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Key terms: cervical disorders; critical literature overview; neck trouble; physical load

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Physical risk factors for neck pain

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To identify physical risk factors for neck pain, a systematic review of the literature was carried out. Based on methodological quality and study design, 4 levels of evidence were defined to establish the strength of evidence for the relationship between risk factors and neck pain. Altogether, 22 cross-sectional studies, 2 prospective cohort studies, and 1 case-referent study were eligible for determining the level of evidence. The results showed some evidence for a positive relationship between neck pain and the duration of sitting and twisting or bending of the trunk. A sensitivity analysis was carried out excluding 3 items of the quality list, the importance of which seemed doubtful. On the basis of this sensitivity analysis, it was concluded that there is some evidence for a positive relationship between neck pain and the following work-related risk factors: neck flexion, arm force, arm posture, duration of sitting, twisting or bending of the trunk, hand-arm vibration, and workplace design.

Key terms cervical disorders, critical literature overview, neck trouble, physical load.

Neck pain is a major problem in modern society. Prevalence data showed that, in a general population, the 1-year prevalence of neck pain was 29% and 40% for men and women, respectively (1). Prevalence data on occupational settings are even more impressive. For instance, Skov et al (2) found the 1-year prevalence of neck symptoms to be 54% for men and 76% for women in a population of salespeople (N=1304).

In The Netherlands, the costs of work-related sick leave and medical consumption in 1995 were very high (approximately 12 billion Dutch guilders for that year). Around 40% of these costs were due to musculoskeletal disorders (3). Although data on the specific costs of neck pain were not available, it is clear that the prevention of musculoskeletal problems, including neck pain, would be of great benefit.

Neck pain is assumed to be a multifactorial disease, and therefore it is assumed that there are several risk factors contributing to its development. Risk factors can be work-related or nonwork-related, and they can be divided roughly into 3 categories (ie, physical, psychosocial, and individual risk factors). Many studies have been conducted in an attempt to identify the risk factors for neck pain. Most of these studies focus on only one or a few risk factors, or on a single category of risk factors. Several reviews on risk factors for neck pain have also been carried out (4—7). However, none of these reviews were based on explicitly stated inclusion and exclusion criteria or defined levels of evidence to establish the strength of the relationship between risk factors and neck pain. Borghouts et al (8) did, however, use explicitly stated inclusion and exclusion criteria, but the focus of their systematic review was on the clinical course and prognostic factors related to neck pain.

To identify physical risk factors for neck pain, a systematic review of the literature was carried out. This article describes the methods applied in this systematic review and presents the results concerning physical risk factors for neck pain.

Material and methods

Identification of studies

On-line searches in Medline, Embase, Psychlit and Sportdiscus, HSELINE, CISDOC and NIOSHTIC were

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carried out for the period 1966 to November 1997 to identify all relevant studies. The following key words were used (MeSH and text words): neck, neck pain, risk factors, determinants, causality, work, exercise, overuse, physical load, work load, psychosocial factors. Titles and abstracts were screened for potential risk factors for neck pain. The abstracts of all identified studies were read. If an abstract was not available, or, if, based on the content of the abstract, it was still not clear whether the article should be included in the review, the entire article was retrieved and read. In order to be included in the review, a study had to meet the following criteria: (i) the population of the study had to be a working population or a community-based population (studies of patient populations were excluded); (ii) the design of the study had to be either case-referent, cross-sectional, prospective cohort, or retrospective cohort with registered data; (iii) the assessment of exposure had to concern at least one physical factor during work or leisure time (studies with exposure solely based on job-title were excluded); (iv) the outcome had to include one or more syndromes, signs, or symptoms related to neck pain, the outcome variable could be either self-reported or a clinical diagnosis, and the outcome must have been separately reported for the neck region; and (v) the study had to be a full, peer-reviewed report published in English, Dutch, or German.

Reference lists of selected studies were screened for additional relevant studies. To check the selection procedure, a random sample of all the articles identified (N=30) was assessed by a second reviewer to determine whether or not the same articles were eligible for inclusion in the review.

Quality assessment

The methodological quality of all the studies included in the review was assessed by means of a methodological quality assessment list. After existing quality assessment lists (6, 8, 9) were studied, a criteria list was developed to assess the methodological quality of observational studies in this review. The list consisted of different items in 5 categories on information, validity, and precision (ie, purpose of the study, study population, exposure measurements, outcome measurements, and analysis and data presentation). Separate quality assessment lists were constructed for cross-sectional, case-referent and cohort studies (table 1). As can be seen from table 1, not all the items applied to all 3 study designs.

For every item on the list, a study was rated "positive" (+), "negative" (-), or "unclear" (?) if a study did or did not meet that item or if no clear information was stated regarding that item, respectively. For each study, a total quality score was calculated by counting the number of items rated positively for validity or precision. On the basis of this score, the studies were categorized as either high or low in quality. A high-quality study was defined as a study that scored positively on at least 50% of the validity or precision items of the relevant methodological quality list, implying that a minimum score required for a classification as a high-quality study was 7 for cross-sectional studies, 9 for case-referent studies, and 8 for cohort studies. Two reviewers (GA and WM) scored all the studies independently; the results were compared and differences were discussed during a consensus meeting. If, after discussion, the reviewers could not agree, a 3rd person (PB) made the final decision.

Studies rated lowest according to the methodological quality list (ie, a score of ≤ 3) were not included in the analysis for the determination of the level of evidence.

Levels of evidence

The strength of evidence for potential risk factors for neck pain was assessed by defining the levels of evidence as follows: (i) *Strong evidence*: consistent findings in multiple high-quality cohort or case-referent studies, (ii) *moderate evidence*: consistent findings in multiple cohort or case-referent studies, of which only 1 study was of high quality, (iii) *some evidence*: findings of 1 cohort or case-referent study, or consistent findings in multiple cross-sectional studies, of which at least 1 study was of high quality, (iv) *inconclusive evidence:* all other cases (ie, consistent findings in multiple low-quality cross-sectional studies, or inconsistent findings in multiple studies). Moreover, inconclusive evidence was defined as findings of only 1 cross-sectional study, irrespective of the quality of the study.

