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Work relatedness of chronic neck pain with physical findings—a systematic review

by Keith T Palmer, DM,[1] Julia Smedley, DM[2]

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Objectives This paper systematically reviews the work-relatedness of neck–shoulder disorders with associated physical findings.
Methods Studies incorporating a physical examination were focused upon. Four detailed reviews were searched, and a systematic search of the MEDLINE, Embase BIDS, and Psychinfo databases was conducted until May 2006, the key words for the outcome and various occupational exposures being combined. The quality of each paper was rated by criteria related to study design, power, sampling methods, response rate, potential for bias, or confounding, and approaches to the assessment of exposure outcome. Weight was given to studies with objective exposure–response information.
Results Twenty-one relevant reports (four prospective) were found. Most considered the outcome neck pain with palpation tenderness (tension neck syndrome) or mixed neck–shoulder disorder (predominantly tension neck syndrome). Most investigations shared common limitations—small sample size, potential for confounding, incomplete blinding, and crude exposure assessment. The overall quality of the information was rated as excellent for only two reports. Exposures included repetitive work (14 studies), static loading (12 studies), neck flexion (7 studies), force (5 studies), and occupational psychosocial factors (7 studies). Moderate evidence was found for a causal relation for repetition at the shoulder and for neck flexion allied with repetition. Limited evidence was found for hand–wrist repetition, neck flexion with respect to static loading and force in the absence of repetition, and high job demands, low control, low job support and job strain.
Conclusion There is some evidence that neck pain with palpation tenderness is causally related to workplace exposures. However, evidence is lacking on the validity, clinical course, and functional importance of this diagnostic entity.

Key terms cervical syndrome; neck disorder; tension neck syndrome.

"Chronic neck–shoulder pain (cervicobrachial syndrome)" was accepted onto the Danish list of prescribed occupational diseases (ie, those for which state compensation can be paid) some 20 years ago. The qualifying exposure is that of "quick and repetitive precision-work with static load of the neck–shoulder area" which has been present for several (by rule of thumb, ≥10) years.

We were asked by the Danish National Board of Industrial Injuries to undertake a systematic review to clarify the appropriateness of this prescription and to explore alternatives by reference to the scientific evidence on the work-relatedness of neck–shoulder disorders. We believe the report, which is provided here with minor modification, has general interest in relation to the compensation of work-related neck disorders and the etiologic assessment of neck–shoulder symptoms in occupational settings.

The commissioning brief imposed the following limits:

- The focus in terms of disease was on "a chronic pain condition of the soft tissue parts of the neck and shoulder girdle" with associated tenderness on palpation, with or without pain radiating into one or both arms. More specific disorders were considered only as a source of diagnostic confusion, and attention was restricted to studies in which symptom reports were supported by findings during a clinical examination.
- The focus in terms of exposure was broad but included the following as possible causal elements:

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(i) *physical risk factors:* forceful exertions, repetitive work, work postures of the neck and shoulder, static work (work with little variation in posture), and precision work, where possible considering these factors separately and in combination, including the effect of different durations and patterns of exposure, and possible exposure–response relationships or thresholds of effect, and (ii) *occupational psychosocial factors*. Factors of personal vulnerability (eg, gender, age, mental health) were also considered.

- The focus in terms of attribution was on the strength of associations between exposures and outcome and the weight of evidence favoring causation as compared with other explanations.

Subsidiary practical questions concerned the validity of the diagnosis and the importance and background characteristics of the disorder under consideration. In respect to the former, reproducibility of the diagnosis was considered. In respect to the latter, we were interested in what was known about the natural history of the disorder, its impact, and its prognosis.

After providing background information, we report the findings of a systematic literature review and a synthesis of evidence directed at these research questions.

The outcome

Neck pain in the general population

Most observations in respect to the general population have concerned neck pain, rather than neck pain with physical signs. In this section we describe the epidemiology of neck pain and conclude with a discussion of few relevant studies on neck pain with supplemental examination findings.

Prevalence. Neck pain is extremely common, as judged by estimates from surveys in various settings. According to studies from Finland and Canada, two-thirds of adults experience neck pain at some time (1, 2). In an age- and gender-stratified sample of adults aged ≥25 years from the Netherlands, the 12-month period prevalence was 31%, with a point prevalence of 21% and a prevalence of chronic symptoms (current pain lasting >3 months in the past 12 months) of 14%(3). A study from the United Kingdom estimated the prevalence of neck pain lasting >1 week in the past 4 weeks in adulthood to be about 14% (4). Three studies from Sweden variously estimated a prevalence of chronic neck pain (>3 or >6 months) of 14–23% (5–7). And a large population survey from Finland indicated a prevalence of severe longstanding neck pain of 9–14% for adults aged ≥30 years (1).

Prevalent neck pain, including chronic neck pain, is reported more often by older persons (8), with a peak sometimes described in mid-life (1, 2, 8, 9). At all ages, symptoms are somewhat more common among women than among men. In a Dutch study by Picavet & Schouten (3), for example, 25% of the women had current neck pain as compared with 16% of the men; in surveys from southern and western Sweden, 19–23% of the women reported chronic symptoms versus 14.5% of the men (5, 6); and in Finland the respective estimates for severe longstanding neck pain were 14% and 9–12% (1).

Other reported associations with prevalent chronic neck pain include smoking (1, 2, 8), obesity (1), local injury (1, 2), low educational level (1, 2), pain at other anatomical sites (1, 2, 8), poor mental health (1, 2, 8, 9), and unemployment (2, 8).

Incidence and natural history of neck pain. A few population-based cohort studies have provided information on the incidence, persistence, and natural history of neck pain in the community. Côté et al (10) studied 1100 randomly selected adults from Saskatchewan. For those free of neck pain in the 6 months prior to the baseline, the 12-month cumulative incidence of new symptoms was 14.6%, but disabling pain (high-intensity pain and at least moderate limitation of activity) developed in only 0.6% of the cohort. Among those with neck pain at baseline, only one-third enjoyed complete resolution a year later; another third reported persistence, almost 10% experienced an aggravation of symptoms, and a fifth had had recurrent episodes of discomfort.

Similar estimates have been obtained in the United Kingdom and the Netherlands. Croft et al (11) found a cumulative annual incidence of 17.9% for neck pain lasting >1 day (for those free of neck pain in the month before the baseline) among adults from south Manchester and a 12-month persistence rate of almost 50% for those who were initially symptomatic (12). Luime et al (13) followed a cohort of 769 service workers from various industries over a 2-year period. The incidence and prevalence rates remained stable in each year of follow-up—with 17% to 18% reporting new symptoms and a third reporting prevalent symptoms. However, the high recurrence rates, at 61% to 65%, suggested that chronic neck pain is an episodic recurrent condition in which the status of many persons shifts over time. In this respect, neck pain appears to behave like low-back pain.

Some studies have identified several nonoccupational risk factors for incidence and persistence. In Saskatchewan women had a generally higher incidence than men (16.9% versus 10.0%), but disabling neck pain was more common among the men (1.1% versus 0.4%) (10). The incidence rate ratios (RR) for persistence, aggravation, and recurrence were all about 1.2 times higher for the women than for the men. In an occupational cohort from

France (14) the incidence of treated neck pain among the women was 2–3 times higher, and that of neck pain lasting >30 days was 5 times higher, than among the men. In Finland, female forestry workers had a higher incidence of radiating neck pain than their male counterparts (15), and in the United Kingdom Croft et al (11) found a similar differential by gender for incidence (RR 1.3) although not for persistence (12). Age has been reported as a risk factor for persistence (10, 12), recurrence (10), and sometimes, but not always, for incidence (10, 11, 14, 15). Several other risk factors have been found to be related to both outcomes, including previous neck injury, concurrent pain at other sites, mental distress, and poor self-assessed health (8, 11, 12, 14, 15). Such factors tended to increase risks by about 1.5- to 2.5-fold. Some studies also suggested possible associations with obesity and smoking (15).

A systematic review of the clinical course of nonspecific neck pain pointed to a shortage of adequately powered and well-conducted studies on the persistence of symptoms (16).

Neck pain with physical signs. Information on the incidence and natural history of neck pain with signs in a clinical examination is more limited still at the population level. However, a few studies provide useful observations. Hoving et al (17) reported an investigation of persistence among Dutch primary care consulters with neck–shoulder pain present for ≥2 weeks and reproduced reliably by passive movement in a physical examination. Around 37% of the cohort was still symptomatic after 12 months of follow-up. Factors associated with nonrecovery were similar to those already mentioned and included age, concomitant low-back pain, and traumatic onset. Other risk factors included female gender and adverse pattern of presenting symptoms (pain >12 weeks, unremitting pain in the 2 weeks prior to presentation, pain radiating below the elbow, and severe functional limitations). In Denmark, a 4-year prospective study of industrial and service workers investigated risk factors for incident neck pain with palpation tenderness (18). New onset symptoms (neck–shoulder pain) arose in 14% of the participants, but the incidence of pain with associated tenderness was substantially lower, at 1.7%. Nonoccupational risk factors for this last outcome included female gender [odds ratio (OR) 1.8, 95% confidence interval (95% CI) 1.1–3.2] and high baseline levels of somatic distress, as measured by a stress profile questionnaire (OR 2.8, 95% CI 1.4–5.4). Finally, Cassou et al (19) studied chronic neck–shoulder pain with limitations of movement in a large cohort of industrial workers undergoing routine health surveillance assessments in France. A comparison of two examinations in 1990 and 1995 suggested a 5-year incidence of 7.3% for men and 12.5% for women, and persistence rates of 35% and 47%, respectively. For both genders, the incidence risk increased with age, as did the risk of persistence among the women (this last pattern being less clear for the men). For both genders, depressive symptoms at baseline were moderately associated with the incidence of neck–shoulder disorders (OR 1.3 for the men and 1.5 for the women).

Pathogenesis

The cervical spine is the most mobile and least stable part of the human spine, with seven vertebrae, five intervertebral discs, and 37 separate articulations, as well as a complex system of ligaments and muscles. Pain may arise from any of these structures.

Unfortunately, although the International Association for the Study of Pain (IASP) recognizes about 60 sources of neck pain, the origin of symptoms is typically unclear (20). The IASP defines three categories as common—cervical spinal pain of unknown origin (neck pain in the absence of a clear diagnosis), zygapophyseal joint pain, and discogenic pain—but the underlying pathology is difficult to distinguish clinically in the absence of invasive tests (eg, discography) (21) or rare special circumstances (eg, trauma, tumors, inflammatory arthropathy, metabolic bone disease). According to classical textbook accounts, pain that arises from deep structures around the neck (ligaments, muscles, joint, discs, or bone) is poorly localized to the neck and shoulders, unless arising from the irritation of nerve roots (22). Radiation occurs the most often to the occiput, nuchal muscles, and superior shoulder, and pain is characteristically altered by neck movement. However, accompanying clinical features tend to be nonspecific. For example, neck stiffness is a common accompaniment of aging and most vertebral diseases, which may or may not be associated with neck pain; numbness and tingling tends to be vague and ill-defined more often than it is segmental or dermatomal; and tenderness is poorly localized, with variable severity. Localized points of myofascial tenderness can be found with nonspecific regional neck pain but also with facet joint disease (21).

Clinical signs tend to accompany symptoms, as evidenced by various epidemiologic reports. Thus tender points are more common in people with neck–shoulder pain than in those without such pain (23), and they increase in number with the reported severity of pain (24, 25). People with neck pain tend to have restricted neck movement more often (26, 27). And those with neck pain are more likely to have positive manual neck provocation tests (28). But tender points and restricted neck movement can also occur in the absence of neck pain (23, 26), and in population samples the correlation between signs and symptoms tends to lie along a continuum, there being no distinct clustering suggestive of different diagnostic entities (25, 26).

Moreover, correlations of symptoms and disability with suspected underlying pathology, although sometimes found, tend to be weak. Degenerative changes (eg, loss of disc height, osteophytosis of vertebral bodies, and osteoarthritis in nearby zygapophyseal joints and other articulating surfaces) can be seen in radiographs of the cervical spine of most adults aged ≥30 years, whether symptomatic or not, and also exist across a continuum of severity. In the EPOZ study in Zoetermeer, radiographs of the lateral cervical spine in anteflexion were assembled for more than 5000 adults and compared with reported symptoms (9). Osteoarthritis of the facet joints and disc degeneration were scored independently by two observers on a 5-point scale according to a standardized atlas. As in other surveys, symptoms were more common at all ages among the women than among the men, and they peaked at around 50 years of age. But, by contrast, the prevalences of disc degeneration and osteoarthritis (which were much lower) were similar for both genders and rose steadily with age. After adjustment for age, the odds ratio for neck pain increased 1.8-fold for the men with advanced disc degeneration and 1.5-fold for the men with advanced changes in osteoarthritis, but no similar relations were found among the women. For both genders, far stronger associations were observed with measures of social inadequacy and therefore suggest that mental health may be a more powerful determinant of neck pain in the general population than radiological evidence of neck pathology. In other general population studies, from northwest England and North America, the number of tender points has been related to measures of depression, fatigue, and sleep disturbance, as well as to female gender and reports of generalized pain (29, 30).

