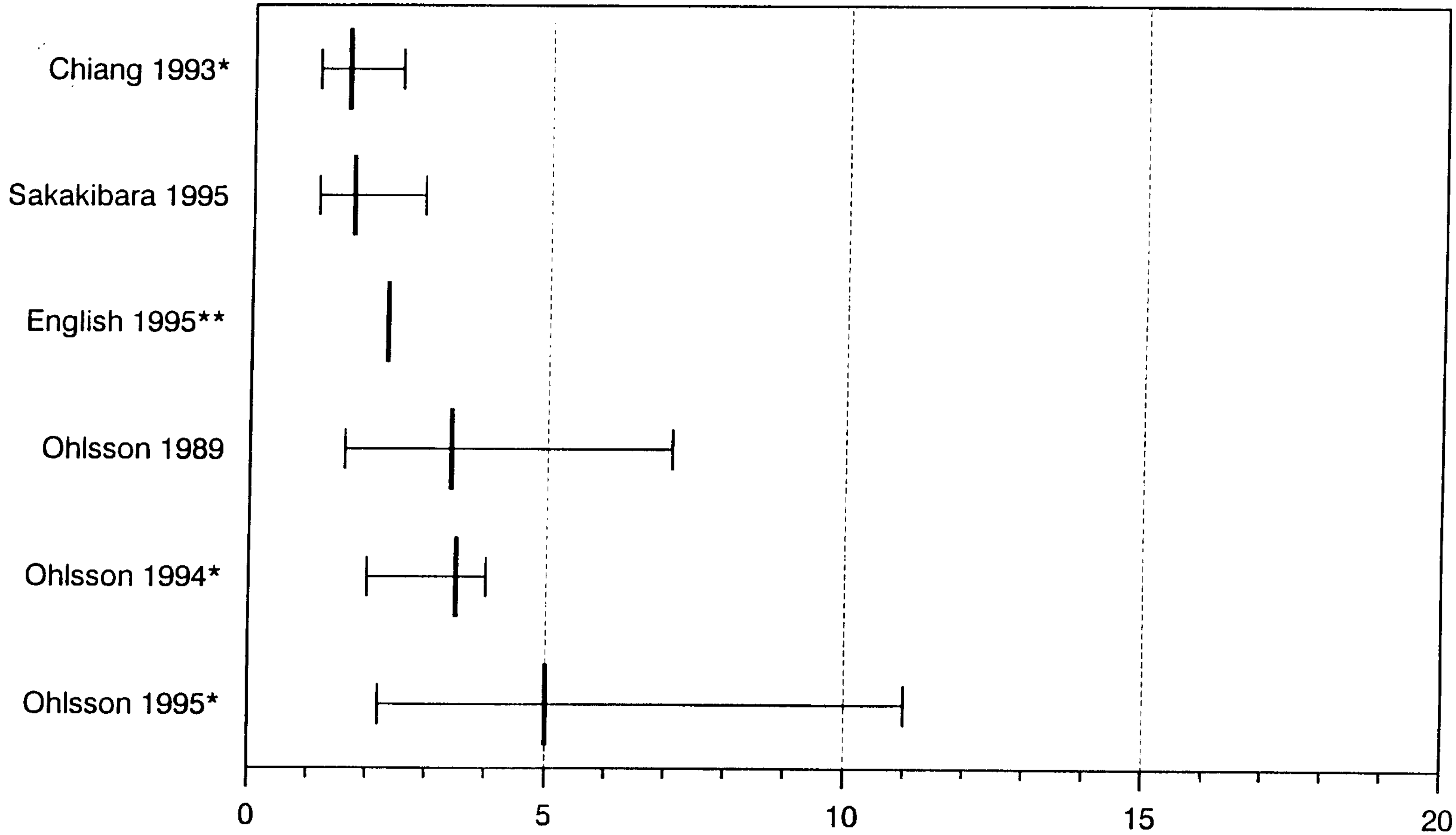
[†]Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

[‡]Not reported.

[§]Repeated shoulder rotation with elevated arm.

Figure 3-1. **Risk Indicator for "Repetition" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

**Risk indicator reported without confidence limits.

Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 3-1.

Table 3-2. Epidemiologic criteria used to examine studies of shoulder 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 shoulder exposure to force
Met all four criteria:					
Chiang 1993	1.8†	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Andersen 1993a	1.38–10.25†	Yes	No	Yes	Job titles or self-reports
Herberts 1981, 1984	15–18†	NR‡	Yes	NR	Job titles or self-reports
Stenlund 1992	2.2–4.0†	Yes	Yes	Yes	Job titles or self-reports
Wells 1983	5.7†	Yes	No	NR	Job titles or self-reports

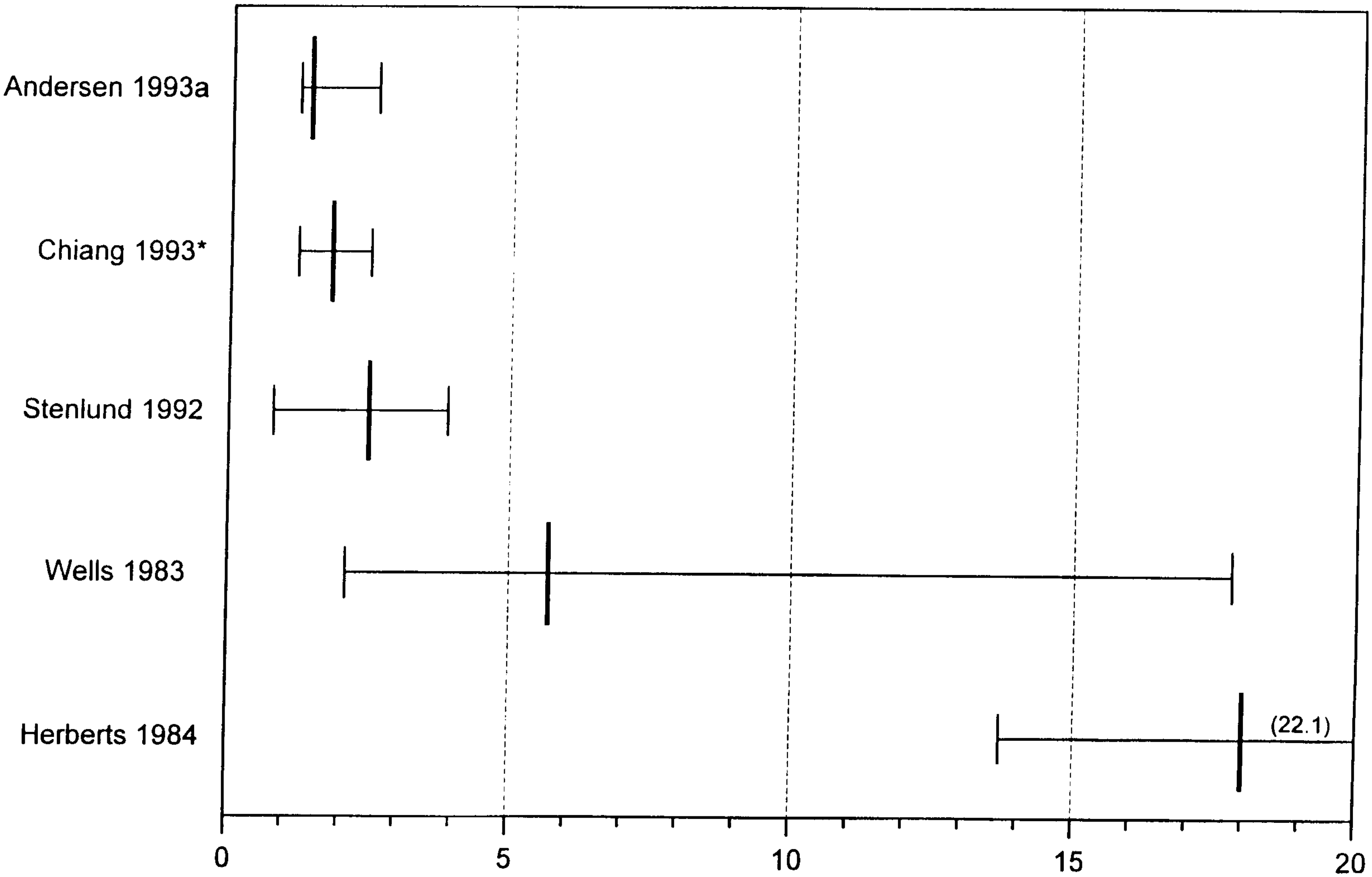
*Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance.

‡Not reported.