A positive effect of a risk factor implied, in line with the hypothesis, an increased risk for the occurrence of neck pain with the presence of this risk factor. A negative effect implied, in contrast to the hypothesis, a decreased risk for the occurrence of neck pain in the presence of this risk factor. Accordingly, no effect of a risk factor implied that the presence of this risk factor was not associated with either an increased or a decreased risk for the occurrence of neck pain.

The focus of this review was on the size and direction of the risk estimate, irrespective of the level of significance. A reported nonsignificant association between a risk factor and neck pain, with no mention of the risk estimate or the direction of the association was disregarded since, in such cases, it was not clear whether the risk estimate was increased or decreased. Reporting a significant association without stating the risk estimate was considered as a finding and thus contributed to the level of evidence.

Consistent findings implied that the results of at least 75% of the studies analyzing the effect of a certain risk factor should be pointing in the same direction. The

measures of effect and the P-values reported by these studies should lead to the same conclusion (ie, that a risk factor was found to have a positive or negative effect or no effect in relation to neck pain.

Results

Identification of relevant studies

Of the 1026 studies identified from the various data bases (the data bases overlap, the implication being that the actual number of studies identified was lower), 40 met the criteria for inclusion in the review. The large majority of these studies (N=37) was cross-sectional. One case-referent study and 2 prospective cohort studies were also included. The most important reason for the exclusion of studies was the use of a combined outcome measure (see, for example, references 10—16), implying that in these studies no separate results were reported for the neck region.

The 2 reviewers agreed on inclusion or exclusion for 90% of the studies of the random sample (N=30). After discussion with a 3rd person, consensus was reached on the inclusion or exclusion of all the studies.

Quality assessment

The overall percentage of agreement between the 2 reviewers on the methodological quality assessment was 84%. Considering the different items on the quality lists separately, the percentage of agreement ranged between 48% and 98%. The item concerning the use of an appropriate statistical model and the presentation of measures of effect (item T in table 1) had the lowest level of agreement. This result was due to an initial difference in interpretation of the item by the 2 reviewers.

During a consensus meeting, all disagreements between the 2 reviewers were resolved, and the final scores per item on the quality assessment lists are presented in the table in the appendix. In the last column of this table, the total quality score is presented for each study.

Table 1. Description of the different items in the quality assessment lists.

Item categories with different item definitions	Design[a]	I, V/P[b]
Study purpose		
A. Positive if a specific, clearly stated purpose was described.	Cr Ca Pr	I
Study design		
B. Positive if the main features (description of sampling frame, distribution by age and gender) of the study population were stated.	Cr Ca Pr	I
C. Positive if the participation rate at the beginning of the study was at least 80%.	Cr Ca Pr	V/P
D. Positive if the cases and referents were drawn from the same population and a clear definition of the cases and referents was stated. Persons with neck pain in the last 90 days had to be excluded from the reference group.	Ca	V/P
E. Positive if the response after 1 year of follow-up was at least 80% or if the nonresponse was not selective.	Pr	V/P
Exposure measurements		
F. Positive if the data on physical load at work were collected and used in the analysis.	Cr Ca Pr	V/P
G. Positive if the data on physical load at work were collected using standardized methods of acceptable quality.[c]	Cr Ca Pr	V/P
H. Positive if the data on psychosocial factors at work were collected and used in the analysis.	Cr Ca Pr	V/P
I. Positive if the data on psychosocial factors at work were collected using standardized methods of acceptable quality.[c]	Cr Ca Pr	V/P
J. Positive if the data on physical and psychosocial factors during leisure time were collected and used in the analysis.	Cr Ca Pr	V/P
K. Positive if the data on historical exposure at work were collected and used in the analysis.	Cr Ca Pr	V/P
L. Positive if the data on history of neck disorders, gender, and age were collected and used in the analysis.	Cr Ca Pr	V/P
M. Positive if the exposure assessment was blinded with respect to disease status.	Cr Ca	V/P
N. Positive if exposure was measured in an identical way among the cases and referents.	Ca	V/P
O. Positive if the exposure was assessed at a time prior to the occurrence of the outcome.	Ca	V/P
Outcome measurements		
P. Positive if the data on outcome were collected using standardized methods of acceptable quality.[d]	Cr Ca Pr	V/P
Q. Positive if the incident cases were used (prospective enrollment).	Ca	V/P
R. Positive if the data on outcome were collected for at least 1 year.	Pr	V/P
S. Positive if the data on outcome were collected at least every 3 months.	Pr	V/P
Analysis and data presentation		
T. Positive if the statistical model used was appropriate for the outcome studied and the measures of association estimated with this model were presented (including confidence intervals).	Cr Ca Pr	V/P
U. Positive if the study controled for confounding.	Cr Ca Pr	V/P
V. Positive if the number of cases in the multivariate analysis was at least 10 times the number of independent variables in the analysis.	Cr Ca Pr	V/P

[a] This column shows whether the item was used in the quality list for cross-sectional (Cr), case-referent (Ca) or prospective cohort (Pr) studies.
[b] This column shows if the stated item was an information (I) or a validity-precision (V/P) item.
[c] This item was scored positive if one of the following criteria was met: (i) for direct measurements, intraclass correlation coefficient >0.60 or kappa >0.40; (ii) for observational methods, intraclass correlation coefficient >0.60 or kappa >0.40 for the inter- or intraobserver reliability; and (iii) for self-reported data, intraclass correlation coefficient >0.60 or kappa >0.40 for the inter- or intraobserver reliability.
[d] This item was scored positive if one of the following criteria was met: (i) for self-reported data, intraclass correlation coefficient > 0.60 or kappa >0.40; (ii) for registered data, data must show that the registration system was valid and reliable; and (iii) for physical examination, intraclass correlation coefficient >0.60 or kappa >0.40 for the inter- or intraobserver reliability.