Classification of neck pain

In the absence of reliable clinical pointers or a clear understanding about underlying pathology and the origin of symptoms, approaches to the classification of neck pain have differed, with confusing variations in practice. It seems, for example, that the term “cervical spondylosis” is variably applied and sometimes includes soft tissue, disc, or degenerative lesions (21). In addition, for some, “cervical syndrome” refers to symptomatic cervical osteoarthritis (31), whereas others use it simply to mean chronic neck pain [Hagberg, personal communication]. Similarly, “cervicobrachial disorder” or “cervicobrachial syndrome” has been used at one extreme to mean symptoms radiating from the neck to an upper limb and, at the other, potentially, to cover all soft-tissue rheumatic disorders of the upper limbs and neck. Within the coding scheme of the International Classification of Diseases (ICD), 10th revision, cervicobrachial syndrome has its own category (M53.1), but neck pain with palpation tenderness can also be represented by other categories related to fibrositis (M79.0) or cervicalgia (M54.2). And within research, the anatomical boundaries used to define the neck–shoulder area have varied across national borders [Viikari-Juntura, personal communication].

The main features of three popular classification schemes for neck pain in occupational research (tension neck syndrome, cervical syndrome, and thoracic outlet syndrome) are summarized in table 1. Tension neck syndrome (synonyms: tension myalgia, nuchitis, occupational cervicobrachial syndrome, fibrositis, myofascial syndrome, fibromyositis), as defined by Waris et al (31) was intended to represent a nonspecific regional pain syndrome, while “cervical syndrome” was symptomatic osteoarthritis, and thoracic outlet syndrome was a compression of the distal nerve roots, brachial plexus, subclavian vessels, or combined neurovascular bundle at various sites between the neck and axilla due to mechanical or functional lesions. In principle, therefore, cervical syndrome and thoracic outlet syndrome are specific pathologies, and, by the terms of this review, conditions to be excluded. However, all of the diagnoses have been operationalized in terms of neck pain with a physical sign and in the absence of investigations to demonstrate pathology. Moreover, case definitions have tended to overlap, both conceptually (34) and in actual datasets that, by inference, include patients satisfying several case definitions [eg, in table III of the report by Andersen & Gaardboe (35)]. No longitudinal or clinical studies have been conducted to suggest that the groups so defined differ distinctly in prognosis or in response to treatment or in objective evidence of underlying pathology—criteria that might be used to justify the application of separate diagnoses (36).

For reasons of clarity or pragmatism, many epidemiologic studies have focused solely on symptoms of neck pain or neck–shoulder pain (2–8, 10–15). A few inquiries incorporating a physical examination employ case definitions that faithfully reflect the limitations of understanding. Thus Andersen et al (18, 37) and Kaergaard & Andersen (38) have reported on chronic neck pain with palpation tenderness, rather than claiming to diagnose a specific pathology.

In the absence of a clear gold standard, the validity of these various approaches to diagnosis is difficult to assess. In particular, the process, although supported by physical findings, remains semisubjective. Reliance is placed on the patient’s reported experiences, outside and within the examination, as well as on the examiner’s judgment. There is thus a potential for simple nondifferential misclassification or bias, the latter being of most concern when outcome is assessed unblinded to exposure categorization.

Table 1. Criteria of three common classification schemes applied in occupational health investigations of neck pain. [Y = mandatory item (Y) = optional item, Y* = either one of these]

Disorder	Symptoms						Signs				
	Neck pain	Stiffness or fatigue in neck	Headaches radiating from neck	Neck pain radiating to upper limbs	Numbness in hands	Weakness in upper limb	>1 tender spots or hardenings	Muscle tightness movement	Limitation of neck movement	Radiating pain on movement	Other
Tension neck syndrome											
Waris et al, 1979 (31)	Y*	Y	Y*	.	.	.	Y	Y	.	.	.
Viikari-Juntura, 1983 (32)	Y*	Y	Y*	.	.	.	Y	.	.	.	.
Ohlsson et al, 1994 (33)	Y	Y	Y	.	.	.	Y	.	.	.	.
Cervical syndrome											
Waris et al, 1979 (31)	.	.	.	Y	(Y)	(Y)	.	.	Y	Y	.
Viikari-Juntura, 1983 (32)	.	.	.	Y	.	.	.	.	Y	Y	.
Ohlsson et al, 1994 (33)	.	.	.	Y	Y	Y	.	.	Y	Y	.
Thoracic outlet syndrome											
Waris et al, 1979 (31)	.	.	.	Y	.	.	.	.	.	.	Morley & Adson positive
Viikari-Juntura, 1983 (32)	.	.	.	Y	.	.	.	.	.	.	Positive elevated arm test
Ohlsson et al, 1994 (33)	.	.	.	Y [a]	Y [a]	.	.	.	.	.	Morley & Roo test positive

[a] Ulnar nerve pattern.

Only limited reassurance can be offered on these issues. Of concern is the wide variation in outcome frequency, even when apparently similar criteria are used. Thus, in some occupational surveys, one-third to two-thirds of the workers are classed as having neck pain with tenderness (35, 38–41), whereas, in others, this outcome is far less common (≤10%) (42–44). In a study of slaughterhouse workers by Viikari-Juntura (32) tension neck syndrome was six times less prevalent than among factory workers, and ten times less common than among scissor makers surveyed by other researchers following the same diagnostic schedule. The within- and between-observer repeatability of clinical examination findings was measured and shown to be reasonable in a few of the core studies covered by this review. A few studies that are independent of the main review suggest that physical signs in the neck–shoulder girdle can be reliably ascertained, at least under some circumstances, and, in the core set, the symptom component was sometimes ascertained using the Standardized Nordic Questionnaire, which is a repeatable instrument according to several accounts (45–47). Well-designed studies have assessed outcome independent of exposure, but many have fallen short of this standard or are simply ambiguous about it.

Exposures under study

The physical risk factors examined in this review include frequent or rapid movements of the shoulders, arms, or upper limbs, including work without sufficient rest breaks; repeated neck flexion or prolonged periods with the neck flexed at work; static loading of the neck–shoulder musculature, including work with the arms elevated above shoulder height; heavy physical work or forceful gripping; precision work; hand-transmitted vibration and lifting. The psychosocial risk factors include high mental demands, workload, or pace of work; limited choice, control over work, or decision latitude; job strain (the combination of high demands and low control); limited support from colleagues or managers; monotony; and work dissatisfaction.

Such factors are common across Europe among working-aged people. Thus, at their interview, 31% of the workers from the large Third European Survey on Working Conditions reported that their jobs involved repetitive movements most of the time; 29% reported low control over their workpace; and >50% felt they worked to tight deadlines with little choice over their work arrangements (48). In a household survey of self-reported work conditions in the United Kingdom, 65% of the respondents said that they repeated the same movements again and again, 70% worked to tight deadlines, 45% worked in awkward or tiring positions, and only 20% perceived the support of line managers to be sufficient (49). In addition, in a population-based case–control study from a municipality north of Stockholm (the MUSIC study), 32–58% of the referents reported high demands or low decision latitude, around a third reported repetitive hand–finger movements, 37–38% reported poor general support at work, and 16–17% perceived high time pressures at work (50). Many of the male referents also reported a high physical workload (24%) and working with their arms above shoulder height for ≥30 minutes/day (29%) or with vibrating tools for at least 1 hour/day (29%).

One difficulty in relating these general observations to the occurrence of neck disorders is the complexity of exposures, another is their overlap, and a third is how to obtain a satisfactory measure of them in studies with an epidemiologic scale. "Repetition", for example, may encompass movements of the neck, the neck–shoulder girdle, the whole arm, or merely the distal arm, wrist, hand or fingers. It can be characterized in various ways—by frequency, duration, opportunity for rest breaks, or range or direction of motion (exposure dose is likely to be a function of duration, as well as intensity). Repetition at one joint may be accompanied by static or forceful loading and repetition elsewhere, and jobs that are repetitive tend also to be monotonous, with low job control, paced demands, and deadlines. Difficult choices arise as to which metrics to assess, in whom, and how; and, over and above this, there is a major challenge in disentangling the separate contributions of risk factors.

Occupational health researchers have followed one of the following two general approaches to exposure assessment and the neck: (i) to assess risks by a comparison of job titles, presuming one group to have more "exposure" than another or (ii) to ask workers to estimate their own exposures by completing a questionnaire.

In the common situation of a crude comparison of job titles, all of the members of an occupational group (eg, sewing machinist, cod trimmer) are assigned a common exposure. Thus a degree of nondifferential exposure misclassification will arise, the size of which will be influenced by true exposure variability. Moreover, where associations are found, there may remain significant uncertainty as to the contributing risk factors. The direct approach of questioning workers offers the potential, cheaply and flexibly, to collect additional data, including some that can only be supplied in this way (eg, perceptions about job satisfaction). But some exposures may be hard to recall or self-estimate (eg, cycle time, number of repetitions during a workday, cumulative exposure time), with the possibility of random measurement error (bias towards the null), and, in retrospective and cross-sectional studies, those with symptoms may recall or report their exposures differently from those without (possibly leading to bias away from the null). Nondifferential (51) and differential (52, 53) misclassification have both been found in surveys that compared self-reports with direct observations, with some authors concluding that "the accuracy of assessments is not good for studying quantitative exposure-effect relationships [p 251]" (52) or that "direct technical measurement may be preferable [p 30]" (53).

Thus, in some surveys, the two broad approaches have been supplemented by direct observations in a sample (eg, video tape analysis) to corroborate and validate reports or to characterize the main ergonomic elements of the work. Direct observational methods of exposure assessment tend to be time-consuming and difficult to apply, other than to quotas of workers doing "representative" work. Methodological challenges include, therefore, representative sampling and the translation of group-assessed average levels of exposure to individual persons.

Many of the core studies included in this review are limited by these problems—in particular, the difficulty of characterizing exposures in sufficient detail to distill the potentially causal elements and explore exposure–response relations and the failure to translate from ergonomic observations to specific exposure assignments that were used to inform health analyses.

Methods

Data sources

Two primary sources of data were used for the review. During 1995 and 1997, two comprehensive reviews on work-related upper-limb disorders were published, a reference textbook edited by Kuorinka & Forcier (54) and a critical review of epidemiologic evidence compiled by the National Institute for Occupational Safety and Health (NIOSH) in the United States (55). In addition, in 1999, the European Agency for Safety and Health at Work produced a review of work-related neck and upper-limb musculoskeletal disorders (56), and it was followed in 2001 by a published thesis on work-related risk factors for neck pain by Ariëns (57). We retrieved all of the unique references to neck–shoulder disorders mentioned in these four reports. For completeness, we also retrieved papers listed in some of these reports under nonspecific diagnostic headings (cumulative trauma disorder, repetitive strain injury and occupational overuse syndrome). We then supplemented this information with a systematic literature search employing the MEDLINE, Embase BIDS, and Psychinfo electronic bibliographic databases.

Search strategy

The search was conducted in three stages. For the first stage, key words and medical subject headings were chosen provisionally to represent each outcome and exposure of interest, as well as words and terms representing the ingredients of a physical examination. These were combined using Boolean strings and logical operators. Titles of papers were scanned, duplicates and obviously irrelevant references were eliminated, and the remaining abstracts were read independently by two researchers (JCS and KTP) to decide on the papers to be retrieved, any differences of opinion being resolved by consensus. At this point we compared the outcome of our search up to 2001 with the list of papers we knew to exist from the four earlier reports. This step served both as a check on the completeness of the source reviews and as a way of helping us to refine and improve the search strategy.

For the second stage, additional search terms were added as necessary. The revised search was then run again in its entirety from the start of each database's electronic record up to the third week of May 2006. Any additional abstracts and titles were identified and processed as before, and any new papers were retrieved and added to the list for review. The references of retrieved papers were searched for additional relevant material (using the process of "snowballing").

Some studies that incorporated a physical examination cited the origin, provenance, and measurement properties of their diagnostic methods by reference to separate methodological reports. In the third stage, we identified and retrieved these additional citations through a scrutiny of relevant papers from the first two stages.

The final search strategy is presented in appendix 1, which can be found on the homepage of the *Scandinavian Journal of Work, Environment & Health*.