Figure 3-2. **Risk Indicator for "Force" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

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

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 shoulder exposure to posture
Met all four criteria:					
Jonsson 1988	NR†,‡	Yes	Yes	Yes	Observation or measurements
Kilbom 1986, 1987	NR†	Yes	Yes	Yes	Observation or measurements
Ohlsson 1994	3.5†	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	5.0†	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Baron 1991	3.9†	No	Yes	Yes	Observation or measurements
Bjelle 1979	10.6†	NR	Yes	No	Observation or measurements
Bjelle 1981	NR†	NR	Yes	Yes	Observation or measurements
English 1995	2.3†,§	Yes	Yes	Yes	Job titles or self-reports
Herberts 1981	8.3	NR	Yes	NR	Job titles or self-reports
Hoekstra 1994	5.1†	Yes	No	Yes	Job titles or self-reports
Milerad 1990	2.4†	Yes	No	NR	Job titles or self-reports
Sakakibara 1995	NR†	Yes	Yes	NR	Observation or measurements
Schibye 1995	NR	Yes	No	NR	Job titles or self-reports

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

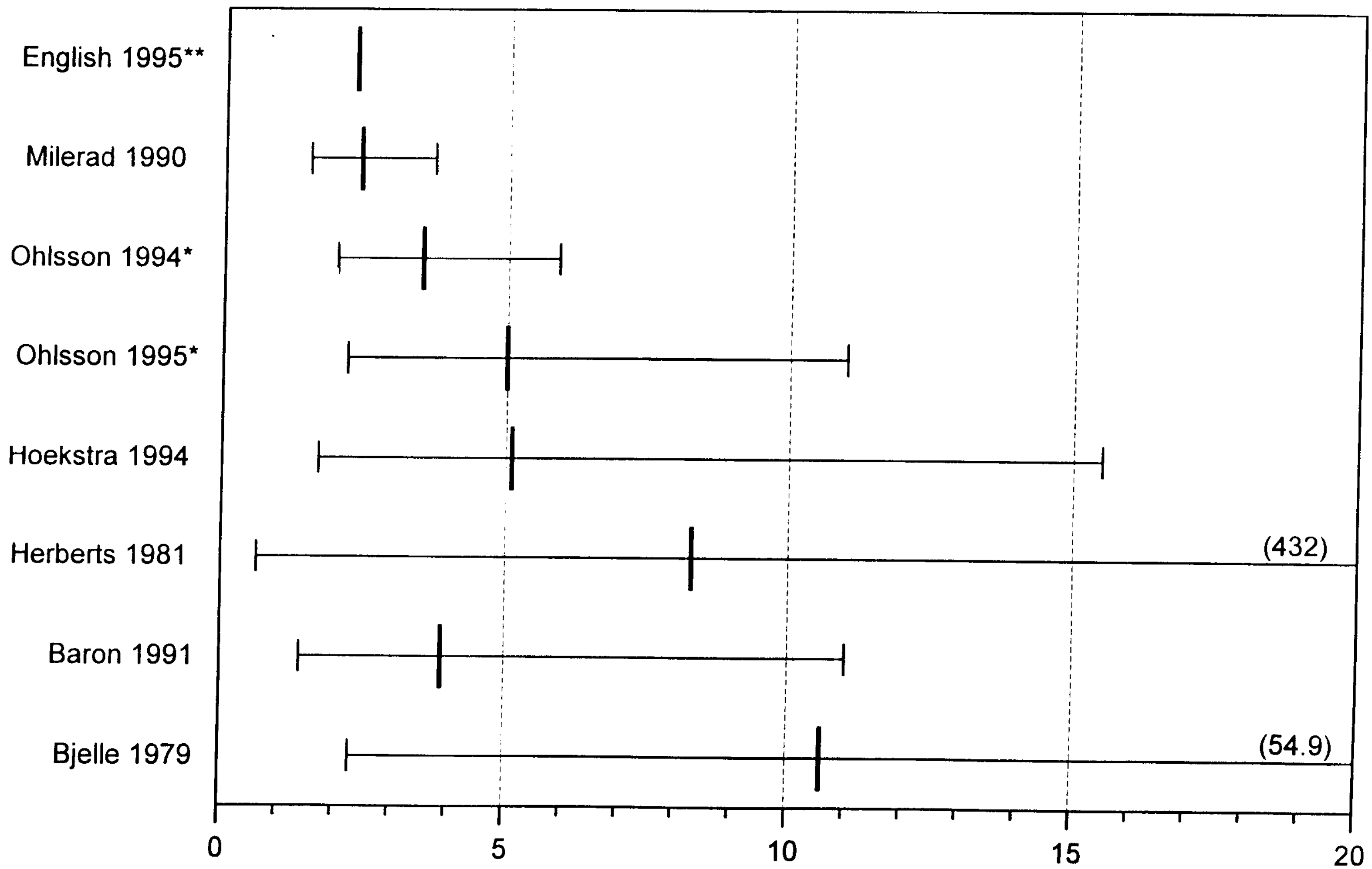
†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

§Repeated shoulder rotation with elevated arm ($p < 0.05$ level, most of study used 0.01 level).

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

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.
**Risk indicator reported without confidence limits.
Note: Four studies indicated statistically significant associations without reporting odds ratios. See Table 3-3.

Table 3-4. Epidemiologic criteria used to examine studies of shoulder MSDs associated with vibration

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 shoulder exposure to vibration
Met at least one criterion:					
Burdorf 1991	1.5	No	No	NR‡	Observation or measurements
Stenlund 1992	2.2–3.1†	Yes	Yes	Yes	Self-reports, weight of tools
Stenlund 1993	1.7–1.8†	Yes	Yes	Yes	Job titles or self-reports

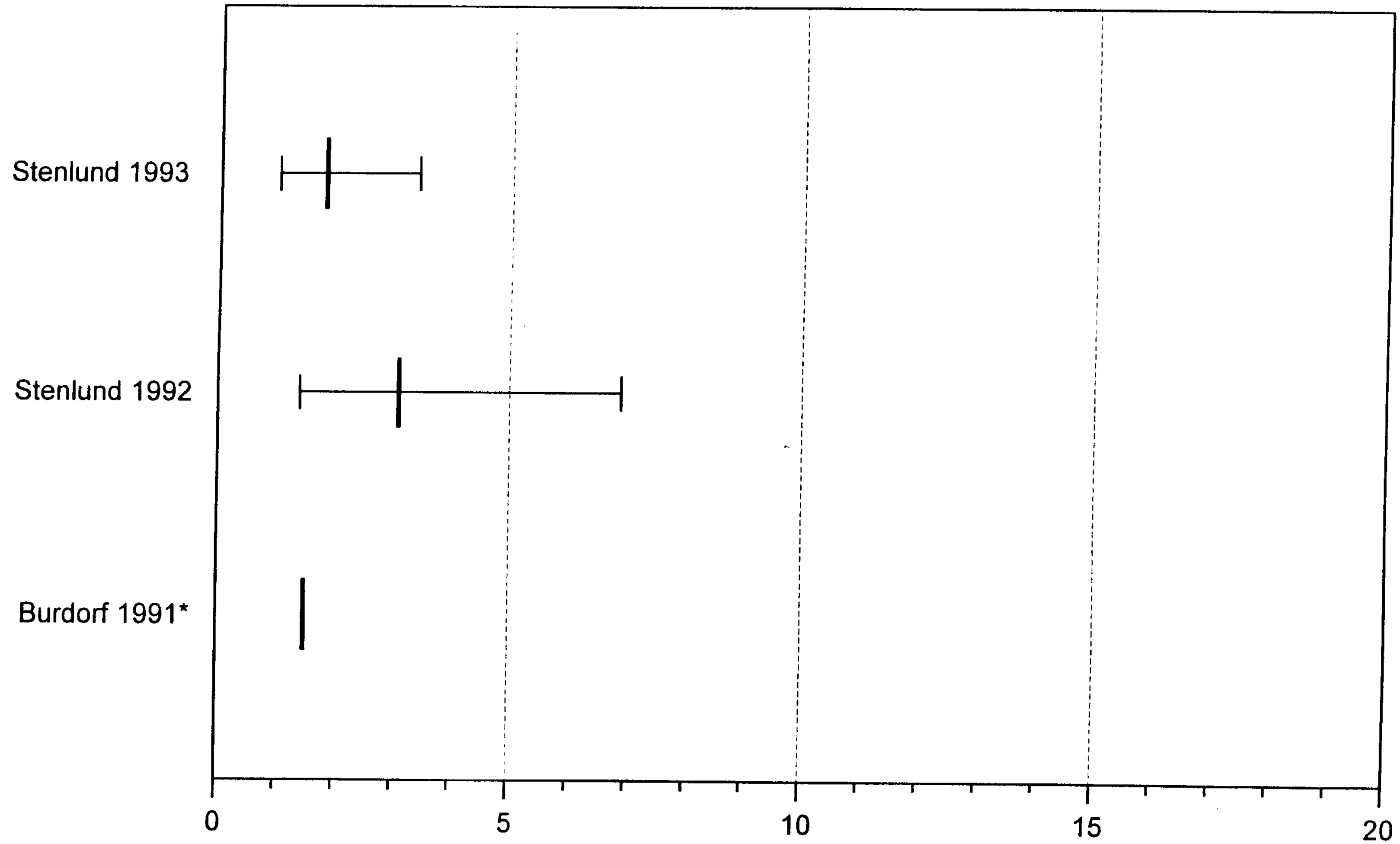
*Some risk indicators are based on a combination of risk factors—not on vibration alone (i.e., vibration plus force, posture, or repetition). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance.

‡Not reported.

Figure 3-4. **Risk Indicator for "Vibration" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Risk indicator reported without confidence limits.