Of the 37 cross-sectional studies, only 4 scored positively on more than 50% of the validity or precision items on the quality list and were rated as high-quality studies (17—20). Of the validity and precision items, the item concerning the measurement and analysis of physical factors at work (item F) was the most often scored positively. This outcome was not very surprising since most literature on physical risk factors for neck pain concentrates on work-related risk factors. The items that were the most often scored as negative or unclear were those concerning the use of standardized measures of acceptable quality (items G, I, and P). Only 1 study provided satisfactory information on the standardization and quality of their exposure measures (20). Two studies provided this information for the outcome measures (20, 21).

Only 1 of the 3 longitudinal studies scored positively on more than 50% of the validity or precision items and was defined as a high-quality study (22). The case-referent study only investigated physical factors during leisure time as risk factors for neck pain (23). Consequently, many items on the quality list were scored negatively. None of the prospective cohort studies gave satisfactory information on the standardization and reliability of the exposure and outcome measures (items G, I, and P), the collection and analysis of data on history of neck pain, age and gender (item L), or the collection of data at least every 3 months (item S).

Of the total of 40 studies in this review, 36 studies collected and analyzed data concerning physical factors at work (item F). Data concerning physical load during leisure time (item J) were collected and analyzed in 11 studies. Of the 40 studies, 15 cross-sectional studies with a total quality score of 3 or less were excluded from the determination of the level of evidence (24—38). Consequently, the final number of studies included in the level of evidence synthesis was 25 [ie, 2 prospective cohort studies (22, 39), 1 case-referent study (23), and 22 cross-sectional studies (2, 17—21, 40—55)]. Table 2 gives a brief description of these studies.

The prospective study carried out by Rundcrantz et al (39) focused on occupational disorders among dentists. The exposure measures used in this study were very job-specific ergonomic factors, which were not comparable with the exposure measures used in any other study and were not related to self-reported neck symptoms. As a consequence, this study was not included in the determination of the level of evidence of any risk factor described in the Results section.

Level of evidence

Eight sets of risk factors were identified for which the level of evidence was determined. First, several neck postures were considered (ie, neck flexion, neck extension and neck rotation). The second set of risk factors involved factors related to the arm (ie, arm force and arm posture). The 3rd, 4th, and 5th set of risk factors concerned sedentary work postures, twisting or bending of the trunk, and hand-arm vibration. The 6th work-related set of risk factors concerned workplace design. Finally, 2 sets of nonwork-related risk factors were identified (ie, driving a vehicle and also sports and exercise).

Neck postures (flexion, extension and rotation). Four low-quality cross-sectional studies reported a relationship between neck pain and neck flexion as a risk factor (43, 45, 48, 55). All 4 studies indicated a positive effect of neck flexion on the occurrence of neck pain. Dartigues et al (43) presented an odds ratio of 1.7 for cervical spine flexion in relation to self-reported neck symptoms. Kilbom et al (48) found a significant positive association between neck flexion and self-reported neck symptoms ($P<0.01$) in a multiple regression analysis. Odds ratios of 3.4 (univariate analysis) and 2.6 (multivariate analysis) were reported by Ignatius et al (45), and a very high and unstable odds ratio (OR 787) was reported by Yu & Wong (55). Based on the availability of only 4 cross-sectional studies with a low quality score, the conclusion was reached that there is inconclusive evidence for a relationship between neck flexion and neck pain, even though the results of these studies all indicated a positive effect.

One study investigated neck extension in relation to neck symptoms (43). The authors found that neck extension was positively associated with self-reported neck symptoms, with an odds ratio of 2.3 in a univariate analysis. In their multivariate analysis they also found a significant association between neck extension and neck symptoms. Since there was only 1 cross-sectional study with a low quality score reporting on neck extension as a risk factor for neck pain, inconclusive evidence was found for a relationship between this measure of exposure and the outcome under study.

Two cross-sectional studies with a low quality score reported on the relationship between neck rotation and neck symptoms (43, 51). Dartiques et al (43) reported a positive effect (OR 2.4) of cervical spine rotation on self-reported neck symptoms. Musson et al (51) only stated that neck rotation was not significantly associated with neck symptoms, without reporting a measure of effect. On the basis of 1 low-quality cross-sectional study, it can be concluded that the evidence is inconclusive for a relationship between neck rotation and neck pain.

Arm force and arm posture. Arm force was studied as a potential risk factor for neck pain in 6 low-quality cross-sectional studies (2, 46, 47, 50, 51, 54). Different definitions and different methods of measuring arm force were used. Four of the studies only reported that arm force was not significantly associated with neck symptoms, but they did not report a measure of effect (2, 46, 51, 54). Linton

Table 2. Descriptive information from the studies used in this review with a total quality score of ≥4. (MQS = methodological quality score, Cr = cross-sectional study design, OR = odds ratio, 95% CI = 95% confidence interval, NS = not significant, Ca = case-referent study design, Pr = prospective study design, RR = rate ratio)