Inclusion and exclusion criteria

Studies were included if (i) the case definition (outcome) included one or more symptoms *plus* one or more physical signs—neck pain or neck–shoulder girdle pain (with or without radiation to the upper limb) allied with some findings on physical examination and (ii) there was an analysis of risks for such an outcome (or enough data to derive estimates of risk) by occupation or occupational exposure(s).

Tension neck syndrome, cervical syndrome, thoracic outlet syndrome, and other researcher-specified diagnostic labels were eligible for inclusion provided that these criteria could be met.

A few studies defined cases according to our criteria but analyzed them in combination with other disorders of the upper limb to enhance the study power. When >50% of the analyzed material fulfilled our case definition, we recorded the findings under the heading of "mixed neck–shoulder disorders". When <50% fulfilled the case definition, or the proportion was unclear, the study was excluded.

We limited our search to primary research reports published in English. We excluded (i) studies that *only* considered symptoms or *only* considered signs (except to explore the general consistency of evidence), (ii) studies of specific neck pathology, as defined by radiological appearance, (iii) studies that considered only distal arm pain or specific pathology of the shoulder (not neck), elbow, forearm, wrist or hand, and (iv) studies that did not include a control group or internal comparator.

Abstracted information

For each paper that was finally reviewed, we abstracted a standard set of information, comprising details of the study populations, study designs and research settings, outcome(s) studied, confounders or effect modifiers considered, exposure contrasts, and estimates of effect (with confidence intervals).

The elements of case definition were noted in detail, as well as the labels allotted by investigators. Where given, we also recorded the provenance of proposed diagnostic schemes and any estimates of within- or between-observer repeatability, either in the reports themselves or in the references they cited as evidence in support of methods. We also noted whether the outcome was assessed blind to knowledge of exposure and vice versa.

Where counts or prevalence estimates were provided but not relative risks, we calculated odds ratios with exact 95% confidence intervals using STATA statistical software (Stata Corporation, College Station, TX, USA).

We also recorded or estimated effects by different durations, categories, and levels of exposure and weighed the evidence for thresholds of effect and dose–response relationships, in as much detail as the source reports allowed.

Quality assessment

We formed a subjective judgment as to the contribution of each report to knowledge ("quality rating") taking into account its limitations of design, potential for bias, or confounding and power to detect important associations. Studies were ranked higher if they were well-powered, employed a representative sampling frame, achieved a high effective response rate, were prospective, controlled adequately for confounding, had a clear and repeatable definition of outcome, assessed outcome blinded to exposure and vice versa, characterized exposures at least in part by objective means, and provided dose–response information.

We rated each of these qualities individually. A summary of some of the components of our decision making follow. We also formulated a final overall assessment on a 5-point scale. [This assessment did not reflect a simple sum of each individual score but instead represented a judgment informed by them.]

Confounding and effect modification. The potential for important confounding is a function of the relative risk associated with a confounder, its prevalence in the population of relevance, and the likelihood that it might vary importantly according to occupational exposures. In addition, some factors may act as effect modifiers—that is, risks may vary according to their presence or level. On the basis of our general understanding of musculoskeletal disease and our summary evidence on nonoccupational risks for the incidence and persistence of neck pain, the factors that should be allowed for in assessments of confounding or effect modification are (i) age, (ii) gender, and (iii) mental health. Other factors that might be considered include (iv) obesity, (v) smoking, and (vi) past history of neck injury. We rated control of confounding as "good" (++) if the analysis or design allowed for all of the first three items, as "moderate" (+) if it covered two of them, and as "poor" if it covered only one or none of them (–). Reports that allowed for five or more of the highlighted factors, including all of the first three, were scored as "excellent" (+++) in this aspect of methodology.

Bias. Two categories of bias need to be distinguished—"inflationary" bias (bias that could cause important overestimation of relative risks) and bias towards the null (bias that could cause elevated relative risks to be underestimated).

Inflationary bias typically arises from nonindependent assessment of exposures and outcomes or from reverse causation. Thus concern arises when blinding is insufficient and when retrospective and cross-sectional studies rely on self-reports of exposure. Estimates of psychosocial risk suffer from the problem that pain may be a cause, rather than a consequence, of low mood. [Inflationary bias can also arise in the context of an investigated cluster. Studies that make a simple comparison of job title are particularly vulnerable to this problem, although we found no reports linked to an explicit outbreak of symptoms.]

Bias towards the null is of more pressing concern when there is simple nondifferential misclassification of exposure or outcome—as might arise, for example, from an unreliable protocol for assessing outcome, simple errors in recall, and self-estimation of complex exposures or a vague definition of exposure. It can also arise from the "healthy worker" effect and the shift of affected workers to jobs with less exposure—a concern in cross-sectional studies and in case–control studies that fail to inquire about exposures preceding the onset of symptoms.

We scored studies separately according to the potential for each of these biases.

Sampling. We checked to see whether the sampling frame and sampling procedures were clearly stated, whether inclusion and exclusion criteria were clear, and whether we could account for all of the participants at each stage of the account. We graded our findings on a 3-point scale.

Outcome assessment. We assessed whether the case definition was explicit and relevant, whether there was empirical evidence to suggest it was repeatable, and whether the assessment of outcome was blinded to exposure.

Exposure characterization. We considered exposure assessment to be the most informative (+++) when objective observations were used, in whole or in part, to subcategorize persons by the level or nature of exposure (eg, duration, intensity, cumulative dose), and these categories were then used in relevant health analyses. We considered it to provide limited additional information (++) when direct observations led to some general statement about typical exposures of workers with a given job title, but health analyses made no use of the extra detail. We noted whether exposures were ascertained blinded to the outcome status.

Exposure–response information. Some studies defined exposures on a quantitative scale (eg, number of shoulder movements per minute, the percentage of time with the neck flexed), whereas others used ordinal measures (eg, "high", "medium", or "low" in the respondent's opinion). We rated the former more highly (+++) than the latter (++) for physical exposures, while recognizing that the latter was a forced choice for estimates of psychosocial risk.

Response rates and sample size. We calculated effective response rates for the analyses of interest (focusing on response at follow-up in the cohort studies) and summed the numbers involved in each analysis. The impact of the former was likely to vary with the reason for nonresponse and the latter according to the study design (case–control studies having greater power for a given sample size than a cohort study). However, in general terms, we rated response rates of ≥85% as "excellent" (+++), of >75–84% as "satisfactory" (++), and of 50–74% as "fair" (+). Studies fell into four sizes, those likely to have had "very good" statistical power (>1000 participants in relevant analyses) and those of "good" (400–600+), "reasonable" (100–399), or "limited" (<100) sample size.

Completeness of reporting. Incomplete reporting sometimes impaired our capacity to assess overall quality. In reaching the final quality rating, we assumed that missing items did not meet the preceding criteria.

Meta-analysis

We considered the scope for meta-analysis, but, as studies rarely employed the same definitions of exposure and outcome, we decided that such an analysis would be inappropriate.

Rating the evidence on causal associations

Finally, we rated the degree of evidence of causal association between a given exposure and a given outcome according to the template of the Scientific Committee of the Danish Society of Occupational and Environmental Medicine (appendix 2), basing our findings on the strength, consistency, quality, and amount of evidence against specific formulations of outcome and exposure.

Results

Altogether the first search identified 82 potentially relevant research reports and six reviews, and all of them were retrieved and assessed. The second computerized literature search identified 1471 unique titles and abstracts, and these were screened by JCS and KTP, the result being the retrieval of an additional 41 primary reports and 1 review. All of the retrieved papers and reviews were checked for additional references of interest, and this step resulted in another 13 research reports and 1 review being obtained and appraised.

Finally, therefore, a total of 136 primary research reports were each read independently by two observers. Among these, 115 were excluded by consensus, the main reasons being that they (i) did not incorporate a physical examination or did not present data for a case definition that combined symptoms with signs (N=46), (ii) did not investigate the diagnostic entity of interest but, instead, pain or pathology at another site (N=26) or a mixed pathology comprising <50% of cases of neck pain with physical signs (N=8), (iii) did not include a reference group or did not provide enough information to derive estimates of occupational risk (N=20), (iv) were published in a language other than English (N=11), (v) were relevant only to secondary questions of reliable diagnosis or natural history (N=5), and (vi) concerned only users of visual display terminals (N=15).

Some papers were excluded for several of these reasons. [A list of excluded papers, with their reasons, is available from us on request.]

The remaining 21 reports from 8 different countries were included in the review. Table 2, which can be found on the homepage of the *Scandinavian Journal of Work, Environment & Health*, summarizes their main features and our quality assessment of them. Additional details of the diagnostic criteria employed are presented in table 3, also available on the homepage of the *Scandinavian Journal of Work, Environment & Health*, while risk estimates by occupational title, physical exposures, and psychosocial work conditions are shown in tables 4 to 6 on the homepage of the *Scandinavian Journal of Work, Environment & Health*.

After a few general observations, we describe each of the studies in turn and comment on their potential strengths and weaknesses. We conclude with a "best evidence" synthesis and discussion, which are summarized in table 7.

General findings

Altogether 15 investigations were cross-sectional in design (32, 35, 37, 39–44, 59–64), 4 were prospective (18, 19, 38, 58) [1 mostly focusing on baseline findings (38)], and 2 were community-based case–referent studies (50, 65). The studies ranged from very large (N >15 000) (19) to very small (N=30) (58). Most of the studies achieved a high response rate, but, for a few

Table 7. Summary of conclusions in relation to neck pain with palpation tenderness (tension neck syndrome or mixed neck–shoulder disorders with a preponderance of tension neck syndrome)

Exposure(s)	Degree of evidence supporting causal association [a]
Physical	
Repetition at the shoulder	++
Repetition at the wrist–hand	+
Repetition of the shoulder with neck flexion	++
Neck flexion in the absence of shoulder repetition	+
Repetition with static loading of neck–shoulder muscles and neck flexion	++
Static loading of neck–shoulder muscles in the absence of repetition	+
Forceful work	+
Precision	0
Rest breaks (independent of repetition)	0
Lifting or manual handling	0
High physical workload	0
Hand–arm vibration	0
Whole-body vibration	0
Psychosocial	
Job demands	+
Control over work	+
Support at work	+
Job strain	+
Job creativity	0
Job satisfaction	0

[a] For criteria, see appendix 2. Exposures and exposure combinations that do not appear in this table were not studied in the reviewed papers.

(44, 61, 62), a high rate could not be confirmed from the description provided.

The case definitions varied, but fell into four broad categories. [See table 3, located on the homepage of the *Scandinavian Journal of Work, Environment & Health*.] There were 16 investigations of neck pain with tenderness (11 of these using tension neck syndrome as the disease label), 6 of neck pain with pain on neck movement (5 called cervical syndrome), 3 of thoracic outlet syndrome (all with very few cases), and 7 reports of mixed neck–shoulder disorder in which tension neck syndrome or neck pain with tenderness was diagnosed in >50% of the cases (35, 38, 41, 50, 62, 64, 65). Several studies reported on more than one outcome. The reproducibility of the diagnosis was demonstrated for 4 of the studies (18, 35, 37, 38) and suggested in 2 others (39, 63). Blinded assessment of outcome was explicitly declared in 5 studies (18, 35, 37, 43, 61), but may have occurred in several others by virtue of design or previously described methodology (19, 38, 58, 65).

Many physical exposures were considered in the studies, including repetition, neck flexion, static loading, forceful work, lifting, work with the arms elevated, sitting, and hand-transmitted and whole-body vibration, while the occupational psychological exposures included control, support, demand, and perceptions of a stressful work environment. In 14 of the 21 reports, the analysis was principally carried out through a comparison of job titles, but, in 11 studies, physical exposures were objectively characterized to a varying extent (18, 37, 39–43, 61–64). Several studies offered exposure–response information by quantified level of exposure (18, 37, 61, 62) or time worked in the job (35, 38, 41), but in others only crude and sometimes composite exposure variables were used. Three studies analyzed the interaction between physical exposures (18, 37, 43).

Confounding was addressed in various ways (restriction, matching, stratification, regression modeling), but to a greater or less extent, even within reports. Altogether 15 of the 21 studies failed fully to control for age, gender, and mental health, as suggested by us earlier in this review.

Many studies shared several limitations in common—typically, a small sample size (limited precision), limited control of confounding, lack of blinding (risk of inflationary bias), and limited exposure assessment (lack of dose–response information). Such papers tended to present only simple contingency tables (predating the advent of more sophisticated approaches to statistical analysis) and rarely considered psychosocial factors.

We rated the overall quality of information as excellent (+++++) (18, 37) for only two reports, as useful but with important limitations for four reports (+++) (19, 41, 61, 62), as moderately informative (++) for five reports (35, 38, 42, 43, 64), and as limited for 10 reports (+) (32, 39, 40, 44, 50, 58–60, 63, 65). [We stress that this assessment is relative to this particular study question. Some reports contained important information for other areas of inquiry.]