Table 3-5. Epidemiologic studies evaluating work-related shoulder 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 (SMO), compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic shoulder pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year.	Shoulder pain: Sewing machine operators, 25.2%	8.5%	3.21	1.68-7.39	Participation rate: 78.2%. Examiners blinded to case status. Respondents excluded if had previous trauma to neck, shoulder, or arms or had inflammatory disease at time of response.
			Exposure: Categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs were those involving high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs were those involving medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	Years of exposure: 0-7=12.3%		1.56	0.76-3.75	ORs adjusted for age, having children, not doing exercise, socioeconomic status, smoking, and current neck/shoulder exposure.
				8-15=33.7%		4.28	2.14-10.0	
				>15=57.1%		7.27	3.82-16.3	Age-matched exposure groups and controls.
			For the analysis, "length of employment as a sewing machine operator" was considered the variable of interest, the rest were confounders.					Presented study as "general survey of health in the garment industry" to minimize information bias.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 120 were randomly selected and 82 exposed workers were categorized by number of years of employment: 0 to 7 years, 8 to 15 years and greater than 15 years. These were compared to a referent group of 25 auxiliary nurses and home helpers. A total of 107 subjects participated.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpatory tenderness in cervical segments or irradiating pain or tingling at maximum movements or positive foraminal test. Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs involved medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	Rotator cuff syndrome: Number of workers by exposure time in years: 0-7: 1; 8-15: 6; >15: 11	Controls: 1	Chi sq for trend=9.51, $p<0.01$		Participation rate: 78.2%; logistic regression limited to a combined neck/shoulder case definition. Age-matched exposure groups and controls. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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	124 Grocery checkers using laser scanners (119 females, 5 males) compared to 157 other grocery workers (56 females, 101 males). Excluded 18 workers in meat, fish, and deli departments, workers under 18, and pregnant workers.	Outcome: Based on symptom questionnaire and physical exam. (1) Rotator cuff syndrome—pain with resisted abduction or deltoid palpation (2) Bicipital tendinitis—pain on Yergason's maneuver. Case defined as having positive symptoms in shoulder and a positive physical exam of a particular body part. Symptoms must have begun after employment at the supermarket and in the current job; lasted one week or occurred once a month during the past year; and where there was no history of acute injury to body part in question. Exposure: Job category and estimates of repetitive and average and peak forces based on observed and videotaped postures, weight of scanned items, and subjective assessment of exertion.	Checkers: 15% Checkers using scanners: 34% Checkers 5'2" or less in height: 21%	Other grocery workers: 7% Other grocery workers 5'2" or less in height: 13%	Checkers vs. others: OR=3.9 Checkers using scanners vs. others: OR=8.6 Checkers <5'2" vs. other grocery workers <5'2": OR=2.1	1.4-11.0 1.0-72.2 0.7- 6.9	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. Logistic regression model adjusted for duration of work. No difference in groups between age, gender, and hobbies so that these were not controlled for. Number of hr worked/week as a checker statistically significantly related to shoulder disorders for workers checking >25-hr/ /week (OR=3.5, $p<0.05$) (OR estimated from figure). 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. Multiple awkward postures recorded for upper extremities among cashiers. No statistical significance associated between duration of employment as a checker and shoulder MSDs.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Bergenudd et al. 1988	Cross-sectional	574 of 830 survey respondents participated in a health exam. In 1983, 1,070 residents of Malmö, Sweden, responded to questions on shoulder pain in a health survey as part of a longitudinal study begun in 1,938 of 1,542 residents.	Outcome: Based on symptom survey: Occurrence of shoulder pain lasting $24 hr during the last month and physical exam (joint motion, tenderness on palpation of supraspinatus, biceps, tendons and acromioclavicular joint). Exposure: Based on job classification; classified as: Light physical demands (white collar) =275; Moderate physical demands (nurses, light industry)=237; Heavy (blue collar, e.g., carpenters, bricklayers)=50.	Prevalence of occupational workload in subjects with shoulder pain Heavy work: 11% Moderate work: 49% Light work: 40%		ö	ö	Participation rate: 69%. Unknown whether examiners blinded to case status. Analysis stratified by gender. Only 9% of workers included in study were in the Heavy Physical Demands Jobs category, compared to 49% in Light category and 42% in moderate category. Only 1% of females were in Heavy Physical Demand Jobs category. Sick leave due to shoulder pain was restricted to males in jobs with moderate or heavy physical demands (*p*<0.05) (data not shown in article). At one year follow-up, 61 (77%) of 79 subjects with shoulder pain re-examined. 35 had continued shoulder pain. Misclassification of work categories a possibility: Likely no observation of job tasks performed.. No differences in overall physical demands of jobs among subjects with shoulder pain compared to those without shoulder pain, but females with signs of supraspi-natus tendinitis more often had jobs with physical demands. Authors state that shoulder pain may be related to intelligence in males in this study; "more talented" males had less shoulder joint symptoms. We question author's conclusions. Females showed significant association with shoulder pain and dissatis-faction. No association with relation to family or friends or level of life success. Author states both groups of females rated their life success low, and subjects with shoulder pain did not rate level of success differently.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Bernard et al. 1994	Cross-sectional	Of a total population of 3,000 workers in the editorial, circulation, classified advertising, and accounting departments, 1,050 were randomly selected for study and 973 participated; 894 responded to the shoulder questions. Cases fulfilling shoulder definition compared to non-cases.	Outcome: Health data and psychosocial information were collected using a self-administered questionnaire. Definition: Presence of pain, numbness, tingling, aching, stiffness or burning in the shoulder occurring $once a month or 7 days continuously within the past year, reported as moderately severe. The symptom must have begun during the current job. Workers with previous injuries to the relevant area were excluded. Exposure: Based on observation of work activity involving keyboard work, work pace, posture, during a typical day of a sample of 40 workers with symptoms and 40 workers without symptoms. Exposure to work organization and psychosocial factors based on questionnaire responses.	17% (case) 3% (case with daily pain)	ô	Female: OR=2.2 Perceived lack of decision making participation: OR=1.6 Years at the newspaper: OR=1.4 Perceived increased job pressure: OR=1.5	1.5-3.3 1.2-2.1 1.2-1.8 1.0-2.2	Participation rate: 93%. Examiners blinded to case and exposure status. For calculation of the ORs of the psychosocial scales, the responses were divided into quartiles, then the 75th percentile was compared to 25th percentile. Model adjusted for race, age, gender, height, psychosocial factors, medical conditions. Age, height, hr typing away from work, other medical conditions were not found to be significant. In a sub-analysis of jobs with comparable number of males and females, there were no significant factors related to shoulder MSDs.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Bjelle et al. 1979	Case-control	17 cases of shoulder tendinitis from a population of male industrial workers who were patients at an occupational health center. These 17 were chosen from 20 consecutive male patients from 6 industries and had been suffering from pain over a period of >3 months in one or both shoulders. 34 non-cases were matched for age and workshop.	Outcome: Cases were non-responsive to analgesics, non-steroidal anti-inflammatory agents, physiotherapy, and outcome measured by exam. Case defined as shoulder pain lasting >3 months with no resolution post-treatment. Exposure: Defined as work with hands at or above shoulder level. 3 classes work performed: (A) with hands below shoulder or acromion height, (B) at or above acromion 3 to 8 times/day (<1/hr plus for duration >1 min) (C) $8 times at or above acromion ($1/hr. plus duration >1 min). Exposure assessed by interview and physician observation and knowledge of work. Electromyographs on 15 cases. Open muscle biopsies on 11 cases.	With work at or above shoulders: 65%	With work at or above shoulders: 15%	10.6	2.3-54.9	Participation rate: Not reported. Matched for age, gender and workshop. Three of the 20 were diagnosed with inflammatory rheumatoid diseases not previously diagnosed, 17 had no inflammatory rheumatic disease. Mean age (53 years) of cases significantly older than other workers (37.6 years). Myopathic signs not found on EMG or muscle biopsies. Muscle enzymes (creatine phosphokinase and/or aldolase) were elevated in 6 cases. Present and previous employment, physical workload not different between cases and referents. Work performed with hands above acromion height significantly greater for cases than referents. 2-year follow-up showed that only 8 cases working in the same or less heavy types of work, 7 of these had slight shoulder complaints.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Bjelle et al. 1981	Case-control	20 workers of industrial plant consecutively seen at health clinic with acute, nontraumatic shoulder-neck pain. Of these, 13 were not due to causative disease or malformation. These 13 were compared to 26 controls, matched on age, gender and place of work.	Outcome: Physician evaluated all patients with acute non-traumatic shoulder-neck pains referred to the outpaient clinic of the rheumatology department. Each patient had to undergo an extensive clinical examination, including local anaesthesia for the definition of pain location. Exploratory puncture of the glenohumeral joint was performed in patients with tenderness over the joint. Exposure: Anthropometric and Isometric muscle strength were tested with strain gauge instruments. Patients asked to perform their max-mal efforts. Measurements made for the following contractions: shoulder elevation at the acromion, abduction and forward flexion of the shoulder joints at neutral position and semipronated. Grip strength measured by vigorimeter. Video recording of arm movements at work. Shoulder loads estimated from videos. Consisted of measuring the duration and frequency of shoulder abduction or forward flexion of >60°. EMG measurement of shoulder load during assembly work on 3 patients and 2 healthy volunteers. Muscular load level determination made by computer analysis of myo-electric amplitude.	