Reference	Design, MQS	Study population	Outcome measure(s)	Physical risk factor(s) and strength of association
Andersen & Gaardboe, 1993 (40)	Cr, 5	Female sewing machine operators (N=424) [response of total cohort 78.2% (N=896)]	Self-reported chronic neck pain	Nonwork-related factors: leisure-time exercise (OR 0.89, 95% CI 0.63—1.25)
Bergqvist et al, 1995 (41)	Cr, 6	Office workers (N=353) [response questionnaire 92%, response physical examination 91%, response workplace assessment 82%]	Tension-neck syndrome	Work-related factors: keyboard placed too high (OR 4.4, 95% CI 1.1—17.6)
Bernard et al, 1994 (17)	Cr, 7	Newspaper employees using video-display terminals [response at base-line 93% (N=973)]	Self-reported neck symptoms	Work-related factors: time spent on telephone (OR 1.4, 95% CI 1.0—1.8), number of times getting up from chair (NS), number of breaks (NS)
Bovenzi et al, 1991 (42)	Cr, 6	Male forestry workers using chain saws (N=65) and male workers who performed maintenance activities in a hospital and were not exposed to vibration (referents, N=31)	Self-reported persisting neck pain, tension-neck syndrome, cervical syndrome	Work-related factors: vibration >7.5 m/s^2 (OR 3.8, P=0.03, for self-reported persisting neck pain; OR 3.8, P=0.03, for tension-neck syndrome; OR 10.7, P<0.005, for cervical syndrome), vibration <7.5 m/s^2 (OR 0.9, NS, for self-reported persisting neck pain; OR 0.9, NS, for tension-neck syndrome OR 2.8, NS, for cervical syndrome)
Bru et al, 1996 (21)	Cr, 5	Female hospital staff [response at base line 85% (N=586)]	Neck pain index (based on self-reported data)	Work-related factors: perceived ergonomic load (NS)
Dartigues et al, 1988 (43)	Cr, 5	A working population (N=990)	Self-reported recurrent cervical pain syndrome	Work-related factors: sitting posture (NS), cervical spine rotation (OR 2.4, 95% CI 1.5—3.8), cervical spine flexion (OR 1.7, 1.0—3.0), cervical spine extension (OR 2.3, 95% CI 1.5—3.7), permanent posture (NS), strenuous muscular activity (NS); nonwork-related factors: strenuous muscular activity in leisure time (OR 0.4, 95% CI 0.2—0.7)
Dimberg et al, 1989 (44)	Cr, 5	Employees from Volvo Flygmotor (N=2933)	Self-reported neck symptoms	Work-related factors: using vibrating tools (P<0.001); nonwork-related factors: playing more racquet sports (P<.001)
Hales et al, 1994 (18)	Cr, 7	Telecommunication employees utilizing video-display terminals for at least 6 hours a day [response at base line 96% (N=512)]	Self-reported neck disorders	Nonwork-related factors: hours per week spent on recreational activities or hobbies (NS)
Ignatius et al, 1993 (45)	Cr, 6	Female typists working in the Government Housing Department [response at base line 52% (N=170)]	Self-reported neck pain	Work-related factors: mismatch of desk and chair heights (OR 3.0, P=0.021; OR 2.98),[a] bending the neck at work (OR 3.4, P=0.012; OR 2.62), daily typing hours (NS), bent back at work (NS)
Johansson & Rubenowitz, 1994 (46)	Cr, 5	Blue- and white-collar workers from 8 large metal industry companies [response at base line 90% (N=450)]	Self-reported neck symptoms, self-reported work-related symptoms	Work-related factors (blue-collar workers): heavy material handling (NS), extreme work posture (NS), light bent work posture (NS), monotonous work movements (NS), for self-reported neck symptoms; heavy material handling (NS), extreme work posture (NS), light bent work posture (NS), monotonous work movements (NS), for self-reported work-related neck symptoms; work-related factors (white-collar workers): bent work postures (P<0.01), monotonous work movements (P<0.001), twisted work postures (P<0.01), for self-reported neck symptoms; bent work postures (P<0.05), monotonous work movements (P<0.001), twisted work postures (P<0.01), for self-reported work-related neck symptoms
Johansson, 1995 (47)	Cr, 6	Home care workers (N=305)	Self-reported neck symptoms, self-reported work-related neck symptoms	Work-related factors: lifting heavy loads (RR 1.21, 95% CI 0.92—1.59), monotonous movements (RR 1.33, 95% CI 1.04—1.69), twisted postures (RR 1.26, 95% CI 0.97—1.63), deep forward flexed trunk (RR 1.33, 95% CI 1.06—1.68; P<0.15), hands above shoulder level (RR 1.17, 95% CI 0.96—1.44), for self-reported neck symptoms; lifting heavy loads (RR 1.74, 95% CI 1.09—2.77), monotonous movements (RR 1.73, 95% CI 1.22—2.47), twisted postures (RR 1.69, 95% CI 1.09—2.63; P<0.15), deep forward flexed trunk (RR 1.68, 95% CI 1.20—2.34; P<0.01), hands above shoulder level (RR 1.38, 95% CI 1.03—1.84), for self-reported work-related neck symptoms
Kamwendo et al, 1991 (19)	Cr, 7	Female medical secretaries and office personnel [response at base line 96% (N=420)]	Self-reported neck pain	Work-related factors: sitting ≥5 hours day (OR 1.49, 95% CI 0.86—2.61), work with office machines ≥5 hours a day (OR 1.65, 95% CI 1.02—2.67)

(continued)

Table 2. Continued.