Description of the individual studies

The short descriptions that follow are arranged alphabetically according to the first author's surname. The studies are also ordered alphabetically within the tables [found on the homepage of the *Scandinavian Journal of Work, Environment & Health*], but they are grouped first, by study design in table 2 [found on the homepage of the *Scandinavian Journal of Work, Environment & Health*] and according to the four broad diagnostic groupings employed by researchers in tables 3–6 [found on the homepage of the *Scandinavian Journal of Work, Environment & Health*].

Åkesson et al (59) compared 84 dental personnel with 27 age- and gender-matched nurses. The details of the sampling frame and selection methods were limited. Although described as a follow-up study, the analysis involved a cross-sectional comparison of workers from an earlier survey. No specific assessment of exposure was made. Dental work was assumed to involve a prolonged static workload to the neck, shoulders, and arms, as well as visually demanding precision work, but the extent of exposure was not quantified. The outcome (tension neck syndrome according to the Ohlsson criteria) was assessed by a single observer with "many years of clinical experience" who may not have been blinded to the occupations of the participants. No details were given on the repeatability of the diagnosis. Tension neck syndrome occurred more often among the dental personnel than among the referents with an (derived) odds ratio of 3.2 (95% CI 0.8–18).

This study had several limitations—small size, cross-sectional sampling, lack of exposure characterization (including the nature and level of exposure), and uncertainty about whether outcomes were assessed blinded to occupational title.

Andersen & Gaardboe (35) conducted a survey of sewing machinists, a group whose work involved repetitive and precise movements of the upper limb, as well as prolonged static loading of the neck, shoulders and arms, and sustained neck flexion. Age-matched auxiliary nurses were selected as a comparator, as they were deemed to have a similar social background but a workload that was more varied. Sewing machinists were recruited in two stages, an initial mailing (78% response) and an invitation for a follow-up examination issued to a subset of respondents still employed 2 years later (chosen at random within the strata of employment duration). At the second stage, refusals were few, but the final sample size was modest. The level of exposure was quantified only crudely, according to years in the job. However, a useful strength was the care over outcome assessment. Definitions were precisely formulated, assessments were conducted by two pretrained observers blinded to the knowledge of exposure, and the between-observer reproducibility of palpation tenderness was assessed and found to be satisfactory (kappa coefficients 0.56–0.78). Two outcomes were relevant to this report, cervicobrachial fibromyalgia (in effect neck pain with palpation tenderness) and cervical syndrome. The frequency of both rose strongly with years of employment. Thus the odds of cervicobrachial fibromyalgia were raised 23-fold after >15 years as a sewing machinist versus no years (nursing group). We derived these estimates from a table of frequencies and so could not adjust for age, but the data imply a much steeper gradient with time than might be accounted for by age as a confounder. An age-adjusted analysis was provided for the combined outcome "neck–shoulder syndrome" (mainly cervicobrachial fibromyalgia, but with a significant proportion of cases with rotator cuff syndrome) and showed an even steeper gradient (OR 36.7, 95% CI 7.1–189.1, for >15 versus 0 years of employment).

The main strength of this paper was its care over diagnosis and blinding. Age may have confounded the findings, but it seems unlikely to explain them. A healthy worker effect would, if anything, bias findings towards the null and point to an even bigger true effect. However, this well-investigated group could have been more aware of the study hypothesis than the referents and more inclined to report physical discomfort. The study depended on a small group of nurses being an appropriate comparator. The exposure characterization was limited.

Andersen et al (37) conducted a cross-sectional study of 3123 workers from 19 workplaces (food processing companies, textile plants, and several other manufacturing and service companies) within the Project on Research and Intervention in Monotonous Work (PRIM) health study of 1994–1995. Almost three-quarters of the target population participated. Neck–shoulder pain was scored (out of 36) according to its severity at worst and on an average within the previous 3 months, its average level over the last 7 days, and its interference with daily activities during the previous 3 months. Three teams of physicians examined persons blinded to exposure and health status. Palpation tenderness was assessed in the neck muscles, the upper trapezius border, and the supraspinatus or infraspinatus muscle. Indisputable tenderness (leading to flinch or withdrawal) was noted. The interrater reliability between three examiners was confirmed in a subgroup of 60 participants (kappa values, 0.45 to 0.57). The cases were defined as neck–shoulder pain with a score of ≥12 *plus* indisputable palpation tenderness. Altogether, 185 participants fulfilled these criteria.

After repeated visits to the factories, 300 repetitive worktasks (eg, de-boning ham or poultry, sewing machine work, packing, data entering, work as a cashier, manual machine feeding) were aggregated into 103 task groups. Between 1 and 7 workers in each task group were videotaped from several angles for at least 10 work cycles or at least 10–15 minutes. The number of shoulder movements/minute, the percentage of time in neck flexion of >20 degrees, the percentage of cycle time spent with no upper-arm support or rest for >2 seconds, and the force requirements (subjectively assessed on a 5-point ordinal scale relative to maximum voluntary contraction) were quantified following repeated reviews of the recordings, and median values of each exposure were assigned to task groups. In the final step, these estimates were linked with workers' reports of the relative time spent in different activities.

Psychosocial risk factors were also assessed using the Whitehall II version of Karasek's job content questionnaire, as well as several individual characteristics [body mass index, pain pressure threshold, short-form 36 (SF-36) questionnaire, and personality traits].

The analyses were adjusted for age, gender, psychosocial factors, past history of neck–shoulder injury, body mass index, and several other factors. Thereafter, dose–response gradients were determined according to categories of repetitive shoulder movement, force requirements, neck flexion, and lack of recovery time. The prevalence ratios (PR) were raised 1.7- to 2.0-fold for high versus low category comparisons. Additional analyses considered the combination of repetition with each of the other factors. [The four ergonomic exposures were significantly correlated, the coefficients ranging from 0.47 to 0.84.] Risks in the top most category (high repetition with high levels of another exposure) were only a little higher than for repetition alone, with prevalence ratios of 1.9 to 2.3.

High self-reported psychosocial demands were associated with the outcome after adjustment for physical risk factors (PR 1.8), but rather weaker associations were found with low control and low social support (PR 1.3–1.4).

After allowance both for physical and for psychosocial workplace factors, associations were found with female gender (PR 1.8), pain pressure threshold (PR 1.6), and neck–shoulder injury (PR 2.6). A nonsignificant association was found with age, but there was no relation to body mass index. Those in pain had worse mean SF-36 scores for several health dimensions, including vitality and mental health, and lower still when palpation tenderness was also present.

This study had numerous strong design features: a large sample, an adequate response rate, a clear sampling strategy, detailed characterization of physical exposures with dose–response information, a clearly defined repeatable measure of outcome, assessment blinded to exposures, and thorough control of confounding. Although 25% of those invited did not take part, nonresponse is unlikely to explain the several dose–response gradients found. Despite painstaking efforts of the authors to measure exposures objectively, however, the final estimate depended also on the persons' reports about their relative time in different job tasks. The challenge of assessing complex time-varying exposures on an epidemiologic scale is considerable in that random measurement errors would tend to obscure dose–response relationships. In theory, however, artefactual dose–response gradients might arise if those with symptoms had a greater propensity to overestimate their exposure to certain activities. [Some empirical evidence suggests that reports of exposures can be differential in this way (52, 53).] A more exacting test is to demonstrate similar dose–response relationships prospectively.

Andersen et al (18) proceeded then to follow-up 3123 workers from the PRIM baseline on three additional occasions, roughly a year apart. They assessed incident neck–shoulder pain and incident neck–shoulder pain with palpation tenderness in the neck–shoulder area. An incident case was defined by a symptom score of <12 at baseline and an increase of 12 score values during the follow-up. The participants with indisputable palpation tenderness in the neck muscles or right upper trapezius border *and* in the right supra- or infraspinatus muscle fulfilled the additional examination criteria to become a "clinical" case. No explicit mention was made of blinding in this report, although the complexity of exposure assignment makes blinding likely, and blinding had previously been reported at baseline. No mention was made of the reliability of outcome assessment, although the methodology appears to have been underpinned by data reported by Andersen et al (37).

Baseline physical exposures were assessed according to the earlier report. At each follow-up round a screening questionnaire was completed on pain status, workplace psychosocial factors, and symptoms of distress. In addition, physical workload was reassessed for new or changed job tasks. The risk of the two outcomes was calculated using a discrete survival model, with time varying measures of observed and perceived workplace factors. In all of the analyses, a lagged function was used to link the outcomes with psychosocial and personal factors reported in the preceding round of follow-up. Risk estimates were adjusted for age, gender, psychosocial factors, level of distress, body mass index, and pain pressure threshold.

The follow-up lasted almost 4 years, and by the end the cohort had roughly halved. Dropouts were attributed mostly to young age (and labor turnover) and to some companies moving their production to eastern Europe. No strong association was found between dropout and exposure or musculoskeletal disorders at baseline, and the prevalence of neck–shoulder pain with pressure tenderness (6.2–6.3%) and the annual incidence (14% for symptom cases and 1.7% for clinical cases) remained stable throughout the study. As with the baseline report, strong exposure–response gradients were found for all of the physical risk factors investigated, and the odds ratios were raised by two- to threefold in each high–low category comparison. The gradients were stronger for symptoms with signs than for symptoms alone. The associations with repetition were not strengthened by its combination with other risk factors, and, for those with low repetition, the associations with the other factors were much closer to the null. Interpretation is hampered by the high correlation between the physical exposures (correlation coefficients 0.3–0.5). However, if anything, the study points to repetition as the major risk factor and suggests that its effects in combination with other physical exposures are less than multiplicative.

Those who reported high job demands had a higher incidence of neck–shoulder pain with pressure tenderness (OR 1.7), after allowance for physical, individual, and other psychosocial risk factors. Weaker nonsignificant associations were also found with low job control and low social support (OR 1.3). Finally, the authors constructed a combined physical exposure or "physical strain" index, the workers in the highest category scoring highly on at least three of the four physical quantitative measures. The odds ratio for becoming a clinical case was 3.2 (95% CI 1.6–6.6) in the high versus low category comparison. In this mutually adjusted model, significant associations were also found with high job demands (OR 2.0), female gender (OR 1.8), and high levels of distress (OR 2.8). The authors concluded that physical and psychosocial workplace factors and high personal levels of distress are predictors of incident neck–shoulder pain with pressure tenderness.

This study had numerous important strengths: a large sample, a clear sampling strategy, a prospective design, a clear outcome (probably repeatable and assessed blind to exposure), sophisticated characterization of physical exposures (including exposures that changed over follow-up), an adequate assessment of workplace psychosocial factors and personal mental health (including changes over follow-up), a sophisticated analytic strategy with thorough control of confounding, and useful exposure–response information. Its main weakness was the substantial losses to follow-up, although some evidence was offered that the losses did not give rise to important selection bias. As with the baseline *assessment, the method of exposure assessment, when applied to individual persons, required self-reports of working patterns. Information bias could thus have arisen, but prospective design and the reporting of exposures before symptom onset seem to have made this an implausible explanation of the findings. A challenge existed in distinguishing the separate contributions of physical risk factors that often occurred together. The evidence points the most clearly to repetitive shoulder movements as a cause of neck–shoulder pain with pressure tenderness; separate smaller contributions from force, neck flexion, and limited recovery time might have existed. A steeper exposure–response gradient was found for incidence than for prevalence. However, the case definitions at baseline and follow-up were not identical, and, broadly speaking, the findings were consistent at the two stages. Independently, a doubling of risk was found with high job demands, as defined in the job content questionnaire of Karasek. Other personal risk factors included female gender and high level of distress, on the assumption that the multiplicative model presented in table 5 [found on the homepage of the* Scandinavian Journal of Work, Environment & Health*] of this report, a female worker with high levels of distress (score >2 on the stress profile questionnaire of Setterland) might have an odds ratio for incident neck–shoulder pain with pressure tenderness of almost 9 in comparison with a male scoring 0 on the same scale.*

A study from the United Stages by *Anderson et al* (60) investigated members of a transit union. A stratified random sample was taken from among bus drivers and nondrivers. Exposures among drivers would have been to whole-body vibration and prolonged sitting, but their extent was not quantified any further. The nondrivers were comprised of clerks, custodians, and mechanics. No refusals were encountered. All of the participants were interviewed and examined by an orthopedic physician who assessed the somewhat ill-defined outcome of "moderate to severe neck disorder" (at least moderate neck pain affecting normal activities of daily life + restriction or pain on neck movement). The between-interviewer reliability of symptom inquiries was said to be "confirmed", but the within-observer reliability of the physical signs was not assessed, nor was the examination explicitly blinded to job category. No control of confounding was attempted. In a crude comparison, the outcome was nonsignificantly more common among the bus drivers (OR 1.8, 95% CI 0.5–7.8).