6 with right shoulder tendinitis: 46%	No Controls with tendinitis: 0%	Cases had significantly longer duration and higher frequency of abduction or forward flexion than controls, *p*<0.001. Cases had significantly higher shoulder loads than controls. Median number of sick-leave days significantly different between cases and controls (*p*<0.01).		Participation rate: Not reported. Video analyses were done blinded to case status. No significant difference between cases and controls in anthropometry. Isometric strength test: controls significantly stronger in 6 of 14 tests but probably influenced by pain inhibition in cases. No significant difference in cycle time (9 vs. 12 min) between cases and controls. The supraspinatus muscle showed a significant change of the mean power frequency (*p*<0.05) towards lower levels, indicating a fatiguing process for four of the five investigated assemblers during work.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Burdorf and Monster 1991	Cross-sectional	194 riveters exposed to vibration compared to 194 workers in the same plant with little or no exposure to vibration.	Outcome: Standardized Nordic questionnaire, pain or stiffness. Exposure: Employed >12 months, not exposed to hand/arm vibration. Observation, time-work studies, measurements of vibrating tools. No shoulder measurements. Occupational history treated as dichotomous variable with "1" for heavy physical work.	31%	20%	1.5		Participation rate: Riveters=76%, controls=64%. Examiners blinded to exposure or case status: Not reported. Confounders controlled for included height, weight, and smoking habits. Age and height significantly different between groups. Years of riveting work associated with pain or stiffness in shoulder (0.05#*p*#0.10). Follow-up of nonrespondants showed no difference in age or work experience. Sick leave significantly different.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Burt et al. 1990	Cross-sectional	836 Newspaper employees in the Editorial Department and selected jobs in the Advertising, Circulation, Data Processing, and Finance Departments from 4 company locations, (460 female and 376 male). Cases compared to non-cases.	Outcome: Based on symptom questionnaire. Case defined as pain, aching, stiffness, burning, numbness or tingling in shoulder lasting >1 week or occurring one time/month in the past year. Symptoms must have begun on current job; no previous accident or acute injury to the joint, no related systemic disease. Exposure: Based on questionnaire and job sampling. Exposure variables included work time spent typing on computer; typing speed; keyboard type; hr worked/week; workload; number of years worked.	Time spent typing: 50% Typing Speed: Slow: 6% Moderate: 11% Fast: 15%	42%	õ Typing Speed: Moderate: 2.6 Fast: 4.1 Pre-existing Arthritis: OR=2.3 Dissatisfied with job: OR=2.3	õ 1.1-5.9 1.8-9.4 1.2-4.4 1.2-4.3	Participation rate: 81%. (Authors note that those out on assignment or ill or on vacation counted as non-participants.) Number of workers in number of non-typing jobs not reported. Reporters characterized by high periodic demands (deadlines) although they had high control and job satisfaction. Job analysis found significant correlation (r=0.56) between reported average typing time/day and observed 8 hr period of typing (*p*<0.0001). Length of employment and symptoms in shoulder not significant.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
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: Shoulder girdle pain as defined by Anderson (1984) (the painful condition of the shoulder with limitation of movement, which may occur in association with tension neck or merge with pain in the suprascapular or upper dorsal regions). Symptoms in these regions occurring in last 30 days and physical exam findings of $two tender points or palpable hardenings which may either be caused or aggravated by work conditions. 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 k=<30 sec or >50% of cycle time performing the same fundamental cycles. Hand force estimate 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 repetition and low force; Group II: Low repetition or low force; Group II: High repetition and high force.	Prevalence of Physician-observed Disorders: Group II: 37% (male 31%; female 39%) Group III: 50% (male 50% female 50%)	Prevalence of Physician-observed Disorders: Group I: 10% (male 9% female 10%)	Repetitive movement of the upper limb (Rep): OR=1.6 Sustained forceful movement of the upper limb (force): OR=1.8 Rep times force: OR=1.4 Age: OR=1.0 Gender: OR=1.1	1.1-2.5 1.2-2.5 1.0-2.0 0.9-1.1 0.7-1.7	Participation rate: Not quantified; however, authors stated that "all of the workers who entered the fish processing industry before June 1990 and were employed there full-time were part of the cohort." Of the 232 employees who agreed to participate, 207 met study criteria. Examiners blinded to exposure status. ("Workers examined in random sequence to prevent observer bias.") Workers with hypertension, diabetes, history of traumatic injuries to upper limbs, arthritis, collagen disease excluded from study group. Eight plants used in study. Authors reported "no plant effect". Case definition based on physician diagnosis not significantly different from definition based on symptoms in Groups II : 37% vs. 44% or Group III: 50% vs. 50%. Group I about 2/3 the prevalence (10% vs. 15%). Dose-response for physician observed shoulder girdle pain among three exposure groups. Dose-response for physician observed shoulder girdle pain by gender in three exposure groups. Logistic model controlled for age and gender. Significant trend found for duration of employment and exposure group in workers <12 months, 12 to 60 months, but not in workers employed >60 months.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
English et al. 1995	Case-control	Cases: n=580; 174 males and 406 females with diagnosed soft tissue conditions of the upper limb at 2 orthopedic clinics; ages 16 to 65 years. Controls: 996 controls; 558 males and 438 females attending the same clinics; diagnosed with conditions other than diseases of the upper limb, cervical or thoracic spine; ages 16 to 65 years.	Outcome: Based on standard diagnosis for rotator cuff injury; rupture of the long head of biceps, shoulder capsulitis, symptomatic acromioclavicular arthritis. Exposure: Based on self-reported risk factors at work for musculoskeletal disorders concentrating on detailed components of movements and activities at work: awkward postures, grip types, wrist motions, lifting, shoulder postures, static postures, hand tool use, and job category. Questionnaire obtained information on repetitive movements of the upper limb: Shoulder flexion, shoulder rotation with elevated arm, keeping the whole arm raised >1 min, shoulder rotation with elbow flexed.	Frequency of shoulder problems Rotator cuff: 8.3% Rupture of long head of biceps: 0.3% Shoulder capsulitis: 3.6% Symptomatic acromiocla-vicular arthritis: 0.2%	 ð ð ð ð	Per 5 years of age: 1.4 For elbow flexion: 0.4 Per hr of total daily elbow flexion: 1.1 Repeated shoulder rotation with elevated arm: RR=2.3 Wrist rotation at low rates: RR=0.18 Wrist rotation with increasing rates: RR=2.02/30 reps/min.	1.2-1.5, *p*<0.01 0.2-0.8, *p*<0.01 0.9-1.2, *p*<0.01 Not reported *p*<0.05 Not reported *p*<0.05 Not reported *p*<0.05	Participation rate: 96%. Administered questionnaire blinded to case status. Controlled for age, height, gender, weight, whether MSD was due to an accident, study center. Total daily exposure to elbow flexion did not contribute to shoulder injury. Risks highest for female hairdressers. "Repetitive" defined as a frequency of >once/min of 14 specific movements. Sporting activities, hobbies; average hr of driving/week; whether claim for compensation made were analyzed in models. Jobs with pinching between thumb and forefinger protective against shoulder disorders. May reflect hand movement and exertion with no shoulder movement or exertion. Small number of subjects/group limits power to detect significant differences.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Flodmark and Aase 1992	Cross-sectional	58 industrial workers making ventilation shafts (51 males and 7 females) compared to symptom prevalence in 170 blue-collar workers in Örebro, Sweden. Compared workers with symptoms to those workers without symptoms for risk factor analysis.	Outcome: Questionnaire survey using Nordic questionnaire for symptoms as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Type A behavior assessed by Bortner questionnaire. Exposure: No objective measurements.	Symptoms in past 12 months: 40%	Symptoms in past 12 months: 23%	2.2	1.4-4.4	Participation rate: 87%. Aim of the study was to further investigate relationship between Type A behavior and musculoskeletal symptoms. The Bortner Score for Type A behavior significantly higher for those with shoulder symptoms than those without. No difference in headache, tiredness, sleeping, irritation, lack of concentration or problems with eyes, nose, stomach, skin. Authors suggest that Type A persons more likely to ignore symptoms to minimize their potential effect on work capacity.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Hales and Fine 1989	Cross-sectional	Of 96 female workers employed in 7 high exposure jobs in poultry processing, 89 were compared to 23 of 25 female workers in low exposure jobs.	Outcome: By questionnaire: Period Prevalence: Symptoms in last 12 months. Case defined as: pain, aching, stiffness, numbness, tingling or burning in the shoulder, and symptoms began after employment at the plant; were not due to a previous injury or trauma to the joint; lasted >8 hr; and, occurred 4 or more times in the past year.	Any symptom of the shoulder: 49% (high exposure group)	43% (low exposure group)	1.2	0.7-2.0	Participation rate: 91%. Examiner blinded to case and exposure status. Analysis adjusted for age and duration of employment.
				Period prevalence for shoulder case: 19%	4%	3.8	0.6-22.8	Although shoulder MSDs surveyed by questionnaire, exposure assessment was based on hand/wrist exposure, so that risk for shoulder may not be accurate.
			Point Prevalence: Determined by physical exam of the upper extremity using standard diagnostic criteria case must also fulfill symptom definition (listed above).	Point prevalence for shoulder case: 7%	4%	0.9	0.1-7.3	High exposure departments: Breast trim, thigh debone, leg cut/disjoint, tender cut, knuckle cut, breast, knuckle cut, thigh fat trim.