Reference	Design, MQS	Study population	Outcome measure(s)	Physical risk factor(s) and strength of association
Kilbom et al, 1986 (48)	Cr, 5	Female assembly-line workers of 2 electronic manufacturing companies [response at base line 77% (N=106)]	Severity of self-reported neck symptoms	Work-related factors: increased average time per work cycle in neck flexion (P<0.01), increased average time per work cycle upper arm 0—30° abducted (P<0.05); nonwork-related factors: leisure-time physical activity (NS)
Lau et al, 1996 (49)	Cr, 5	All adults >30 years of age living in 2 apartment buildings in Shatin, Hong Kong	Self-reported neck pain	Nonwork- related factors: sports activity (NS)
Linton, 1990 (50)	Cr, 6	Full-time employees working daytimes (N=22 180)	Self-reported neck pain	Work-related factors: heavy lifting (OR 1.41—1.83),[b] monotonous work (OR 2.25—2.95), sitting (OR 0.94—1.33), uncomfortable posture (OR 1.59—2.42); nonwork-related factors: exercise (OR 0.91—1.06)
Mäkelä et al, 1991 (20)	Cr, 9	Finnish adults drawn from the population register, representing the Finnish adult population of ≥30 years [response at baseline 90% (N=7217)]	Chronic neck syndrome	Work-related factors (age 30—64 years): physical stress at work (OR 1.35, 95% CI 1.27—1.42; OR 1.26, 95% CI 1.18—1.33); work-related risk factors (age >64 years): physical stress at work (OR 1.21, 95% CI 1.08—1.34; OR 1.12, 95% CI 1.00—1.26)
Mundt et al, 1993 (23)	Ca, 6	Cases: patients with cervical disc herniation (N=68); referents: persons free of disc herniation (N=63) [N=63 cases were matched to a referent (93%)]	Herniated cervical disc	Nonwork-related factors: baseball (RR 1.05, 95% CI 0.40—2.75), golf (RR 0.59, 95% CI 0.21—2.61), bowling (RR 1.63, 95% CI 0.70—3.83), swimming (RR 0.71, 95% CI 0.31—1.63), diving (RR 0.96, 95% CI 0.36—2.52), jogging (RR 0.86, 95% CI 0.41—1.81), aerobics (RR 0.94, 95% CI 0.39—2.29), racket sports (RR 1.14, 95% CI 0.50—2.60), playing any of these sports (RR 0.39, 95% CI 0.12—1.30), use of free weights (RR 1.87, 95% CI 0.74—4.74), weight lifting (RR 0.75, 95% CI 0.31—1.78)
Musson et al, 1989 (51)	Cr, 4	Workers using various types of impact tools (N=445) [response at base line 38% (N=169)]	Self-reported regularly pain or stiffness in the neck	Work-related factors: vibration (ß=0.044, P=0.01), lifting heavy loads while handling impact tool (NS), turning neck while handling impact tool (NS), bending forward while handling impact tool (NS), bending aside while handling impact tool (NS)
Rundcrantz et al, 1991 (39)	Pr, 5	Official dentists in Malmö [response at base line 90% (N=359), response at follow-up 92% (N=315)]	Self-reported neck symptoms	Work-related factors: change own position to the patient to obtain a direct view (NS), alter the position of the patient to obtain a direct view (NS)
Schibye et al, 1995 (52)	Cr, 5	Female sewing machine operators [response at base line 94% (N=306)]	Self-reported neck symptoms	Work-related factors: individual adjustment of table and chair (NS)
Skov et al, 1996 (2)	Cr, 6	Random 8% sample of the members of the Association of Danish Active Salespeople [response at base line 66% (N=1306)	Self-reported neck symptoms	Work-related factors: one-quarter of worktime sitting (OR 2.68, 95% CI 1.31—5.49), half of worktime sitting (OR 1.92, 95% CI 0.98—3.79), three-quarters of worktime sitting (OR 2.18, 95% CI 1.11—4.29), all of worktime sitting (OR 2.80, 95% CI 1.40—5.59), lifting heavy loads (NS); nonwork-related factors: annual driving distance 5—10 000 km (OR 0.99, 95% CI 0.45—1.76), annual driving distance 10—15 000 km (OR 1.48, 95% CI 0.75—2.93), annual driving distance 15—30 000 km (OR 1.74, 95% CI 1.01—2.99), annual driving distance 30—50 000 km (OR 2.10, 95% CI 1.24—3.54), annual driving distance >50 000 km (OR 2.43, 95% CI 1.36—4.34), time spent in the car (NS), leisure-time sports activities (NS)
Tharr, 1995 (53)	Cr, 6	Teleservice representatives from 2 teleservice centers [response at base line 95% (N=108)]	Self-reported neck symptoms	Work-related factors: chair discomfort (OR 3.5, 95% CI 1.4—8.9), hours spent typing at video display workstation (NS), number of hours spent on the telephone (NS), length of time continuously sitting on a chair (NS)
Viikari-Juntura et al, 1994 (22)	Pr, 9	Male machine operators, carpenters and office workers; response at base line 69% (N=2222) [response at follow-up 82% (N=1832)]	Self-reported neck pain, change from 1984 to 1987: none to moderate, none to severe, persistent severe	Work-related factors: rather or very much twisting or bending at work (OR 1.8; 95% CI 1.2—2.7), for the category none to moderate; rather or very much twisting or bending at work (OR 1.9; 95% CI 1.2—3.2), for the category none to severe; twisting or bending at work (NS), for the category persistent severe; nonwork-related factors: physical exercise (NS) and annual car driving (NS), for the category none to moderate; physical excercise (NS) and annual car driving (NS), for the category none to severe; physical exercise (NS) and annual car driving (NS), for the category persistent severe
Wells et al, 1983 (54)	Cr, 4	Male letter carriers, meter readers and postal clerks	Self-reported current symptoms of neck pain	Work-related factors: weight carrying (NS)
Yu & Wong, 1996 (55)	Cr, 4	Video-display unit workers in a Hong Kong bank; response at base line 80% (N=121)	Self reported neck discomfort or ache during work after starting job	Work-related factors: longer daily video-display use workhours (P=0.013), bending back at work (P<0.001), inclining neck at work (P<0.001; 787.400, 33.280—18630), incorrect height of chair (P=0.010), repetitive movements (P=0.232), fixed keyboard distance (P=0.549), fixed keyboard height (P=0.005; 90.060, 7.684—1056), fixed keyboard tilt (P=0.341), fixed screen distance (P=1.000), fixed screen height (P=0.061), fixed screen tilt (P=.571)

[a] If 2 analyses were carried out for a specific exposure and outcome, both results are presented.
[b] Several age-specific odds ratios, ranging from 1.41 to 1.83, are presented in this study.