This study had many limitations.

Bovenzi et al (61) investigated 65 male foresters and 31 male blue-collar maintenance workers (mechanics, electricians, and painters). No information was given on the sampling frame, selection methods, or response rate. The main strength of this study lies in its exposure assessment. Measurements of vibration magnitude were made on the front and rear handles of three chain saws in use. The participants were asked about their frequency of daily exposures, and each person was assigned an estimated vibration dose using the formula in ISO 5349 (1986). In addition, care was taken to define the outcome criteria closely [based on Waris et al (31) and Viikari-Juntura (32)] and to assess outcomes blinded to exposure. On the other hand, no details were given on the reliability of the diagnosis. Ergonomic assessment was limited to the use of a modified Michigan's checklist, which scored the proportion of work conditions "potentially associated with upper-extremity musculoskeletal disorders". The foresters were rated as at "slight excess risk". The proportion of short cycle time tasks (<30 seconds) was nonsignificantly more common among the referents. Forestry would have involved work with the arms elevated and forceful gripping, as well as exposure to hand-transmitted vibration, but no details were given on these exposures. Three groups were analyzed—with daily vibration exposures to >7.5 m/s^2, >0–<7.5 m/s^2, and none (maintenance workers as a common reference category). The risk estimates were controlled for age and gender. The adjusted odds ratio rose in a dose–response pattern for cervical syndrome and increased almost 11-fold in the top category. That for tension neck syndrome was increased almost fourfold in the same comparison, but not increased for the workers with a lower daily vibration dose. In a simple comparison by job title the odds ratios for tension neck syndrome and cervical syndrome were also significantly increased, by 2.1 and 6.8, respectively.

The limitations of this study included its small size, cross-sectional design, ambiguous sampling methods, and failure to fully consider exposures concurrent with vibration. Its strengths included most aspects of outcome and exposure assessment, as well as its attempt to offer exposure–response data.

Cassou et al (19) conducted a prospective investigation (ESTEV) of workers from various industries. The participants attended compulsory medical examinations in 1990 and 1995 under the supervision of 400 French occupational physicians. Almost 17 000 persons were studied, selected in age and gender strata to mimic the age-gender distribution of French employees as a whole. The cases were defined as those with chronic neck–shoulder pain (present on the day of the examination and for at least 6 months before and causing functional limitation) *plus* neck or shoulder pain on passive movement. The assessments were performed by "trained" occupational physicians, but no details were given of the steps to ensure standardization or the reliability of the diagnosis. The exposures were all self-reported and were limited in detail. For example, a participant was considered to be exposed to "awkward work" if he or she reported being exposed to at least one of the following: awkward posture, the carrying of heavy loads, vibration, or forceful operation of tools or machines. They had "low job control" if at least one of the following factors was reported: no means to carry out high-quality work, no possibility of choosing the way in which work would be carried out, no variety of work, or no learning of new things at work. The intensity and frequency of exposure to these composite measures were not recorded.

The analyses focused separately on incidence and persistence. Both outcomes were more common among the women than among the men and rose with age. However, not all of the findings were adjusted for age. Depressive symptoms were considered in some, but not all, of the analyses.

The outcome had a 5-year incidence of 7.3% for the men and 12.5% for the women. Among the workers with chronic neck–shoulder pain at baseline, around one-third of the men and one-half of the women still had the disorder at follow-up. Tables 5 and 6, which can be found on the homepage of the *Scandinavian Journal of Work, Environment & Health*, present various findings on the incidence of, and recovery from, chronic neck pain. The exposures were assessed prior to 1990 (baseline), as well as during 1990, in case any workers had changed their work because of symptoms. Associations were examined for repetitive work under time constraints, awkward work, and low job control. In general, incident events were only slightly more common (PR ≤1.4) for those with exposures than for those without, although some associations were significant at the 5% level. Little association was found between recovery from the outcome and awkward work, precise work, or low job control, but recovery was significantly less common among the women undertaking repetitive work prior to 1990 (OR 0.5, 95% CI 0.3–0.7) and among both men and women who reported high demands (OR 0.7) and depression at baseline (OR 1.3 to 1.5).

This study had several strengths, including a large sample size, a prospective design, and a high response rate. Its major limitation was the poor characterization of exposure—self-reported without corroborating objective measures and comprising crude composite measures, not tailored specifically to ergonomic stressors of the neck–shoulder region. Confounding was weakly controlled. Only modest associations were found with repetitive work and with high self-reported job demands. However, nondifferential misclassification of exposures could easily have biased estimates of association towards the null.

Ekberg et al (65) compared 109 "cases" (patients consulting a physician for musculoskeletal disorders of the neck, shoulder, or arm and who had been on sick leave for ≤4 weeks) with 327 population controls, chosen from an insurance register. The response rate for the cases was not reported; for the controls it was said to be 73%, although the numbers finally analyzed suggest a lower response. The participants completed a Nordic questionnaire and were classified according to the criteria of Waris et al (31) (no details were provided on the reliability of the diagnosis or blinding). They also answered a questionnaire about work conditions, including uncomfortable sitting positions, physically demanding work, lifting, repetitive movements demanding precision, work with the arms lifted, high pace of work, demands on attention, and the quality of work content. Among the cases, 47% had tension neck syndrome, and 18% had cervical syndrome or radiating neurological symptoms. The cases and controls were poorly matched with respect to gender (80% versus 39% female) and current smoking (62% versus 25%). Both of these factors showed strong associations with outcome (ORs 11.4 and 3.7, respectively), but no adjustment was made for confounding. In the crude analyses, very strong associations were found with repetitive precision movements (OR 7.5 for high versus low), lifting (OR 13.6 for medium and high versus low), and ambiguity of work role (OR 16.5 for high versus low). Odds ratios of 2.6 to 3.8 were also found with high levels of uncomfortable sitting, rushed workpace, high demands on attention, and low self-rated quality of work content.

This study had several limitations related to sampling and response rates, outcome definition, and control of confounding. In addition, the exposures were self-reported retrospectively and may have been differential between the cases and controls, leading to information bias. Associations were found with all of the physical exposures, rather than being specific to a few, and were large in comparison with the findings of other reports.

Hansson et al (62) compared 87 workers from the laminate industry (assemblers, pressers, and finishers) with 33 office and 35 industrial workers in mobile and varied work. The selection methods and response rates are unclear. The participants (all female) completed a Nordic questionnaire and were examined and classified by a single observer [using the Ohlsson criteria (33)]. No information was given on the repeatability of the diagnosis or on blinding. Muscle loads (*m trapezius* and *m infraspinatus*) were assessed by electromyography, and wrist positions, and movements were measured using electrogoniometers. At the interview, questions were asked about psychological demands and decision latitude. Muscle loading was similar among the laminate workers and industrial controls and higher than among the office workers, while there was a gradient across the three groups for speed and frequency of wrist flexion and deviation (the greatest for the laminate workers and the least for the office controls). Tension neck syndrome was significantly more common among the laminate workers than among the office referents (crude OR 2.9, 95% CI 1.0–9.4), but only slightly higher than among the industrial referents (OR 1.4). Age-adjusted odds ratios for "neck disorder" (tension neck syndrome with a few cases of cervicalgia) were also higher among the medium to high categories of muscle loading (OR 1.9 and 1.5) and wrist movement (OR 5.4 and 3.1) than among those with low exposures. Additional adjustment for psychosocial factors had little effect on risk estimates.

This study was limited in terms of sample size, sampling procedures, cross-sectional design, and outcome assessment. However, exposures were characterized and used in health analyses, with reasonable control of confounding.

In a study by *Hinnen et al* (63), cashiers using laser scanners were compared with other conventional cashiers. The sampling procedures were not fully described. However, the study excluded workers who were off sick or had had previous injuries and so may have been prone to healthy worker selection bias. A high response rate was achieved among the remainder, who completed a self-administered questionnaire and were examined by a single physician who was not explicitly blinded to their work history. The outcome studied was neck pain or neck stiffness with examination findings (painful pressure points, with or without restricted range of movement). The interobserver reliability of the overall examination (which included shoulder movements) was described as "satisfactory", with a Spearman rank correlation of 0.7 between two independent examining teams, but the components of comparison and assessment protocol were not described. In a subsample, estimates were made of the number of items handled, and work postures were scored according to a checklist (Ovako Working-posture Analysis System) and subjected to movement analysis. However, these observations were not used in the analyses of health outcome; rather, a simple internal comparison of cashiers was presented according to the use of laser scanners and the presence or absence of job rotation. Gender was controlled for in the analysis, but other potential confounders were not. No significant associations were found with the use of the laser scanner or work rotation.

This study had many limitations. In addition, despite some detailed ergonomic assessment, we found it hard to achieve a firm understanding of the main ergonomic contrasts.

Kaergard & Andersen (38) studied a group of sewing machine operators, comprised of a subset of the Danish PRIM study. Altogether 238 female sewing machinists completed a questionnaire and clinical examination at baseline, as did 357 women whose jobs were varied and nonrepetitive. The participants were followed over an additional 2 years, although the analyses related to the baseline comparison. The outcome of interest, myofascial pain syndrome, was comprised of neck–shoulder pain with moderate to pronounced palpation tenderness. No mention was made about the repeatability of the diagnosis, although other reports by the same group implied an established repeatable methodology. The exposures were characterized only in terms of duration of employment. Additional information was collected on several personal risk factors (age, smoking, body mass index, job strain, social support, and a personal stress scale). The prevalence of myofascial pain syndrome was higher among the sewing machine operators (15.2%) than among the controls (9%) (PR 1.7, 95% CI 1.1–2.6). In a crude comparison, there was a U-shaped relationship with the duration of employment. The multivariable analysis considered only the outcome of mixed neck–shoulder disorder (mostly tension neck syndrome). In a comparison with those employed for 2–10 years, prevalence ratios were increased 2.4-fold among those employed for ≤2 years and 4.4-fold among those employed for >20 years. A significant association was also found with high personal stress (PR 2.5), and nonsignificant associations were shown with smoking (PR 1.6) and low social support (PR 1.7). Many dropouts were encountered over the follow–up, the final material comprising 150 persons who had undergone the baseline examination and at least one follow-up examination. Among this group, low social support was a predictor of incident mixed neck–shoulder disorder, with an adjusted rate ratio of 3.7 (95% CI 1.2–11.3).

This study had some strengths but also some important limitations. Most of the analyses relevant to this review were cross-sectional, the study size was small, and there was limited control of confounding (other than for the analyses of mixed neck–shoulder disorder). The examination was blinded with respect to the questionnaire responses, but may not have been blind to the occupational titles. The U-shaped relation with the duration of employment raises the possibility of healthy worker selection bias (but, in this event, the true effects may have been even greater.)

In Finland, *Kuorinka & Koskinen* (39) conducted a cross-sectional study of 93 factory workers performing scissor-making operations. These workers were compared with 163 other factory workers and 143 shop assistants whose findings were reported in a separate paper. The sampling excluded persons with recent trauma and those off sick, although the latter included only one suspected case of occupational rheumatic disease. The outcome studied was tension neck syndrome. A physiotherapist, who was not blinded to work history, completed a standardized interview and examination; the diagnosis was assigned later according to the criteria of Waris et al (31) by a team of specialists. The between-observer agreement on palpable hardenings and tender points in the neck was reported to be reliable (Yule's modified coefficient of contingency: 0.73–0.83), but the details of the study leading to these estimates were not given. Scissor-making was characterized according to the number of items handled (estimated from individual productivity records), selected video taping, and visual observations of workstations. All of the tasks were considered repetitive, with a cycle time of ≤26 seconds, although none of the detailed aspects of the job assessment were incorporated into the health analyses. All but three of those studied were female. No control of other potential confounders was attempted, although the comparison groups were similar in mean age. In the crude (derived) analyses, the odds ratios for tension neck syndrome were increased by 2.6–4.1-fold for the scissor makers relative to those in other occupations, but no relation was found to the number of items handled per year.

There were many limitations, including a small sample, a cross-sectional sampling frame, an unblinded assessment of outcome, and an external reference group. The characterization of exposure was limited in relation to the health outcome.