			Exposure: Observation and walk-through; jobs categorized as High exposure and Low exposure based on estimated hand force and hand repetition, not shoulder exposure.					Lower exposure departments: Breast, thigh, or quality control inspectors.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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	533 Telecommunication workers (416 females and 117 males) in 3 offices, employed $6 months. "Cases" fulfilling shoulder WRMSD definition compared to non-cases.	Outcome: Self-administered questionnaire and standard physical examination; case defined as: pain, aching, stiffness, burning, numbness or tingling >1 week or >12 times a year; no previous traumatic injury to the area; occurring after employment on current job within the last year and positive physical exam: moderate to worst pain experienced with positive physical finding of the symptomatic joint. Exposure: Work practices and work organization assessed by questionnaire and observation; number of keystrokes/day. Physical workstation and postural measurements obtained but not used in final analyses.	Rotator cuff tendinitis: 6% (n=513) Bicipital tendinitis: less than 1% (n=516) Overall shoulder: 6%		Fear of replacement by computers: 1.5 Number of times arising from chair: 1.9	1.1-2.0 1.2-3.2	Participation rate: 93%. Physician examiner blinded to worker case study. Logistic analysis adjusted for demographics, work practices, work organization, individual factors; electronic performance monitoring; DAO keystrokes; Denver DAO keystrokes/day. ORs for psychosocial variables represent risk at scores one standard deviation above mean score compared to risk at scores one SD below mean. Because of readjustments and changes of workstations during study period, measurements of VDT workstations considered unreliable and excluded from analyses. Number of hr spent in hobbies and recreational activities not significant. Although keystrokes/day was found to not be significant, data available was for workers typing an average of 8 words/min over 8-hr period. 97% of participants used VDT $6 hr/day, so not enough variance to evaluate hr of typing. Over 70 variables analyzed in models may have multiple comparison bias.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Herberts et al. 1981	Cross-sectional	131 male shipyard welders with >5 years of work experience compared to 57 male office clerks. All workers participated in the shipyard's medical program which offered medical exams every 5 years.	Outcome: Positive answers to questions about repeated occurrences of shoulder pain during work; shoulder stiffness that affected work and weakness in shoulder that affected work or weakness or numbness in arm or hand and participation in a follow up exam. Clinical examination with joint range of motion, active and passive and simultaneous pain analysis, rating of gross power in flexion, abduction and rotation, rating of tenderness to palpation. Exposure: Estimation of workload with assessment of the workplace into 3 groups very high, high or low. Static loading while holding tools; awkward postures; shoulder level or overhead work.	Supraspinatus tendinitis (ST) results of 23 welders called back for clinical follow-up exams: 16 welders had supraspinatus tendinitis. Shoulder Pain reports from the questionnaire: 27%	Shoulder Pain Prevalence from questionnaire: 1.8%	Prevalence rate ratio (PRR) of shoulder pain results from questionnaire, welders vs. office workers: PRR=15.2 PRR from estimated prevalence ("proportionation" of cases) reported in article: PRR=18.3	2.1-108 (90% CI) 14.7-22.1 (90% CI)	Participation rate: Not reported. Incidence estimated to be 15 to 20% a year. Welders with and without tendinitis were age-matched. We question the methods used to approximate the prevalence of shoulder tendinitis. Authors stated that they took into account the missing data in the investigation and assumed that the drop-out group did not deviate from the examined group, so they used "proportionation" to obtain the number of cases of supraspinatus tendinitis cases in the welders for calculations of prevalence rate ratios; number of supraspinatus tendinitis cases increased from 16 to 24. Number of years active welding, shoulder load, and welding years showed no significant difference. However, a sample size of 11 matched pairs may not have enough power to detect a difference. Turnover of shipyard welders mentioned at 33%. Shoulder tendinitis was not found to be associated with increasing age.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Herberts et al. 1984	Cross-sectional	131 male shipyard welders and 188 plate workers compared to 57 male office clerks. Welders and plateworkers chosen had >5 years of job experience. 23 symptomatic welders, 30 symptomatic plate workers compared to 18 asymptomatic welders and 30 plate workers by clinical exam. Age-matched pairs: 11 welders; 15 plateworkers.	Nurse-administered symptom questionnaire: Case defined as pain, weakness, stiffness in shoulder excluding effects originating from neck, plus clinical exam with tenderness, range of motion gross power measured by dynamometer. Exposure: Observation of jobs; workers compared by use of job title; EMG measurements of muscles of shoulder region. Electromyographic analysis of the shoulder muscle load completed on 9 volunteers to study the influence of hand tool mass and arm posture.	Question-naire results, shoulder pain of the supra-spinatus tendinitis type Welders: 27% Plate-workers: 32% Supraspi-natus tendinitis results of 23 welders called back for clinical follow-up exams: 16 welders had supra-spinatus tendinitis Supraspi-natus tendinitis results of 30 plate-workers called back for clinical follow-up exams: 15 plateworkers had supra-spinatus tendinitis	Question-naire results, shoulder pain of the supraspi-natus tendinitis type: Office worker: 2%	PRR=18.3 PRR=16.2	13.7-22.1 (90% CI) 10.9-21.5 (90% CI)	Participation rate: Not reported. Not mentioned whether examiners blinded to case or exposure status. Controls were matched for age and gender. Plateworkers with shoulder pain averaged 6 years older than welders with shoulder pain. EMG analysis using fine monopolar wire electrodes showed that in work where the hand was positioned overhead, the intramuscular pressure in the supraspinatus muscle had extremely high pressure levels compared to pressure levels in other skeletal muscles. Turnover rate of welders was 30%; may be explanation for lack of association with duration. Welding seen as static work; plateworking dynamic work.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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 shoulder, and no previous injury; symptoms began after starting the job; lasting >1 week or occurred once a month within the past year; reported as “moderate” or greater on a 5-point scale. Exposure: Observation of work stations, measurement and evaluation of work station; observation of postures.	Center A: 13%		õ	õ	Participation rate: 95%. Representatives perceived little control over actions of others; little participation in decision making; little freedom to regulate own activities. Perception that workload was high and variable. Analysis controlled for gender and location and interactions checked. Variables considered in logistic model included location, age, seniority, hr spent typing at VDT, hr on the phone, 3 chair variables, and perceived adequacy of: (1) chair adjustment, VDT screen, (2) keyboard adjustment, VDT screen, (3) desk adjustment; job control, workload variability. Center B location had nonadjustable work stations and mostly nonadjustable chairs causing elevated arms, hunched shoulders and other undesirable postures. Linear regression also performed on psychosocial variables in separate models for health outcomes of job dissatisfaction and mental and physical exhaustion (not for shoulder MSDs). Did not include non-work-related variables in analyses.
				Center B: 44%		4.0	1.2-13.1	
				Non-optimally adjusted desk height work		5.1	1.7-15.5	
				Non-optimally adjusted screen		3.9	1.4-11.5	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Hughes et al. 1997	Cross-sectional	104 male aluminum smelter workers: 62 carbon setters, 36 crand operators, 9 carbon plant workers. There were 14 workers who were not from selected jobs and were excluded.	Outcome: Symptoms occurring in the shoulder >once per month or lasting longer than 1 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 used. Exposure: For carbon setters and crane operators (non-repetitive jobs) and modified job-surveillance checklist method was used. Job task analysis used a formula based on the relative frequency of occurrence of posture during tasks.	14.9% with positive symptoms and physical exam. 24% had symptoms in the elbow-forearm in the previous week.	ð	Model based on MSD defined by symptoms and physical exam Age: OR=0.93 Good health: OR=0.35 Low decision latitude: OR=4.0 Years of forearm twist: OR=46 Model based on MSD defined by symptoms Age: OR=0.96 Smoker: OR=0.41 Low decision latitude: OR=4.5 High Job demand: OR=3.0 Years forearm twist: 92	 0.8-1.0 0.1-0.87 0.8-19 3.8-550 0.8-0.98 0.1-1.4 1.3-16 0.7-13 7.3-4	Participation rate: carbon setters: 65%; crane operators: 56%; carbon plant: 33%. Examiners blinded to exposure and health status: Not reported. 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 of handling >2.7 kgs./hand, (2) push/pull, (3) lift/carry, (4) pinching, (5) wrist flexion/extension, 60 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 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Ignatius et al. 1993	Cross-sectional	1,917 of 3,248 male postal employees completed an interviewer-administered questionnaire; 1,081 were letter delivery postmen compared to 836 other postal workers.	Outcome: history of symptoms and severity of recurrent joint pain as defined by Wells et al. [1983]. Exposure: work factors related to weight of letter bags, distance walked each day, use of transporting tools. Postmen carry/day an average load of 45 lbs; walked 4.5 km plus 1,300 steps for 3.7 hr/day.	Recurrent joint pain: 55.1%	38.4%	1.8	1.5 -2.2	Participation rate: 59% Severe shoulder pain associated with age, work experience, bag weight and walking time. Bags usually carried on one shoulder.
				Severe joint pain: 12.0%	6.2%	2.2	1.5-3.1	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Jonsson et al. 1988	Prospec-tive	Electronics Workers (n=69 females) out of initial 96 workers. (See Kilbom et al. 1986 for initial study.)	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of $2, on a 4 point scale; "severe" symptom score equals 4. Exposure: Carried out at outset of study: Maximum voluntary isometric contraction (MVC) of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Videotaping performed for the analysis of working postures and movements. Reallocation tasks: Non sitting; no inspection of small details on printed circuit boards; standing and walking, occasionally sitting; caretaker work; surveillance of machinery; and assembling bigger and heavier equipment.	Severe shoulder disorders: 22% at 2nd exam After 1 year; 24%	Initially: 11% of subjects had shoulder MSDs 20% with unchan-ged working conditions	At 3rd exam during 3rd year of longi-tudinal study: 38 subjects reallocated to varied tasks had improved (16% of these had severe symptoms initially) significance at *p*<0.05 Those with unchanged working tasks deteriorated further (26%).		Participation rate: 72% of original group had 3 exams one year apart. 80% had 1st and 3rd year exams. Questionnaire included spare time physical activity, hobbies, perceived psychological stress at work, work satisfaction, number of breaks, rest pauses. Most of physiologic and ergonomic evaluations conducted only at outset of study. Low muscle strength not a risk factor for subsequent symptoms. Relative time spent with shoulder elevated negatively related to "remaining healthy" after both 1 and 2 years. Muscular strength and endurance not related to improvement nor remaining healthy. At 2nd and 3rd examination, there was a strong negative relationship between "remaining healthy" and satisfaction with colleagues. Predictors of remaining healthy were work without elevating the shoulders and satisfaction with work tasks. No mention of examiner being blinded to case status. Predictors of deterioration were previously physically heavy jobs, high productivity (after 1 year), and previous sick leave. Predictors of improvement were reallocation, physical activity in spare time, and high productivity (after 2 years).