(50) studied the relationship between heavy lifting and self-reported neck symptoms in specific age groups, the result being odds ratios varying between 1.41 and 1.83, indicating a positive effect of heavy lifting on the occurrence of neck symptoms. Johansson reported an age-stratified rate ratio of 1.21 for the relationship between heavy lifting and self-reported neck symptoms (47). If the outcome measure was defined as self-reported work-related neck symptoms, the rate ratio was 1.74.

In summary, the level of evidence for arm force is based on the results of 2 cross-sectional studies, both with a low quality score (47, 50). The results of both studies point in the same direction (ie, that there is a positive effect of arm force on the occurrence of neck pain). However, due to the low quality of the studies, it can be concluded that there is inconclusive evidence for a relationship between arm force and neck pain.

Several low-quality cross-sectional studies reported on the relationship between arm posture and neck pain (46—49, 50, 55). As described earlier for arm force, arm posture was also operationalized in different ways in these studies, for example, as static arm posture, as repetitive movements of the arms, or as nonneutral positions of the upper arm. Yu & Wong only stated that the relationship between repetitive movements and self-reported neck symptoms was not significant, not mentioning any measure of effect (55). In their study, Johansson & Rubenowitz (46) found a significant positive correlation coefficient ($P<0.001$) between monotonous work movements and self-reported neck symptoms among white-collar workers, and Kilbom et al (48) found a significant positive relationship ($P<0.05$) between the time spent in upper arm abduction and self-reported neck symptoms. Moreover, 2 studies reported positive measures of effect for arm load on the occurrence of neck symptoms (47, 50). Linton (50) reported odds ratios varying for specific age groups from 2.25 to 2.95. Johansson (47) found a rate ratio of 1.33 for monotonous movements and a rate ratio of 1.17 for work with the hands above shoulder level in relation to neck symptoms. In relation to work-related neck symptoms, Johansson found rate ratios of 1.73 and 1.38 for monotonous work and work with the hands above shoulder level, respectively. Again, in spite of the many positive associations reported, it can be concluded that there is inconclusive evidence for a relationship between arm load and neck pain because no high-quality study reported this relationship.

Duration of (fixed) sedentary work postures. A total of 8 cross-sectional studies investigated the duration of sitting as a risk factor for neck pain (2, 17, 19, 43, 45, 50, 53, 55). Two of them were rated as high in quality (17, 19). All of them used different methods to measure the sitting posture of the worker. For example, Bernard et al (17) measured "the time spent on the telephone" and Kamwendo et al (19) studied "the time spent working with office machines" and "sitting for more than 5 hours a day" as potential risk factors for neck pain. Three studies only reported that the association between sitting and neck pain was not significant, but they did not describe a measure of effect (43, 45, 53). Kamwendo et al (19) reported an odds ratio of 1.49 for sitting more than 5 hours a day in relation to self-reported neck symptoms. Furthermore, they reported an odds ratio of 1.65 for the relationship between working with office machines for more than 5 hours a day and self-reported neck symptoms. Bernard et al (17) reported an odds ratio of 1.4 in a multivariate analysis for the relationship between increased time spent on the telephone and self-reported neck symptoms. In the study carried out by Skov et al (2) the values of the odds ratios for sitting in relation to self-reported neck symptoms were slightly higher. In a multivariate analysis, 4 categories of "sitting time" were found to be related to neck symptoms. The odds ratios ranged from 1.92 to 2.80, the odds ratios increasing for increased "sitting time". Finally, Yu & Wong (55) also reported a significant association ($P=0.013$) between increased hours of video display terminal (VDT) work and self-reported neck discomfort. Linton (50) reported 4 odds ratios for specific age groups (0.94, 1.00, 1.12 and 1.33) for the relationship between sedentary posture and self-reported neck pain. From this study it is not clear whether there was a positive effect or no effect of sedentary postures on neck pain.

In summary, 4 cross-sectional studies, 2 of which were of high quality, reported a positive effect of sitting posture on the occurrence of neck pain, the conclusion therefore being that there is some evidence for a relationship between sitting posture and neck pain.

Twisting or bending of the trunk. Six studies reported on twisting or bending of the trunk as risk factors for neck pain. One was a high-quality prospective cohort study (22), and the other 5 were of cross-sectional design and low in quality (45—47, 51, 55). In the high-quality prospective cohort study, carried out by Viikari-Juntura et al (22), an odds ratio of 1.8 was reported for "rather" or "very much" bending or twisting and the development of self-reported neck trouble during follow-up. An odds ratio of 1.9 was found for "rather" or "very much" twisting or bending in relation to the development of self-reported severe neck trouble during follow-up. Two low-quality cross-sectional studies reported a nonsignificant relationship between bending and neck symptoms, without mentioning any measure of effect (45, 51). The results of the remaining 3 low-quality cross-sectional studies all point in the same direction as the results of the prospective cohort study (46, 47, 55).

Based on the prospective findings of Viikari-Juntura et al (22), it can be concluded that there is some evidence

for a positive relationship between twisting or bending of the trunk and neck pain.