A parallel study by *Luopajärvi et al* (40) provided the referents for Kuorinka & Koskinen's study (39) of scissor makers. In the report by Luopajärvi et al, 152 female assembly packers were compared with 133 female shop assistants. The two groups had a similar mean age. Those with recent trauma and those off sick were excluded from the study, but none of them appear to have had neck disorders. Among the remainder, a high response rate was achieved. A pretrained physiotherapist assessed the outcomes of tension neck syndrome and cervical syndrome [Waris criteria (31)], but no mention was made about the repeatability of the protocol or blinding. Workplaces were assessed ergonomically by an expert team, and work movements were evaluated by a work study engineer and a physician. At a semiquantitative level, the exposures of packers were characterized as mostly involving repetitive finger–hand movements (up to 25 000 cycles/workday), some static loading of upper-limb muscles, extremes of wrist and finger movement, and lifting (average daily load 5000 kg). However, no comparable data were collected on the controls, no individual exposure assessments were made, and no analyses were presented that made use of these ergonomic observations. The odds ratio for tension neck syndrome was moderately and nonsignificantly elevated for the assembly-line packers relative to the shop assistants (OR 1.6, 95% CI 0.9–2.7).

There were several limitations, including a small sample, a cross-sectional sampling frame, and a potentially unblinded assessment of the outcome. The exposures were assessed in a semiquantitative way but only characterized at the group level.

Nordander et al (42) investigated 322 fish processors and 337 other workers from the same communities (caretakers, park keepers, gardeners, maintenance workers). The sampling frame comprehensively covered all of the fish processors from 13 plants on the southeast coast of Sweden. Those on long-term sick leave were also studied, and high levels of response were achieved overall. Tension neck syndrome and cervical syndrome were confirmed [Ohlsson criteria (33)] by a single examiner following a standardized protocol. No mention was made, however, about the repeatability of the method or about blinding.

The ergonomic assessment was based on direct observations and videotaping. Worktasks of six types (trimming cod, packing, work on herring machine, etc) were classified according to 60 permutations of workload (weights handled, cycle time, and degree of constrained neck posture). The women were estimated to spend 63% of their time in nonlifting jobs (<1 kg) with a cycle time of <10 seconds and a constrained neck posture, and a quarter of their time was spent lifting loads of 1–10 kg in longer cycles (10–60 seconds) without neck constraint. The men spent only 21% of their time in repetitious work that constrained neck posture, 34% of the time lifting weights of ≥25 kg with cycle times of 10–60 seconds, and 26% in jobs with the minimum of all three exposures. However, no comparable assessment was made of the controls, and the findings concerning the two health outcomes, although stratified by gender, were presented only at the general group level (fish processors versus referents). They were also unadjusted for age or other confounders, although the comparison groups had similar mean ages. The odds ratio for tension neck syndrome was 2.6 for the men and 3.0 for the women; cervical syndrome was also more common among the fish processors than among the referents, but the difference was confined to the women (5% versus 0%).

The main limitations of this study were the cross-sectional sampling, the potentially unblinded assessment of the outcome, weak control of confounding, and the lack of analysis by level or type of exposure. On the other hand, the ergonomic ingredients of fish processing were well described at the group level.

A report by *Ohlsson et al* (64) represents another investigation of the same workforce as that of Norlander et al (42). On this occasion, 206 female fish processors were compared with 208 women of similar mean age, employed in the same localities (in day nurseries and elderly care or in offices). As before, those on long-term sick leave were included. The health and exposure assessments followed similar protocols, with the same potential strengths and weaknesses. In addition, direct observations and videotaping enabled the range, velocity, and pattern of wrist movements to be assessed, and a questionnaire collected information on psychosocial aspects of the work (eg, difficulty of decision making, attentiveness required, control, stimulation, fellowship, social network, work strain, stress or worry, and self-reported muscular tension). The main tasks were packing fish (44% of time), trimming cod (32%), or filleting herring (11%). These jobs were all characterized as highly repetitive (cycle time <30 seconds), with constant wrist movements (hand still <1% of the time), a "poor" standing posture, and moderate levels of physical activity. Job complexity was rated as simple with few challenges. No subanalyses were conducted—all of the workers were considered to share these exposure patterns in common and were compared with the controls according to job title. As in the study by Nordander et al (42), tension neck syndrome and cervical syndrome were diagnosed more often among the fish processors [tension neck syndrome: OR of 4.7 (95% CI 1.9–12.8), cervical syndrome: 5% versus 0%]. For the outcome of mixed neck–shoulder disorder (mainly tension neck syndrome or cervical syndrome), strong associations were found with self-report of high versus low job strain (OR 6.6), as well as high versus low muscle tension (OR 4.0) and high versus low stress or worry (OR 3.2). Similar gradients were shown for the controls.

This study had limitations similar to those described by Nordander et al (42).

Separately, *Ohlsson et al* (41) compared 82 female industrial workers in highly repetitive jobs (assembling fuses and electronic equipment) with 64 women in more varied work (office, supermarket, and canteen workers). In addition, 79 former workers from the first group and 25 from the latter were contacted. All of the participants completed a Nordic questionnaire and were examined by a single observer according to a standard protocol (Ohlsson criteria). The examiner was blinded to information on the worktasks of the exposed women, but was not blinded to the exposed–referent status. The outcomes of relevance were tension neck syndrome and thoracic outlet syndrome (cervical syndrome was present in only one worker). The exposed participants were classified by job category (assembly, polishing, or "fairly mobile") and duration of employment. In addition, videotape recordings were made of representative worktasks for 74 of the 82 exposed workers, and work postures and movements were systematically scored by two independent observers. Estimates were made for the proportion of time with the neck flexed, or the upper arm elevated or abducted, and the number of movement changes/hour at the neck and shoulder. Exposures were compared for the three job categories (assembly, polishing, mobile work). Half of the study group worked with their neck flexed (>30 degrees) for >90% of the time and with the upper arm elevated (>30 degrees) for >11% of the time. Assembly and polishing more often involved neck flexion and neck and arm movements than mobile work, while assembly work involved more extremes of arm movement than polishing did. Work rotation was less common in the study group as a whole than among the referents (26% versus 97%), but short pauses during work were more common (71% versus 55%).

In the crude analysis, tension neck syndrome was almost five times more common among the industrial workers. Thoracic outlet syndrome was diagnosed for 4% of this group versus none of the referents. Most of the analyses employed a definition of "mixed neck–shoulder disorder" (80% of the cases had tension neck syndrome). The odds ratio for this outcome, when adjusted for age and mental health, was similar to that in the crude analysis for tension neck syndrome overall. It was also higher for assembly workers (OR 6.7) and polishers (OR 4.4) than for industrial workers whose tasks were "fairly mobile" (OR 2.3). The risks were much higher in the first 10 years of employment (OR 9.6) than for those who had worked for ≥20 years (OR 3.8). These findings suggest the possibility of a healthy worker survival bias, and "pain in the musculoskeletal system" was cited as a reason for leaving by 28% of the former industrial workers (although the corresponding figure for the referents was 35%). The final multivariate model was tested on the subset of 74 industrial workers who were videotaped, replacing the repetitive work factor with the videotape variables. In the stepwise regression, neck flexion proved to be a highly significant variable (P=0.005).

This study had some useful strengths, including an internal comparison of job titles supported by exposure measurements. It highlights the possibility of a healthy worker survival bias.

Silverstein (43) studied 574 persons from various industries (electronic assembly, motor appliance manufacture, investment casting, apparel, foundry and bearing manufacture). Tension neck syndrome was assessed using criteria modified from Waris et al (31) and other authors and explicitly defined in an appendix to this research thesis. The test-retest reliability of the diagnosis was not assessed, although the diagnosis was made blinded to exposure history. A particular strength of this study was the detailed job analysis. At least three workers in each selected job were videotaped performing the work for at least three cycles. For each participant filmed, a stopwatch was used to estimate mean cycle time. Electromyographic recordings incorporated into the video record were used to estimate grip forces (from previous calibration plots). The jobs were classified as of high repetition if the cycle time was <30 seconds or >50% of the cycle time involved the same kind of fundamental cycle. High force was defined as an adjusted force of >6 kg. According to work histories and a job analysis, the participants were placed in one of four of the following mutually exclusive categories: low force–low repetition, high force–low repetition, low force–high repetition, and high force–high repetition. However, only 1.4% of the men and 7.7% of the women fulfilled the case definition of tension neck syndrome. The proportions with the outcome were presented graphically for each exposure category. Our derived estimates of the rate ratios for the women (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*) take low-repetition–low-force jobs as the reference group. In comparison, only the odds ratios of the workers in high-force–low-repetition work were elevated (OR 1.7–1.9), and the difference was not significant at the 5% level. Tension neck syndrome was actually less common in the high-repetition–high-force jobs than in the reference category.

This landmark survey has several well-known strengths, including careful characterization of exposures and outcomes. However, the outcome of tension neck syndrome was uncommon, and the data were presented without control for confounding (other than by gender stratification). The numbers within the subanalyses were small, giving rise to wide confidence intervals. However, and in contrast to its findings on other upper-limb disorders, this study did not suggest a strong association between physical risk factors and tension neck syndrome.

Toomingas et al (44) investigated 71 platers (engaged in welding, plating, grinding, and hammering metal sheets), 71 vehicle assembly workers (engaged in screwing metal components) and 45 white-collar workers. Details were not given about the sampling frame, sampling procedures, or response rates. The outcome of tension neck syndrome was clearly defined and ascertained by two physicians, one examining the platers and controls, and the other the assemblers. Blinding to exposure was thus incomplete. No details were given of the between-observer repeatability of diagnosis. The acceleration levels of sample tools (nutrunners, impulse wrenches, screwdrivers, wrenches) were measured, and the persons completed a questionnaire about their daily exposure times, but no estimate of exposure dose was used in the analyses of interest. The groups were gender-matched but differed significantly in age. The crude (derived) odds ratio for tension neck syndrome was 4.5 (95% CI 0.6–194.1) for the platers and assemblers versus the referents.

This study had several limitations in terms of sample size, outcome assessment, control of confounding, and exposure characterization. The findings are, however, consistent with those of Bovenzi et al (61) for vibration-exposed foresters.

Tornqvist et al (50) reported a case–control study concerning people who sought care for neck or shoulder disorders from 70 care givers in the municipality of Norrtälje during 1994–1997. The controls were selected at random from the study base using a population register. Those who had sought care for neck or shoulder or low-back disorders in the 6 months prior to 1994 were excluded. The remainder completed a self-administered questionnaire, a structured interview, and a physical examination and were classified as having tension neck syndrome, cervical brachialgia, shoulder tendonitis, or none of these. The criteria employed were not clearly stated, although a research abstract (66) suggests that the diagnoses were repeatable between observers. The analysis was conducted only for "mixed neck–shoulder disorders". Among the women, tension neck syndrome comprised 53% of the case material. Questionnaire data were collected on repetitive hand and finger movements (many times/minute ≥2 days/week), work with vibrating tools (≥60 minutes/day), and work organization and psychosocial factors (job demands, decision latitude, job strain, time pressure, level of social support at work, quantitative work demands). An assessment was also made using a structured interview concerning energy expenditure in the job, work with hands above shoulder height (≥30 minutes/day), constrained sitting (≥4 hours/day), visually demanding precision work (≥4 hours/day), the opportunity for creativity, and demands relative to competence. The analysis was stratified by gender and adjusted for age and previous chronic neck–shoulder symptoms. Significant associations were found with repetition (OR 2.2, 95% CI 1.5–3.2), work with hands above shoulder height (OR 1.6, 95% CI 1.0–2.7), work with visual display units (OR 1.9, 95% CI 1.0–3.4), and job strain (OR 1.6, 95% CI 1.1–2.5), as well as poor support at work (OR 1.4, 95% CI 1.0–2.0). The cases were also more likely to report long workhours, nonfixed salary, and isolated work conditions. The authors estimated a population attributable proportion of 18% for the women with respect to work with repetitive hand–finger movements.

The main limitations of this study were reliance on self-reported exposures, with a potential for information bias, and the failure to analyze tension neck syndrome and cervical brachialgia as independent outcomes.

Veiersted & Westgaard (58) prospectively investigated 30 female workers during the first year of their employment in a chocolate manufacturing plant. The recruitment was confined to those who had not consulted medical services during the previous year for neck–shoulder pain and who had no known disorder predisposing to myalgia. A questionnaire was administered about postures perceived as strenuous to the neck and shoulder muscles. At 10-week intervals over the next year the women were reassessed by a physician. An incident case of trapezius myalgia was recorded if neck–shoulder pain lasting >2 weeks and causing work interference was linked with one tender or trigger point in the trapezius muscle. No details were given on the repeatability of the diagnosis, and no comment was made about blinding. Seventeen of the women fulfilled the case definition. After allowance for self-reported stress, the hazard ratio for this outcome showed a nearly 11-fold increase for those who had perceived their neck–shoulder postures to be strenuous at baseline.

This small study lacked information on the reliability of outcome and blinding and had no objective characterization of exposure. Although self-reports about work posture were collected prior to symptom onset, those who were dissatisfied with their work environment may have had a higher awareness of symptoms and may have been more apprehensive (tender) during the examination.