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Kiken et al. 1990	Cross-sectional	294 Poultry Processors at 2 plants. Plant #1=174 Plant #2=120	Outcome: Period prevalence symptom in last 12 months by questionnaire. Case: Pain, aching, stiffness, burning, numbness or tingling in the shoulder, began after employment at the plant; not due to previous accident or injury outside work; lasted >8 hr and occurred 4 or more times in the past year.	Plant #1: Any symptom for shoulder case: 46%	28%	1.6	0.9-2.9	Participation rate: 98%. Examiners blinded to case and exposure status. Analysis stratified for gender and age.
				Period prevalence: 13%	3%	4.0	0.6-29	Higher exposure jobs (HE) were located in the receiving, evisceration, whole bird grading, cut up and deboning departments. Lower exposure jobs (LE) were located in the maintenance, sanitation, quality assurance and clerical departments.
			Point prevalence determined by physical exam. Rotator cuff defined as pain $3 on a 0 to 8 scale on active and resisted shoulder abduction. Case must fulfill symptom definition (listed above).	Point prevalence for shoulder case: 3%	0%	Indeterminate	ŏ	30% of workers involved in a job rotation program may have influenced associations made.
			Exposure: Determined by observation; level of exposure was based on exposure to repetitive and forceful hand motions, not shoulder.	Plant #2: Any symptom for shoulder case: 50%	30%	1.7	0.8 -3.3	Annual turnover rate close to 50% at plant 1 and 70% at plant 2 making survivor bias a strong possibility -- leading to underestimation of associations.
				Period prevalence: 14%	5%	2.8	0.4-19.6	
			Exposure measurements estimated for the hand and wrist region and *NOT* the shoulder area.	Point prevalence for shoulder case: 3%	0%	Indeterminate	ŏ	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Kilbom et al. 1986	Cross-sectional	106 of 138 female assemblers in two electronic manufacturing companies agreed to participate; 10 excluded because of symptoms in past 12 months. 96 underwent medical, physiological, and ergonomic evaluation. (See Jonsson et al. 1988, earlier in this table, for follow-up.)	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of $2, on a 4 point scale; "severe" symptom score equals 4. Exposure: Carried out at outset of study: Maximum voluntary isometric contraction (MVC) of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Videotaping during the representative part of working day from rear and side. Upper arm studied at rest and in 0 to 30E, 30 to 60E, 60 to 90E, in extension and >90E abduction. The shoulder recorded as resting or elevated; also frequency of changes in posture between different angular sectors/hr, duration of postures. Work cycle time and number of cycles/hr, time at rest for arm, shoulder, head.	MSD symptoms in the shoulder using a four point severity scale: None: 84% Slight: 5% Moderate: 7% Severe: 3%		Logistic Regression model (all variables significant at the $p<0.05$ level). Shorter stature Years of employment in electronics. Fewer total number of upper arm flexions/hr. Greater percentage of work cycle time with upper arm abducted 0 to 30E.		Participation rate: 77%. See Jonsson et al. 1988 for follow-up. No relation between maximal static strength and symptoms. Examiner blinded to case status. Questions included spare time physical activities, hobbies, perceived psychosocial stress at work, work satisfaction, number of breaks, rest pauses. 59% had no symptoms or only slight ones. There were no cases of shoulder tendinitis. Age showed a weak positive correlation. Years of employment, productivity, muscle strength were not related to symptoms. There was large inter-worker variation in working posture and working techniques. The authors followed up on the non-participants and found no significant differences from participants. The more dynamic working technique, the less symptoms.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Kvarnström 1983b	Cross-sectional and Case-control	112 cases of prolonged shoulder disorders identified in a workplace of 11,000 employees. The total number of employees was approximately half factory workers and half office workers. Case more than control study: Controls chosen at random from factory workers, matched for age and gender.	Outcome: Shoulder cases fulfilled the following: symptoms from shoulder was the main reason for inability to work, off work longer than 4 weeks, fatigue in one of both shoulders, pain in shoulder brought on by work and aching at rest were present, and Clinical examination demonstrated tenderness of the shoulder muscles, especially muscularis trapezius, levator scapulae, and/or infraspinatus and/or tenderness at the tendon insertions of the rotator cuff muscles. Muscle strength in shoulder assessed with regards to four functions Exposure: (1) Information obtained through interview: organization of work, physical work load, physical environment, psychosocial work environment, social and ethnic conditions, (2) detailed work history. Factors 0,1, or 2 given to different types of work depending on the workload borne by the shoulder. This factor multiplied by number of years spent at job, and products were added, (3) 2 company engineers graded the degree of monotony and repetitiveness in each job held by cases and controls.			Die casting machine operators (involved heavy work with repetitive movements of the shoulders): RR=5.4 Plastic workers: RR=2.2 Spray painters: RR=3.7 Surface treatment operators: RR=4.7 Assembly line workers: RR=5.2 Ergonomic experts' evaluation: cases had significantly more monotonous and repetitive work than controls.		Participation rate: Not reported. Examiners not blinded to exposure, but selection based on diagnosis of shoulder MSD. All 112 shoulder disorders occurred in laborers; none in office workers. RR for Swedish workers: 0.46; RR for immigrants: 3.1. All cases except one were paid piece rate. "Young persons significantly less ill than middled-aged." The following questionnaire responses were significantly different between cases and controls: Group piece rate, shift work, heavy work, monotonous, stressful, detrimental to health, heavy lifting, and unsuitable working conditions. 9 cases and 1 control cited poor relationship with supervisor. No difference in environmental condition, job content. Cases more likely to be married, have ill spouses, have children at home, work alternating shifts than controls. Work history showed no difference between points for cases and controls (see exposure column). Muscle strength bilaterally significantly lower in cases in four functions.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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	Manufacturing workers: packaging or folding workers (41 males, 328 females); sewing workers (28 males, 534 females); boarding workers (19 males, 277 females) compared to knitting workers (203 males, 149 females); non-office workers (204 males, 264 females) compared with knitting workers (203 males, 149 females). These groups were compared to a referent group consisting of non-office workers maintaining machinery, involved in transportation, or worked as cleaners and sweepers. None of the referent group used rapid repetitive movements comparable to the employees in the other job categories. 21, 25 and 36 operators from each group and 25 of 55 auxiliary nurses and home helpers (controls) participated in the study.	Outcome: Questionnaire and physical examination initially by nurse screening; if employee answered affirmative to question regarding symptoms in upper extremity and/or had any positive physical findings, then had physician examination. The term "shoulder condition" used to define abnormalities of shoulder; consisted of bursitis, bicipital tendinitis and impingement syndrome. Exposure: Based on observation of job activities; only the boarding workers had activities requiring reaching overhead (from personal communication with first author).	Packaging/ folding workers: 2.7%	non-office workers: 2.1%	1.3	0.5-3.8	Participation rate: 91%. Examiners not blinded to exposure status (information obtained from personal communication). 11 Physician examiners; inter-examiner potential problem acknowledged by authors. Questionnaire asked types of jobs, length of time on job, production rate, nature and type of upper extremity complaint and general health history. Age, sex, race, job category and years of employment not statistically significant with "shoulder conditions." Patients with objective diagnostic shoulder findings: Of 45 cases diagnosed: 25 graded as "mild", 19 graded as "moderate; 1 graded as severe.
				Sewing workers: 2.5%	2.1%	1.2	0.5-2.7	
				Boarding workers: 2.4%	2.1%	1.1	0.4-2.9	
				Knitting workers: 1.1%	2.1%	1.3	0.5-3.1	