Hand-arm vibration. Hand-arm vibration was studied in 3 cross-sectional studies with a low quality score (42, 44, 51). Dimberg et al (44) found a positive significant relationship (P<0.001) between hand-arm vibration and neck symptoms. Bovenzi et al (42) reported several odds ratios for different outcome measures for 2 categories of vibration, compared with no vibration, the results indicating a positive effect of vibration on neck pain. For self-reported neck pain the odds ratios were 0.9 for the low category and 3.8 for the high category, compared with no vibration. For the outcome measure tension neck syndrome the same odds ratios were found. For the outcome measure cervical syndrome, an odds ratio of 2.8 was reported for the low category and that of 10.7 for the high category, compared with no vibration. Musson et al (51) reported a beta of 0.44 with a P-value of 0.01 for the relationship between hand-arm vibration and self-reported neck pain. In spite of the consistent positive findings of these 3 studies, it is concluded that there is inconclusive evidence for a relationship between hand-arm vibration and neck pain, due to the low quality of the studies.

Workplace design. A total of 5 low-quality cross-sectional studies investigated the relationship between workplace design and neck pain (41, 45, 52, 53, 55). Schibye et al (52) studied the lack of individual adjustment for a table and chair as a risk factor for self-reported neck symptoms but found no significant relationship between the 2 factors, and no measure of effect was reported. Ignatius et al (45) reported odds ratios of 3.0 (univariate analysis) and 2.98 (multivariate analysis) for the relationship between a mismatch of table and chair height and self-reported neck pain. Tharr (53) reported an odds ratio of 3.5 for the relationship between chair discomfort and self-reported neck symptoms. Yu & Wong (55) studied many workplace design factors, all concerning the chair and the VDT. They reported a positive significant relationship (P=0.01) between incorrect chair height and self-reported neck symptoms. For the factors concerning the VDT they reported a significant positive association between a fixed keyboard height and self-reported neck symptoms (P=0.005). The odds ratio in the multivariate analysis for this relationship was 90, which is extremely high and therefore probably unstable. For all the other factors, concerning the VDT, Yu & Wong only reported that the relationships between these factors and neck symptoms were not significant, without mentioning any measure of effect. Bergqvist et al (41) reported a significant association between insufficient table space and tension neck syndrome without mentioning the P-value. Furthermore, they reported an odds ratio of 4.4 for too high a keyboard placement in relation to tension neck syndrome.

Based on 4 low-quality cross-sectional studies, the conclusion is that there is inconclusive evidence for a relationship between workplace design factors and neck pain.

Driving a vehicle. Driving a vehicle as a risk factor for neck pain was assessed in 2 studies. One was a low-quality cross-sectional study (2), and the other was a high-quality prospective cohort study (22). Skov et al (2) studied annual driving distance in relation to neck pain. Six distance categories were distinguished (<5000 km, 5000—10 000 km, 10 000—15 000 km, 15 000—30 000 km, 30 000—50 000 km, and >50 000 km) as risk factors for self-reported neck pain. They found odds ratios ranging from 0.99 to 2.43 (multivariate analysis) for the different categories, with increasing values for the odds ratio with increasing distance, implying a positive effect of annual driving distance on neck pain. In their prospective cohort study, Viikari-Juntura et al (22) found that the relationship between annual car driving and neck pain was not significant, without mentioning a measure of effect. On the basis of 1 low-quality cross-sectional study, it can be concluded that there is inconclusive evidence for a relationship between car driving and neck pain.

Sports and exercise. Sports and exercise during leisure time were investigated in 8 studies, 6 of which were low-quality and cross-sectional in nature (2, 40, 44, 48—50), 1 was a low-quality case-referent study (23), and 1 was a high-quality prospective cohort study (22). Some of the studies hypothesized a favorable effect of participation in sports on neck pain, while others considered participation in sports to be a risk factor for neck pain. In their high-quality prospective study, Viikari-Juntura et al (22) found that the relationship between physical exercise during leisure time and self-reported neck trouble was not significant, but they reported no measure of effect.

Mundt et al (23) studied the relationship between participation in sports and herniated cervical disc in a low-quality case-referent study, finding positive, negative, and no effects for the various sports studied. They calculated rate ratios for participation in various types of sports at least 10 times in the 2 years prior to the occurrence of cervical herniated disc: baseball (RR 1.05), golf (RR 0.59), bowling (RR 0.63), swimming (RR 0.71), diving (RR=0.96), jogging (RR 0.86), aerobics (RR 0.94), racket sports (RR 1.14). The rate ratio (RR) for participation in any of these sports at least 10 times in the 2 years prior to the occurrence of cervical disc herniation was 0.39. The rate ratio for the use of free weights was 1.87 and that for weight lifting was 0.75. On the basis of these inconsistent results, it is concluded that there is incon-

clusive evidence for a relationship between sports and exercise and neck pain.

There were also several low-quality cross-sectional studies in which the relationship between leisure-time exercise and neck pain was investigated. Three studies found that the relationship between exercise and neck pain was not significant, but they did not report any measure of effect (2, 48, 49). Linton (50) and Andersen & Gaardboe (40) reported odds ratios for the relationship between exercise and neck pain, but neither study indicated an effect. Linton (50) reported odds ratios ranging for different age groups from 0.91 to 1.06 , and Andersen & Gaardboe (40) found an odds ratio of 0.89. Dimberg et al (44) more specifically studied the relationship between participating in racket sports and self-reported neck symptoms. The results of their multivariate analysis showed that increased participation in racket sports was significantly associated with fewer neck symptoms ($P<0.001$). Based on the hypothesis that sports and exercise induce neck pain, this finding should be interpreted as a negative effect.

On the basis of the case-referent study of Mundt et al (23), it can be concluded that there is inconclusive evidence for a relationship between sports and exercise and neck pain.

Discussion

To identify physical risk factors for neck pain, a systematic review of the literature was carried out. The results showed some evidence for a positive relationship between the duration of (fixed) sedentary work posture and twisting or bending of the trunk and the occurrence of neck pain. Inconclusive evidence was found for the other physical risk factors studied (ie, neck flexion, neck extension, neck rotation, arm force and posture, hand-arm vibration, workplace design, driving a vehicle, and sports and exercise).