Viikari-Juntura (32) assessed 113 slaughterhouse workers for tension neck syndrome. She compared her estimate of prevalence with those for scissor makers, shop assistants, and factory workers, the reference data coming from the studies of Kuorinka & Koskinen (39) and Luopajärvi et al (40). The workers on sick leave were excluded, although none had a relevant musculoskeletal illness. A high response rate was achieved. A single observer examined all of the workers, following a closely defined prespecified diagnostic schedule [an extension of the Waris criteria (31)]. No mention was made of the repeatability of the protocol, and the study design precluded blinding. Ergonomic exposures were not characterized in detail. However, other studies from the industry suggest that the work involves forceful repetitive use of the upper limb in the cutting of some 1200 kg of veal or 3000 kg of pork/day. The slaughterhouse workers were poorly matched to the referents in terms of gender. A crude comparison indicates that tension neck syndrome was >5 times less common among the slaughterhouse workers than among the factory workers and 10 times less common than among the scissor makers.

This study made an important contribution to the development of diagnostic criteria for upper-limb and neck disorders, but it has several limitations in the context of this review. These limitations include a small sample size, limited exposure characterization, and a lack of a true reference group. However, it highlights large differences in the prevalence of neck disorders when different research groups have attempted to apply the same diagnostic criteria in different settings.

Discussion and evidence synthesis

Our method of investigation had some potential limitations. In particular, although we aimed at making the search thorough, it may not have been comprehensive. It did not, for example, encompass the nonpeer review ("grey") literature or publications in languages other than English (much of the interest in occupational cervicobrachial syndrome has come from Japan and Scandinavia) or an approach to authors active in the field. Moreover, defining search terms for an outcome with many synonyms and a wide variety of exposures was challenging. However, we think it unlikely that important high-quality reports were overlooked by the strategy. Our review focused on neck pain with physical signs rather than on neck pain as a whole. As a check on the impact of this limitation, we re-ran the search omitting the filter for physical examination but applying one to retrieve higher quality prospective studies (details available on request). We found and read 10 additional cohort reports, but found only one with detailed exposure assessment (referred to later in this discussion) and none that would cause us to change our appraisal of the evidence.

Among the studies we did identify, the smaller ones were not clearly more positive than the larger ones, and this lack of a difference tends to argue against significant publication bias.

A more important limitation lies in the nature of the reports that we found. According to our assessment, the evidence based on occupation and neck pain with physical signs rests substantially on two high-quality investigations in the same study population, plus sundry other observations of less quality, almost always based on retrospective or cross-sectional observations and typically limited by poor precision and control of confounding.

The exposures of interest are complex and usually seen in combination. Analyses based on a comparison of job title (most of the reports) offer only a general indication of the nature and extent of these exposures, while those based on an analysis of work activities have adopted a variety of approaches to exposure categorization that hinders synthesis.

The approaches to case definition also varied (at the extremes from a brief to a long-lasting duration of symptoms—see table 3 on the homepage of the *Scandinavian*

Journal of Work, Environment & Health), but were more homogeneous than those to exposure. An important consideration in synthesis is the extent to which studies based on a different outcome can be considered together. We think they can—in part for the reasons set out earlier in the section on pathogenesis, but also because the differences in practice seem small. The bulk of the evidence relates either to neck pain with palpation tenderness or to mixed neck–shoulder disorder (mainly tension neck syndrome). Surveys with these end points sometimes also reported on thoracic outlet syndrome (3 studies) (41, 62, 64) or cervical syndrome (6 studies) (35, 40, 42, 60, 61, 64), but, as can be seen from table 4 of our review [found on the homepage of the *Scandinavian Journal of Work, Environment & Health*], such studies reached similar conclusions for these disease labels as they did for tension neck syndrome.

For simplicity, therefore, we focused on the evidence synthesis that follows on neck pain with palpation tenderness and mixed neck–shoulder disorder (mainly tension neck syndrome), considered as a single group. Two other studies with less specific outcomes—neck–shoulder pain with examination findings (19, 63)—are included in passing.

Physical risk factors

Repetition. Seven reports (six investigations) from table 5 of our review (18, 37, 41, 43, 50, 62, 65) and nine from table 4 (32, 35, 38–42, 62, 64) [both found on the homepage of the *Scandinavian Journal of Work, Environment & Health*], a total of 14 when overlaps are allowed for (41, 62), concerned repetition or repetitive jobs and these outcomes. Only one of the studies offered prospective information (18).

Relative risks of ≥1.7 (P<0.05) were reported, for at least some comparisons, in 11 of the 14 studies and a relative risk of >1.5 in 1 of the remaining 3 studies. Moreover, both papers with the highest quality rating (+++++) pointed to a relative risk of ≥1.8, with an exposure–response relation for repetitive shoulder movements (18, 37), and both of the two rated next highest in quality (+++) were similarly positive. Another study of low quality found a strong exposure–response gradient (65), as did an analysis based on years of employment in an exposed job (35). Two other cross-sectional studies did not show a clear relation to employment duration, but they hinted instead at an effect from healthy worker selection (38, 41). Repetition was sometimes defined at the shoulder (18, 37), sometimes at the wrist, hand or fingers (40, 50, 62, 64), and sometimes ambiguously. Positive findings were not clearly limited to one category of definition.

The evidence in favor of a causal association relies mainly on the findings of one high-quality investigation at baseline and at follow-up, but it is supported by consistent observations from many smaller studies of less quality. Such a pattern is unlikely to arise by chance or through confounding (even though control of confounding was often suboptimal). Moreover, among the 14 studies, we rated 5 as low in potential for inflationary bias (18, 35, 37, 38, 43) and 4 of these were positive (RR≥1.7, P<0.05).

On balance, we conclude that, by the criteria presented in appendix 2, there is moderate evidence (++) of a causal relationship between repetition at the shoulder and neck–shoulder pain with palpation tenderness, but less conclusive evidence (+) for repetition at the hand–wrist.

Neck flexion. The two surveys by Andersen et al (18, 37) also found an exposure–response relation between the proportion of cycle time and the neck flexed >20 degrees (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*), the rate ratios being raised significantly (1.7- to 2.6-fold) in the highest category. Indirect support for these findings comes from four surveys of moderate quality that compared job titles—two with ergonomic observations of constrained neck posture with neck flexion (41, 42) and three others in which constrained neck posture with neck flexion seemed likely given the nature of the work (35, 38, 59) (table 4, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*). All of the studies found a more than doubling of risk (P<0.05); we rated two of the five as having a low potential for inflationary bias.

The major limitation of this interpretation is that the exposed groups in these studies were likely to have been exposed also to repetitious work (and so feature in the preceding section). Disentangling the separate contributions of repetition and neck posture is difficult. However, the analyses of Andersen et al (18, 37) (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*) suggest that repetitive movement of the shoulder carries a significant risk of incident and prevalent complaints even in the absence of neck flexion, that the combination of exposures is not clearly more injurious, and that the risk estimates associated with neck flexion in the absence of repetition are only moderately and nonsignificantly higher (OR 1.4 to 1.6, P>0.05).

The evidence in favor of a causal association is almost as good for neck flexion with repetition as with repetition alone. However, there is only limited evidence on neck flexion in the absence of repetition, and none that clearly excludes chance as an explanation of the findings. Using the criteria presented in appendix 2, we conclude that there is moderate evidence (++) of a causal relationship between the combination of neck *flexion with repetition and neck–shoulder pain with palpation tenderness, and there is limited evidence (+) for exposure to neck flexion in the absence of repetition.*

Other postures and static loading. We found studies that assessed several other metrics of posture. Exposure definitions differed considerably—there being one study of electromyographic activity (62), two of work with hands above shoulder height (50, 65), and one based on self-reports of "postures strenuous to the neck and shoulders" (58). Several of these studies will have involved static loading of the neck–shoulder musculature, as may some of the occupational studies on sewing machinists (35, 38), dental personnel (59), foresters (61), and female fish processors (42, 64) (although also involving repetition and constrained neck posture). The most specific investigation, of electromyographic activity in the trapezius muscle by Hansson et al (62), found odds ratios that were nonsignificantly increased 1.5- to 1.9-fold in a study of limited statistical power. The two case–control studies that asked about work with the arms above shoulder height reported positive associations with mixed neck–shoulder disorder [OR 1.6 (50) and 4.8 (65)], but we rated both as having important potential for inflationary bias. Questions were also posed in these investigations about "constrained" (50) or "uncomfortable" (65) sitting (OR ranging from 1.6 to 3.6), with the same potential limitation.

There is moderate evidence (++) that static loading of the neck–shoulder musculature in combination with repetition and neck flexion increases the risks of neck pain with palpation tenderness. There is suggestive but inconclusive evidence (+) that static loading of the neck–shoulder musculature makes an independent contribution, over and above repetition.

Forceful work. The high-quality studies by Andersen et al (18, 37) found an exposure–response relation with forceful gripping, assessed as the proportion of maximum voluntary contraction (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*). The relative risks were significantly raised twofold in the highest category. However, for the subset of workers with high grip force but low repetition of shoulder movements, the odds ratios were more modestly increased (≤1.4-fold), and the associations were not significant at the 5% level. Silverstein (43) also found an elevation of risk for work involving high force but low repetition (versus low-force–low-repetition jobs) (OR 1.7 to 1.9), but, in a considerably smaller analysis, these did not achieve statistical significance. The study by Viikari-Juntura (32) found a much lower risk for tension neck syndrome among slaughterhouse workers than various other comparison groups, although their work was described as involving forceful use of the upper limb. Finally, Andersen & Gaardboe (35) found an exposure–response relationship with respect to years as a sewing machinist, a job described as not only involving force, but also repetition and static neck postures.

There was only limited evidence (+) that force is a causal risk factor in the absence of repetition and none that clearly excluded chance as an explanation of the findings.

Other physical exposures

Precision work. We found two studies that investigated the exposure of "visually demanding precision work" (50) or "work with precise movements" (19) (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*); neither of these was positive, however. It is possible to imagine that some of the occupations in table 4 [found on the homepage of the *Scandinavian Journal of Work, Environment & Health*] also had a requirement for precision—including dental personnel (59), fish processors (42, 64), and sewing machinists (35, 38). *If there is an effect on the risk of neck disorders, we would expect this risk to arise through its requirement for a constrained neck posture or static loading of the neck–shoulder girdle and so to be encompassed by the preceding evidence statements.*

Rest breaks. The studies by Andersen et al (18, 37) also analyzed the proportion of the work cycle in which micropause rest breaks were absent. Where this proportion reached or exceeded 80%, the rate ratios for prevalent and incident outcomes were roughly doubled, there being some evidence of an exposure–response gradient (table 5, found on the homepage of the *Scandinavian Journal of Work, Environment & Health*). No other studies considered this exposure. In practice, repetition and rest breaks are related, but Andersen et al described subgroups in which the high relative absence of micropauses was combined with a low repetition of shoulder movements and for which the risks were only moderately and nonsignificantly elevated (PR 1.4). *We found insufficient evidence (0) to draw a conclusion about rest breaks separate from repetition.*

Lifting and manual handling. In two case–control studies of mixed neck–shoulder disorder, inquiries were made about manual handling, with contrasting results. Tornqvist et al (50) found an odds ratio of 0.8 for manual material handling (≥50 Newtons, ≥60 minutes/day), whereas Ekberg et al (65) estimated a much higher risk (OR 13.6) for the self-report of moderate to heavy lifting as compared with light lifting. In the study by Luopajärvi et al (40) assemblers were noted to carry loads averaging 5000 kg/day and were found to have a nonsignificantly greater risk of tension neck syndrome

(OR 1.6) and a nonsignificantly lower risk of cervical syndrome (OR 0.3) than shop assistants. *On the basis of this review there is insufficient evidence of a causal association (0).*

High physical workload. Tornqvist et al (50) also found no association between high estimated energy expenditure among women [≥3 time-weighted average metabolic equivalent (MET)] and mixed neck–shoulder disorder. *On the basis of this review, there is insufficient evidence of a causal association (0).*

Vibration. We found three studies related to hand-transmitted vibration. Bovenzi et al (61) reported significant associations between a daily vibration dose of >7.5 m/s^2 and both tension neck syndrome (OR 3.8) and cervical syndrome (OR 10.7), with an exposure–response gradient for cervical syndrome. Data from Toomingas et al (44) imply an odds ratio of 4.5 for tension neck syndrome among platers and assemblers with exposure to hand-transmitted vibration versus other workers, but with very wide confidence intervals, and a case–control study by Tornqvist et al (50) found no association between mixed neck–shoulder disorder and exposure time of >60 minutes/day, albeit for women. [A stronger association was found for men, whose magnitudes of exposure may have been higher, but in this group tension neck syndrome was only a minority of the analyzed material.] We rated two of the studies as low in quality of information, however, and all three as having some potential for inflationary bias. [In two studies the selection methods were not described.] The most convincing were the findings of Bovenzi et al (61). But the foresters (the exposed group) were also likely to have had exposure to work that loaded the neck–shoulder girdle, and an apparent relation to estimated vibration dose could have reflected the duration of neck–shoulder straining work (a component of dose estimation). *On the basis of this review there is insufficient evidence of a causal association (0).*

We found a single study on whole-body vibration and moderate-to-severe neck pain with physical signs. The risks were nonsignificantly raised (OR 1.8) in a study of limited quality with potential for inflationary bias. *On the basis of this review there is insufficient evidence of a causal association (0).*

Occupational psychosocial factors

Job demands. We found four studies that assessed occupational demands against the outcome of neck pain with tenderness or mixed neck–shoulder disorder (18, 37, 50, 65) and one study of chronic neck pain with physical signs (19). In three of these studies, exposure was defined according to Karasek's job content questionnaire (18, 37, 50). In the studies by Andersen et al, high demands were associated similarly with the prevalence (37) and incidence (18) of neck pain with tenderness (RR 1.8 and 2.0, P<0.05); while mixed neck–shoulder disorder was significantly associated with high demands on attention in one case–control study (OR 3.8) (65). However, the findings have not been wholly consistent. In the case–control study (50), a significant association was found with high job strain, but not with high demands, high time pressure, or demands relative to competence, and job demands were significantly but only moderately related to incident chronic neck disorder (OR 1.2) and recovery from chronic neck disorder (OR 0.7) in the large cohort study by Cassou et al (19).