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Milerad and Ekenvall 1990	Cross-sectional	99 Dentists randomly selected from Stockholm dentist registry who practiced $10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire: Shoulder symptoms at any time before the interview "lifetime prevalence." Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Exposure: Questionnaire included: (1) abduction of arm, particularly in sit-down dentistry, (2) static postures, (3) work hr/day.	Male: 36% Female: 67% Neck and shoulder: 36% Neck and shoulder and upper arm: 16%	15% 28% 17% 3%	2.4 2.4 2.1 5.4	1.0 -5.4 1.5-3.7 1.3-3.0 1.6-17.9	Participation rate: 99%. Stratified analysis by gender. No difference in leisure time exposure, smoking, systemic disease, exposure to vibration. Symptoms increased with age in female dentists only. Duration of employment highly correlated with age (r=0.84, 0.89). No relation between symptoms and duration of employment. Equal problems dominant and nondominant sides.

(Continued)

Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Ohara et al. 1976	Cross-sectional and Pro-spective	For cross-sectional study: 399 cash register operators compared with 99 office machine operators and 410 other workers (clerks and saleswomen). All female. For prospective study: 56 workers employed <7 months had testing pre- and post-intervention using questionnaire and physical exam. 86 operators, newly hired after interventions, also had evaluation after 10 months of working.	Outcome: Assessed by standard health inventory and medical examination (used clinical classification according to the committee on cervicobrachial disorders of the Japan Association of Industrial Health, in Table 3 in the paper). Periodic physical exam performed twice a year from 1973. Primary exams performed on 371 operators. 130 (35%) received detailed exams. Exposure: To repetitive movements relocating merchandise across counter and bagging, involved muscle activity of the fingers, hands, and arms; extreme and sustained postures. Interventions: (1) a 2-operator system, 1 working the register, one packing articles, changing roles every hr; (2) continuous operating time <60 min; max. working hr/day 4.5 hr; (3) 15- min resting period every hr; (4) electronic cash registers with light touch keyboard substituted for half of previously used mechanical cash registers.	Shoulder stiffness: Cashiers: 81% Shoulder dullness and pain: Cashiers: 49%	Shoulder stiffness : Office Workers: 72% Shoulder dullness and pain: Other workers: 68% Office workers: 30%	1.7 2.0 2.2	1.0-2.8 1.4-2.8 1.4-3.5	Participation rate: for prospective study = 100%. Participation rate: for cross-sectional study, not reported. Unknown whether examiners blinded to case status. Interventions did not reduce complaints in the shoulder region, but did improve symptoms in the arms, hands, fingers, low back, and legs. The lack of improvement in the shoulder region was stated to be due to the use of the same narrow check stands, unsuitable counter height, and necessity of continuous lifting of the upper limbs. Operators hired after the interventions and then examined after 10 months had less Grade I, II , or III occupational cervicobrachial disorders in examination than those hired before intervention. Only 14.5% with >3 years employment at worksite. Narrow work space and counter height not adjusted for height of worker.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**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: Based on questionnaire: Any shoulder pain, shoulder pain affecting work ability, and shoulder pain in the last 7 days. Exposure: Based on job category.	Shoulder pain in previous 12 months: 55%	45%	2.0	1.1-4.0	Participation rate: Not reported. Significant association for shoulder symptoms and medium and fast pace compared to slow pace but not very fast pace.
				Shoulder pain in previous 7 days: 38%	18%	3.4	1.6-7.1	Significant association with duration of employment (*p*=0.03), but much stronger for workers <35 years than workers >35 years. Significant interaction between age and employment.
				Work in auxiliary previous 12 months: 21%	10%	2.4	1.0-5.8	Older females employed for shorter periods had more symptoms than younger ones.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Ohlsson et al. 1994	Cross-sectional	Exposed Group: 206 of 247 females working in 13 fish processing plants participated. 322 females who left employment in the fish processing industry in the 10 years prior to the study. Comparison group: All 208 females employed in the same towns as the exposed; 71 were employed in day nurseries; 92 in offices; 42 caretakers of elderly; 3 gardeners.	Outcome: Defined by criteria from questionnaire and physical examination: standard diagnosis of frozen shoulder, supraspinatus tendinitis, infraspinatus tendinitis, bicipital tendinitis acromioclavicular syndrome. Exposure: Assessed by questionnaire (length of employment; psychosocial factors, physical factors) and by observational methods (Ergonomic Workplace Analysis) and NIOSH guidelines for lifting. Analyzed 10 items: work site, general physical activity, lifting, work postures and movements, job content, job restrictiveness, worker communication, difficulty of decision making, repetitiveness of the work, and attentiveness. 74 workers videotaped $10 min. from the back and sides. Average counts of two independent readers for frequencies, duration and critical angles of movement used.	Frozen shoulder: 2%	0.5%	4.1	0.5-37	Participation rate: 83%. No exposure information available to examiners, however, it was not possible to completely blind the study/referent group status. All activities (trimming of cod, packing fish and herring filleting) were found to be highly repetitive with poor working postures and fast movements by standardized “ergonomic workplace analysis” (EWA) methods; very few pauses in the work cycle; tasks not varied. Sports activities were highly associated with shoulder tendinitis (OR=4, 9) in multiple logistic regression analysis. In the control group, prevalences of upper limb disorders increased substantially with age. Among the exposed, the prevalence remained almost constant with age. Excess prevalence for exposed females most pronounced for females <45 years. There was a pronounced dose-response for disorders of the neck or shoulders vs. duration of exposure in the industry. No such associations seen in group >45 years. Authors explained as perhaps due to the “healthy worker effect,” but, it would be more accurate to describe it as “survivor bias.” Psychosocial work environment, stress and worry factors, tendencies towards muscular tension differed significantly between exposed and controls.
				Supraspinatus tendinitis: 15%	5%	3.4	1.6-7.2	
				Infraspinatus tendinitis: 12%	3%	4.7	1.4-15.2	
				Bicipital tendinitis: 10%	4%	2.4	1.1-5.4	
				Acromioclavicular syndrome: 17%	6%	3.1	1.6-6.0	
						PRR of shoulder disorders: 2.95	2.2-4.0	
						PRR for suprapinatus, infraspinatus and bicipial tendinitis: 3.03	2.0-4.6	
						PRR for suprapinatus and infraspinatus tendinitis alone: 3.5	2.0-5.9	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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. 1995	Cross-Sectional	Industrial Workers (n=82 females) exposed to repetitive tasks with short cycles mostly far <30 sec, usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the 7 years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs (female residents of a nearby town currently employed as customer service, ordering and price marking in supermarkets, as office workers (no constant computer work) or as kitchen workers.	Outcome: Measured by physical exam and questionnaire. Frozen shoulder: Limited out-ward rotation and abduction. Infraspinatus, supraspinatus tendinitis: Local tenderness over tender insertion, pain with resisted abduction. Bicipital tendinitis: Pain with resisted elevation of arm, resisted flexion of elbow. Acromicoclavicular syndrome: Pain with horizontal adduction and/or outward rotation of arm. Exposure: Videotaping and observation. Analysis of elevation of the arm: 0E, 30E, 60E, and for abduction 30E, 60E, 90E. 74 workers videotaped $10 min. from back and sides. Average counts of two inde-pendent readers for frequencies, duration, and critical angles of movement used. Repetitive industrial work tasks divided into 3 groups: (a) fairly mobile work, (b) assembling or pressing items, and © sorting, polishing and packing items Weekly working time, work rotation, patterns of breaks, individual performance rate (piece rate). Only exposure readings from right arm were used. Muscle strength (maximum voluntary capacity) measured by hand dynamometer at elevation,	50% (n=82) Employment duration: <10 years (n=19): 53% 10 to 19 years (n=25): 48% >20 years (n=38): 50%	16% (n=64)	5.0 9.6 4.4 3.8	2.2-11.0 2.8-33.0 1.5-13.0 1.4-10.0	Participation rate: current workers: 96%; past workers: 86%; referents: 100%. Questionnaire included individual factors, work/environment, symptoms. No exposure information available to examiners, however, it was not possible to completely blind the study/referent group status. Psychosocial scales assessed: control over one's work, stimulation, psychological climate, work strain, fellowship at work and social network at work. Age, stress/worry tendency, subjective muscular tension tendency, social network outside of work, psychosomatic symptoms. Age and employment status (repetitive vs. referent) controlled for in logistic model. For continuous variables, OR are for 75th vs. 25th percentiles. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks. Logistic models replacing repetitive work with videotape variables found muscular tension tendency and neck flexion movements significantly associated with neck/shoulder diagnoses. Significant association between time spent with upper arm abducted >60° and neck/shoulder diagnoses.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence				Comments
				Exposed workers	Referent group	RR, OR, or PRR	95% CI	
Onishi et al. 1976	Cross-sectional	Female industrial workers: 42 reservationists; 95 fluorescent lamp assemblers; 109 photographic film rollers; 46 teachers of handicapped children; 101 office workers.	Outcome: Based on (1) symptoms of shoulder stiffness, dullness, pain, numbness; (2) pressure (<1.5 kv/cm²) measured by strain transducer at which subject felt pain. (3) physical exam: range of motion, tests, nerve compression tenderness.	Shoulder Tenderness:				Participation rate: Not reported. Unknown whether examiners blinded to case status.
				Reserva- tionists: assemblers: 70%	Office workers (n=101): 48%	1.1	0.6-1.9	Body height, weight skin fold thickness and muscle strength, grip strength, obtained.
			Exposure: Observation of job tasks, then job categorization.	Film rollers: 84%		6.0	3.0-12.2	Body height and weight differences not significant.
			Reservations; Key 15,000 to 20,000 strokes/day or more on busy days 2 to 3 times/week.	Teachers: 58%		1.6	0.7-3.3	Significant difference between body fat in reservationists and office workers.
			Assemblers inspect lamps once every 3.5 to 4.5 sec; all work 12 hr/day.	Shoulder Stiffness:				Significant difference in grip strength in teachers and nurses compared with office workers.
			Film rollers wind 1 roll of 35mm film every 2.5 to 5 sec over 7.5 hr/day.	Reservatio- nists (N=45): 56.6%	34.7%	2.5	1.1-5.6	Those with habitual shoulder stiffness had lower threshold of local tenderness than those without stiffness.
			Prolonged contraction of trapezius noted in 2 film rollers.	Assemblers (N=94): 66.6%		3.7	2.0-7.0	No difference between workers with tenderness threshold above 1.5 Kb/cm² and those below with respect to age, height, weight, skin fold thickness, grip strength, upper arm abduction strength, back muscle strength.
			Teachers and nurses daily care of disabled children e.g., lifting.	Film Rollers (N=127): 59.1%		2.7	1.5-4.9	
			Office workers: Record keeping, copying, etc.	Teachers (N=52): 65.4%		2.1	0.9-4.6	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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 techs or therapists; food service workers. Employees typing >4 hr/day excluded from comparison group.	Outcome: Self-administered questionnaire about pain and standardized physical exam. Cases defined as the presences of persistent shoulder pain (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 NHANES. Exposure: Self-administered questionnaire; number of years in the industry, job category, previous work history.	Garment workers: 19.6%	Hospital employees 8.8%	Shoulder MSDs in Garment workers vs. Hospital employees: OR= 2.2 Shoulder MSDs in Straight stitch workers vs. Hospital employees: OR=3.9 Shoulder MSDs in Top stitch workers vs. Hospital employees OR=5.0	1.0-4.9 *p*#0.05 *p*#0.05	Participation rate: 97% (garment workers), 40% (hospital workers). Analysis stratified for number of years employed, decade of age, native language. Age and length of employment not a predictor of risk of shoulder 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 ($p<0.03$). Logistic regression model found garment work and language significantly related to shoulder pain.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Rossignol et al. 1987	Cross-sectional	191 computer and data processing services, public utilities of Massachusetts State Department, 28 of whom did not use a keyboard with a VDT. Centers selected at random from 38 work sites with >50 employees.	Outcome: Self-administered questionnaire case defined as: "Almost always experienced" shoulder pain, stiffness or soreness or missed work due to shoulder pain, stiffness or soreness. Exposure: Self-reported number of hr/day working on a keyboard with a VDT. Subjects selected after observation of work sites.	0.5 to 3 hr of VDT use/day (n=31): 35% 4 to 6 hr of VDT use/day (n=28): 48% >7 hr of VDT use/day (n=104): 51%	Comparison group (with no computer use) (n=28): 18%	Up to 3 hr of VDT use compared to 0 hr of use. OR=2.5 4 to 6 hr of VDT use compared to 0 hr of use: OR=4.0 >7 hr of VDT use compared to 0 hr of use: OR=4.8	0.7-10.8 1.0-16.9 1.6-17.2	Participation rate: in six industry groups 67 to 100%. Participation rate: for individual clerical workers: 94 to 99%. "Assessed magnitude of confounding by age, cigarette smoking, industry, educational VDT training." The study was presented as "General health survey to avoid observation bias."

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Sakakibara et al. 1987	Cross-sectional	48 Orchard workers (20 males and 20 females). Compared symptoms after completion of thinning of pears, bagging of pears and bagging of apples (covering fruit with paper bags while on the trees). Internal comparison using same study population.	Outcome: Shoulder pain described as the presence of stiffness and pain daily. Exposure: Observation of jobs. Angles of flexion of the shoulder on one subject were measured every 25 min. during a whole day doing each task. Farmers worked approximately 8 hr/day for 10.6 to 13.6 days each year bagging or thinning pears and bagging apples. Median shoulder flexion was 110E to 119E for thinning pears and bagging pears; 30E bagging apples.	Workers thinning pears (estimated from histograms): 46% Workers bagging pears (estimated from histograms): 29%	Workers bagging apples: 21%	Workers thinning pears vs. workers bagging apples: OR=2.2 Workers bagging pears vs. bagging apples: OR=1.4	1.2-4.1 0.7-2.8	Participation rate: 77%. Stratified by gender. General fatigue, gastric disturbances, appetite loss and headache showed no difference in frequency between tasks. Stiffness and pain in shoulders significantly higher from thinning and bagging pears than apples which authors attributed to working posture of elevated arms and neck extension. Exposure data based on measurement of one worker may not be generalized to others. The proportion of workers with >90E forward shoulder flexion was significantly higher for thinning out pears and bagging pears than for bagging apples.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Sakakibara et al. 1995	Cross-sectional	Of 65 female Japanese farmers. 52 completed the questionnaire and physical exam in late June for bagging pears and late July for bagging apples.	Questionnaire: Stiffness and pain in shoulder region. Symptoms in past 12 months for $one day, or symptoms in past 12 months for $8 days. Exam: Muscular tenderness in shoulder region; maximal grasping power measured by dynamometer and back muscle power by myosphenometer. Exposure: Observation of tasks and measurements of representative workers (only two workers measured). Angle of arm elevation during bagging was measured in one subject. Angle of forward flexion of shoulder for bagging pears was 110 to 139º. 75% of angles were above 90º. For bagging apples the angle of forward flexion was 0 to 140º; 41% of the angles were >90º.	Pear bagging Muscle tenderness: 48.1% Pain in joint motion: 23.1%	Apple bagging Muscle tender-ness: 28.8% Pain in joint motion: 21.2% controls	Workers bagging pears with muscle tenderness vs. apple bagging with muscle tenderness: OR=1.7 Workers bagging pears with pain in joint motion vs. apple bagging with pain in joint motion: OR=1.1	1.1-2.9 0.53-2.3	Participation rate: 80%. Examiners not blinded to case status due to design of study. Same population examined two times. 2nd exam occurred one month after first. These results used in analyses for comparison of two tasks. Stiffness and pain during apple bagging may have been pain that was a residual of pear bagging operations. Number of fruit bagged/day was significantly more in pear bagging than in apple bagging. Exposure measurements only obtained on 2 workers and generalized to all workers.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Schibye et al. 1995	Pro-spective	Follow-up of 303 sewing machine operators at nine factories representing different technology levels who completed questionnaire in 1985. In April 1991, 241 of 279 traced workers responded to same questionnaire.	Outcome: Cases defined by the Nordic questionnaire for symptoms as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Exposure: Assessed by questions regarding type of machine operated, work organization, workplace design, units produced/day, and payment system, time of employment as a sewing machine operator.	Workers who delivered or collected their own materials: 18% shoulder symptoms; the rest 33%	õ	õ	õ	Participation Rate in 1985: 94%. Participation Rate in 1991: 86%. All participants were female. 77 of 241 workers still operated a sewing machine in 1991. 82 workers had another job in 1991. Among those 35 years or younger, 77% had left their jobs; among those above 35 years, 57% had left their jobs. 20% reported musculoskeletal symptoms as the reason for leaving job. No significant changes in prevalences among those employed as sewing machine operators from 1985 to 1991; significant decrease in those who changed employment.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Stenlund et al. 1992	Cross-sectional	55 of 75 rockblastors, 54 of 75 bricklayers randomly selected from union records and 98 of 110 foremen selected from foremen employed in large construction firms.	Outcome: Based on a grading of acromioclavicular joints of shoulders. Grade 0 = normal Grade 1 = minimal changes Grade 2 = moderate changes Grade 3 = severe osteoarthritis Grade 4 = joint destroyed Exposure: Based on self-reported estimates of loads lifted, hr of exposure to vibration, job title, and years of employment. The weights of tools also obtained. Bricklayers lifted a mean of 29,439 tonnes; Rockblasters, a mean of 33,210 tonnes; Foremen, a mean of 2,261 tonnes.	Bricklayers Rt side: 59.3% Lt side: 40.7% Rockblasters Rt side: 61.8% Lt side: 56.4%	Foremen 36.7% 23.4% Foremen 36.7% 23.4%	 2.2 1.8 2.1 4.0 Years of manual work >28 years vs. <10 years Rt side: 2.9 Lt side: 2.5 10 to 28 years vs. <10 years Rt side: 1.1 Lt side: 2.3 Load lifted 725,000 vs. 710 tonnes Rt side: 3.2 Lt side:10.3 Vibration 725,000 hr vs <9001 hr Rt side: 2.2 Lt side: 3.1	 1.0-4.7 0.8-3.9 0.9-4.6 1.8-9.2 1.2-7.4 1.0-5.9 1.1-4.7 1.0-5.3 1.1-9.2 3.1-34.5 1.0-4.6 1.4-6.9	Participation rate: 80%. Classification of X-rays achieved with blinding of investigators to age, name or exposure status. Study looked at manual work and exposure to vibration and relationship to osteoarthritis in acromioclavicular joint using shoulder x-rays. Logistic regression models adjusted for age, smoking, dexterity, checked for interactions. Questionnaire included questions about smoking, dexterity, ethnicity, citizenship. Risks were elevated as length of employment increased and as exposure to vibration and amount lifted increased. X-ray grades 2 and 3 for analysis. Smoking significantly associated with osteoarthritis of right shoulder (OR=2, 2.4) but not left side. Significance found, but is it meaningful? Left handedness significantly associated with osteoarthritis of left side (OR=2.5). The age adjusted odds ratio for osteoarthrosis in the right acromioclavicular joint for brick layers and rock blasters as compared with foremen, was 2.16 on the right side 95%CI(1.14-4.09), and was 2.56 95% CI (1.33-4.93).

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Stenlund et al. 1993	Cross-sectional	55 of 75 rockblasters and 54 of 75 bricklayers selected randomly from union records, and 98 of 110 foremen randomly selected from foremen employed in large construction companies.	Outcome: Based on questionnaire of previous injuries and diseases of musculoskeletal system and previous shoulder pain, and physical exam. Case defined as “Signs of shoulder tendinitis” as palpable pain of the muscle attachment or pronounced pain reaction to isometric contraction in any of the 4 rotator cuff muscles or biceps muscles. ”Clinical entity of tendinitis” defined as pain during the last year, pronounced pain reaction to palpation or isometric contraction. Exposure: Based on self-reported estimates of load lifted, hr of exposure to vibration, job title and years of employment. Load defined as 0 to 709 tonnes, 710 to 25,999 tonnes, >25,999 tonnes vibration defined as hr of exposure: 0 to 8,999, 9000 to 255,199, >255,999 hr to each tool multiplied by factor corresponding to vibration energy. Years of manual work: 0 to 9, 10 to 28, >28 years.	Bricklayers Rt. side: 11.1%; Lt. side: 14.8% Rockblasters Rt. side: 32.7% Lt. side: 40.0%	Foremen 8.2% 17.1% 8.2% 17.1%	 0.4 õ 1.7 3.3 Clinical Entity Load Rt. side: 1.0 Lt. side: 1.6 Vibration Rt. side: 1.9 Lt. side: 2.5 Manual Work Rt. side: 0.9 Lt. side: 2.3 Signs of Tendinitis Load Rt. side: 1.0 Lt. side: 1.8 Vibration Rt. side: 1.7 Lt. side: 1.8 Manual Work Rt side: 1.1 Lt side: 1.9	 0.2-1.3 õ 0.7-4 1.2-9.3 0.5-2.2 0.6-4.1 1.0-3.4 1.1-5.9 0.5-1.8 0.9-6.3 0.6-1.8 0.9-3.4 1.1-2.6 1.1-3.1 0.7-1.8 1.0-3.4	Participation rate: 80%. Examiners blinded to exposure status or job title. Unconditional multiple regression analysis adjusted for age, handedness, smoking and sport activities. In all models left and right sides calculated separately. Vibration related to shoulder tendinitis although confounded by static loads and lifting. Interactions tested for. The study looked at manual work and exposure to vibration and their relationship to signs of tendinitis of the shoulder. Exposure-response found where comparison of high vibration exposure compared to low exposure.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Sweeney et al. 1994	Cross-sectional	105 of 164 sign language interpreters for the deaf, who attended a professional conference of sign language interpreters.	Outcome: Symptom questionnaire and physical exam: Symptom case defined as the presence of pain, aching, stiffness, burning, numbness or tingling in the shoulder lasting $ one week or once/month within the past 12 months; no previous injury and symptoms occurred after becoming a sign-language interpreter. Symptom-exam case: Defined as the presence of symptoms and a positive exam for the shoulder. Exposure: Based on questionnaire (years of employment as a sign language interpreter; numbers of hrs/week engaged in signing).	Symptom case: 22% Symptom case with moderate to severe shoulder discomfort: 50%	>20 hr signing, compared to <10 hr/week	2.5	0.8- 8.2	Participation rate: 64%. Examiner blinded to exposure status. Generalizability of results to other sign language interpreters is limited.
				Positive symptom + positive exam: 1%	ō	ō	ō	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder 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
Wells et al. 1983	Cross-sectional	Of 199 letter carriers, 196 were compared to 76 of 79 meter readers and 127 of 131 postal clerks.	Outcome: Telephone interview based on current pain; frequency, severity, interference with work, etc; score of 20 required to be a case. More points given to neck and shoulder problems that interfered with routine daily activities.	All letter carriers: 18%	Postal clerks: 5%	3.6	1.8-7.8	Participation rate: 99% among letter carriers, 92% meter readers, 97% postal clerks. Schooling and marital status asked.
				Letter carriers: increased weight: 23%	Postal clerks: 5%	5.7	2.1-17.8	Symptoms alone used for MSD definition.
			Exposure: Based on job category; based on self-reported information on weight carried, previous work involving lifting and work-related injuries.	Letter carriers: no weight increase: 13%	Postal clerks: 5%	3.3	1.1-11.1	Comparison group (gas meter readers) used because of similar "walking rate" without carrying weight compared to letter carriers. Postal clerks neither walk nor carry weight. During analysis, more weight was given to scoring neck and shoulder than other body regions. Outcome influenced results when ranking of body MSDs, though, would not influence group comparison. Adjusted for age, number of years on the job, quetlet ratio and previous work experience. 104 letter carriers had bag weight increased from 25 to 35 lbs in the year prior to the study. Letter carriers with increased bag weight walked on average 5.24 hr; those with no change in bag weight walked 4.83 hr. Letter bags usually carried on the shoulder.