A problem of interpretation (applying to all of the psychosocial factors) is that, in the absence of an independent measure of exposure, findings may be unusually prone to common instrument bias (eg, a general tendency to complain may be manifest both for physical symptoms and for negative perceptions about the work environment). There is no ready answer to this problem. None of the studies attempted an independent assessment of demands (or control or support in relation to the sections that follow); but some adjusted for distress (18, 38) or depressive symptoms (19), which could be a marker of such a tendency.

Another issue is that views about work demands could actually reflect a fast and repetitive pace of work. The cohort studies by Andersen et al (18) and Cassou et al (19) attempted to allow for occupational physical activity as a confounder. However, in doing so, they identified risks of a somewhat different magnitude for somewhat different end points.

The two studies of highest quality suggest an association between job demands and neck pain with tenderness that could be causal, but the remaining literature is contradictory and relatively small. Chance and common instrument bias may be other explanations of the positive reports. We therefore rate the evidence for a causal association as limited (+).

Control over work. Five studies considered control over work. Those by Andersen et al estimated rate ratios of 1.4 cross-sectionally (37) and 1.3 prospectively (18). The case–control study by Tornqvist et al (50) reported odds ratios of 1.1 for low decision latitude and 1.4 for low participation in planning. The cohort study by Cassou et al (19) placed the risk estimates close to unity, both for new onset complaints and for recovery from complaints at the start of the follow-up. Finally, a cross-sectional study of fish processors found a lower risk (OR 0.68) for those with high job control. The findings of these investigations were seldom significant at the 5% level.

Limited literature is consistent in ruling out a more-than-moderate association between low job control and neck disorders. The study of highest quality by Andersen et al (18) was careful to control for many confounders, including physical activities, but it did not exclude chance as an explanation of the 30% increase incident risk. Moreover, even a prospective design does not exclude the possibility of common instrument bias. We therefore rate the evidence for a causal association as limited (+).

Job strain. Three studies reported on job strain (38, 50, 64), including two that defined strain as the combination of high demands and low control according to the Karasek model (38, 50, 64). Positive associations were found in one cross-sectional study (OR 3.0 with an exposure–response pattern) (64) and one case–control study (OR 1.6) (50), but not in the cross-sectional study by Kaergaard & Andersen (38). In the cohort study by Andersen et al (18), although demand and support were independent weak predictors of incident neck pain with palpation tenderness, no significant contribution was found by adding an interaction term for the combination of the two.

On the basis that there is some evidence for an independent contribution from the component items of strain and none that suggests a negative interaction between the two, we assign the same rating for evidence of causal association as for demands and control (+).

Support at work. Four studies considered job support, including two with a prospective element. Those by Andersen et al (18, 37) found risks raised by an amount similar to that for low job control, as did the case–control study by Tornqvist et al (OR 1.3–1.4) (50). The study by Kaergaard & Andersen (38), which was nested within the PRIM study, was somewhat more positive. The adjusted prevalence ratio for prevalent neck–shoulder disorder was 1.66 and that for incident neck–shoulder disorder was raised by 3.7-fold, although, based on an analysis of only 149 persons and with substantial losses to follow-up. Findings in the two large studies by Andersen et al were not significant at the 5% level.

The two studies of highest quality point to a moderate association (RR 1.3), but do not rule out chance as an explanation for the findings. The alternative evidence is scant. We therefore rate the evidence for a causal association as limited (+).

Other psychosocial factors. We found single reports concerning job creativity, satisfaction with job content, and perceptions that work was stimulating. These came from two case–control studies that we rated lower in quality and high in potential for inflationary bias. Poor content of work carried a higher risk of mixed neck shoulder disorder (OR 2.9), while belief that work was stimulating was associated with a lower risk (0.35), lack of job creativity being neutral (OR 1.0). None of these findings was significant at the 5% level. *There is insufficient evidence (0) to draw meaningful conclusions about these exposures.*

Relation to the wider literature

We are aware of several other reviews of neck pain and occupational risk factors (54–57, 67–69), although none focused specifically on neck pain with physical signs. Many of the reports included in these reviews cover users of computers and visual display terminals (who were excluded from our commissioning brief).

Bernard & Fine (55) examined over 40 studies of neck or neck–shoulder disorders and concluded that there was "evidence" (++ by the criteria in appendix 2) of a causal relation with highly repetitive work and forceful exertion, strong evidence (+++) concerning static contraction, prolonged static loading, or extreme work postures involving the neck–shoulder muscles (many of these reports also involved repetition), and insufficient evidence for hand–arm vibration. The criteria for "high" quality in the review by Bernard & Fine (55) (participation rate >70%, included a physical examination, blinding, and some objective exposure assessment) were less stringent than ours to the extent that issues of bias, confounding, repeatability of outcome, and precision were not addressed in detail. Little weight was given to quantitative dose–response information, and several studies were accepted that did not furnish risk estimates but only tests of statistical significance. A review by Ariëns et al (67) (which predates the main PRIM reports) was more critical. Among 22 cross-sectional studies, 2 cohort studies, and 1 case–referent study relevant to physical risk factors (3 including an examination), they identified "some evidence" on positive relations with neck flexion (4 reports), forceful use of the arm (2 reports), arm posture (6 reports), prolonged sitting (8 reports), twisting or bending of the trunk (6 reports), and hand–arm vibration (3 reports), but noted that almost all of the studies were cross-sectional and most were low in quality. Kuorinka & Forcier (54) focused in their review on applying the Bradford-Hill criteria of causality to research evidence on occupational exposures and tension neck syndrome. They concluded that the strongest evidence was related to repetitive work and constrained neck posture.

Occupational psychosocial risk factors were considered in another review by Ariëns et al (68), who reported "some evidence" for a positive relationship between neck pain and high job demands, low social (co-worker) support, low job control, high and low skill discretion, and low job satisfaction. Inconclusive evidence was found for high job strain and low supervisory support.

Since then, the Dutch researchers have published two reports on neck pain from their 3-year study on musculoskeletal disorders, absenteeism, stress, and health (SMASH) (70, 71). In common with the PRIM investigators, they assessed physical workload through detailed analyses of video recordings but took as their outcome incident symptoms, rather than symptoms with physical signs. An exposure–response relation was found for neck flexion of ≥20 degrees, the rate ratio being 1.6 (95% CI 0.7–3.8) for those with this exposure for >70% of the time as compared with exposure for <60% of the time (70). A significant association was also reported with sitting, but only at the extremes of the exposure distribution (OR 2.3 for sitting >95% versus <1% of the time). No association was found with neck rotation. However, neck flexion, neck rotation, and low decision authority were risk factors for sickness absence due to neck pain (71).

Broadly speaking, our conclusions are in agreement with those of the wider literature, despite some differences in focus. They are also plausible from an ergonomic viewpoint. While the mechanism that causes neck pain with palpation tenderness is uncertain, Kuorinka et al (54) have identified several possibilities that could stem from repetitive movements of the arm, static neck posture, and loading of the neck–shoulder musculature, including overload of type I muscle fibers in the trapezius muscle, reduced microcirculation in the trapezius muscle with pain sensitization, ATP (adenosine triphosphate) depletion or dysfunctional energy metabolism in contracting muscles with activity-related pain, selective motor unit fatigue, and muscle fiber rupture. [See the report edited by Kuorinka & Forcier (54, p 91–93).]

Concluding remarks

Table 7 on page 173 summarizes our assessment of the causal evidence in relation to neck pain with palpation tenderness. This evidence is strongest for repetition, by itself or in combination with neck flexion or static loading of the neck–shoulder musculature (++); suggestive for static loading, neck flexion, or force in the absence of repetition (+), high job demands (+), low control of work (+), and low social support (+); and insufficient (0) for lifting and manual handling, physical workload, vibration, and certain other little-studied psychosocial factors.

In attempts to define a threshold at which repetition significantly increases risk, the only useful information comes from the prospective study of Andersen et al (18). This study represents a single study and defines repetition solely in terms of shoulder movements. [We found no good evidence that would enable an assessment of risks by duration of exposure or cumulative dose, based on time and frequency of movement.] Only in the highest category of repetition (>15 shoulder movements/minute) were risks significantly increased at the 5% level. The attributable fraction for exposed workers at this level would be 67%, on the assumption of causal relations and the assumption of a true unbiased estimate of risk.

Female gender and mental distress appear to be significant risk factors for the outcome, even after allowance for occupational exposures. The studies by occupational title have generally addressed gender by restriction or matching, and analyses of occupational activity have typically treated gender and mental health as confounders. Thus we found no data on the potential for effect modification by these personal risk factors.

One final issue of relevance to interpretation but not much discussed in the literature we found, concerns the disorder under review. Some authorities (34) would question whether tension neck syndrome, or neck pain with palpation tenderness, is a distinct diagnostic entity—there being no strong pathological, pathoanatomical, or epidemiologic evidence to justify disease labeling (despite the theories advanced). Moreover, evidence on the clinical course and functional impact of this outcome is strictly limited, and it is not clear how often the condition persists, given the continuation or discontinuation of exposure. The best studies have shown that the diagnostic label of neck pain with palpation tenderness can be reproducible between observers at the research level, with sufficient care and training; but reproducibility may well be lower between clinicians in routine practice. In our view, the case for compensation (as a starting point of our review) begins with case definition, and there is significant scientific doubt about the disorder as a diagnostic entity, principally because of a lack of evidence that neck pain with tenderness differs from neck pain alone in its causes and outcome.

If there is acceptance of tension neck syndrome as a compensable entity, then there is reasonable evidence to suggest a causal association, on the balance of probabilities, with certain repetitive movements of the upper limb and with neck flexion or static loading of the neck–shoulder musculature. A practical and challenging need would arise to identify such exposures in claimants, and this need might be met by the application of nationally representative job-exposure matrices or population surveys of exposure, should these exist. If there is not acceptance of a distinct disease entity at present, then future research effort should be directed towards a better understanding of pathogenesis, to improve outcome classification, and a better characterization of clinical course.

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Appendix 1

Search strategy

See the homepage of the *Scandinavian journal of Work, Environment & Health* for the contents of the appendix.

Appendix 2

Framework of the Scientific Committee of the Danish Society of Occupational and Environmental Medicine for assessing the evidence on causal associations

Strong evidence of a causal association (+++)

A causal relationship is very likely. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiologic studies. It can be ruled out with reasonable confidence that this relationship is explained by chance, bias, or confounding.

Moderate evidence of a causal association (++)

A causal relationship is likely. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiologic studies. It cannot be ruled out with reasonable confidence that this relationship can be explained by chance, bias, or confounding, although this is not a very likely explanation.

Limited evidence of a causal association (+)

A causal relationship is uncertain. A positive relationship between exposure to the risk factor and the outcome has been observed in several epidemiologic studies. It is not unlikely that this relationship can be explained by chance, bias, or confounding.

Insufficient evidence of a causal association (0)

The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association.

Evidence suggesting lack of a causal association (–)

Several studies of sufficient quality, consistency, and statistical power indicate that the specific risk factor is not causally related to the specific outcome.