Kuorinka & Forcier (4) identified risk factors for tension neck syndrome in their review. Repetitive work and constrained arm and head posture appeared to be associated with an increased risk for tension neck syndrome among working populations. In the present review neither of these factors were found to be related to neck pain. In his review, Bernard (5) found evidence for a relationship between neck disorders and repetitive work (continuous arm or hand movements that generate load to the neck or shoulder area), repetitive neck movements, forceful arm movements, and static postures involving the neck or shoulder muscles. These results are similar to the results found by Kuorinka & Forcier (4), although they differ from the results reported in the present review. Stock (6) did not find any evidence for risk factors related to tension neck syndrome, possibly due to the very strict inclusion criteria which were applied, resulting in the inclusion of only 3 studies. Stock excluded studies using self-reported neck symptoms as an outcome measure. Most studies included in the present review actually used self-reported neck symptoms as an outcome measure. Consequently, the results of these reviews are barely comparable. In the review carried out by Hagberg & Wegman (7), several exposures based on job titles were compared. For keyboard operators, an increased odds ratio was found for tension neck syndrome. In the present review, studies assessing exposure based on job titles were excluded. Consequently, it is difficult to make a comparison between the results of this review and the results reported by Hagberg & Wegman.

Selection of studies

For this review several data bases were systematically searched to identify all relevant studies. Many studies on risk factors do not focus on 1 single outcome measure, but report on several separate outcome measures, of which neck pain is one. If, in these studies, the main focus is not on neck pain but, for example, on low-back pain, key words could have been used which only relate to low-back pain and not to neck pain. Consequently these studies may have been missed during the literature search. Furthermore, no effort was made to identify unpublished studies concerning risk factors for neck pain. These 2 facts may have introduced bias in the identification of studies for this review.

The most important reason for exclusion was the fact that the results of a study were not reported for the neck region separately. Many studies did not use neck pain as an outcome measure, but used a combination of neck and shoulder pain as an outcome measure (for example, references 10—16). Since the objective of this review was to identify risk factors for neck pain, it was decided to exclude these studies. Moreover, in the excluded studies, it was often unclear what was meant by neck or shoulder pain. Pain in the proximal part of the upper arm may have been included in these studies. Since it is possible that other risk factors may be of influence in determining the existence of pain in the neck or shoulder region, these studies were not included in the review. However, this procedure may have led to the exclusion of some studies that actually did investigate the neck region.

Most of the studies identified were of cross-sectional design. Only 1 case-referent study (23) and 2 prospective cohort studies (22, 39) were identified. In cross-sectional research the temporal relationship between exposure and outcome, and thus causality, cannot be firmly established. The reason cross-sectional studies were included in this review, despite this disadvantage, was that most of the research on risk factors for neck pain was actually based on a cross-sectional design. It would

not have been acceptable to neglect the vast amount of information obtained from cross-sectional research. However, the fact that the majority of studies evaluated were cross-sectional does imply that only some evidence could be established in this review.

The studies included in the review were very heterogeneous with regard to both the exposure measures and the outcome measures. Most of the studies used a self-reported outcome measure, but 4 used clinical diagnosis as the outcome measure (20, 23, 41, 42). Some studies presented extensive definitions of the outcome measures in regard to the intensity and duration of neck symptoms, while other studies only used the occurrence of neck symptoms during the previous 12 months as an outcome measure, irrespective of the intensity and duration of symptoms.

One of the inclusion criteria for this review was that studies either reported on specific or nonspecific neck symptoms. This criterion resulted in the inclusion of only 1 study that used a specific neck outcome (cervical herniated disc) (23). Although the outcome used in this study, carried out by Mundt et al (23), may be essentially different in comparison with the outcomes used in the other studies included in the review, it was combined with all other studies for the determination of the level of evidence for the risk factor "sports and exercise". Inconclusive evidence was found for a relationship between sports and exercise and neck pain, due to the inconsistent findings reported by Mundt et al (23), but, even if these findings were ignored, the results regarding the level of evidence for the risk factor "sports and exercise" would not have been influenced. On the basis of 3 low-quality cross-sectional studies reporting mixed results, it can be concluded that there is inconclusive evidence for a relationship between sports and exercise and neck pain.

Some studies used very general exposure measures for the assessment of physical load. For example, Dartigues et al (43) used self-reported "strenuous muscular activity at work" as a general measure of exposure, and Mäkelä et al (20) used self-reported "physical stress at work" as the only physical exposure measure in their high-quality cross-sectional study . In the same way, general measures were used for activities during leisure time and for entire body postures. No level of evidence was determined for these general measures because the focus of this review was on neck-specific risk factors, such as neck postures and neck movements. Although at first sight the risk factors sedentary work posture, twisting or bending of the trunk, workplace design, and car driving may also not be classified as neck-specific risk factors, the level of evidence for these factors was determined. The reason for this approach was that they are surrogate factors for awkward neck postures or neck movements.

Little is known about the mechanisms leading from physical exposure to musculoskeletal disorders. Winkel & Mathiassen (56) suggest the following 3 main dimensions to quantify physical exposure: the level (the magnitude of the mechanical force), repetitiveness (the frequency of shifts between force levels), and the duration (the time period) of exposure. In most studies in the review little quantitative information on the level, time pattern, or duration of the exposure to the risk factor under study was reported. In future epidemiologic studies, all 3 dimensions should be considered in the assessment of physical exposure in relation to musculoskeletal disorders.

Methodological quality and levels of evidence

A quality list was constructed to assess the methodological quality of the studies in this review. This list consisted of several items concerning information, validity, and precision in different categories. A total quality score was calculated by counting the number of validity and precision items that were scored positively on the criteria list. Based on the total quality score, studies were defined as high or low in quality. Four levels of evidence were defined to establish the strength of evidence for a relationship between a risk factor and neck pain. These levels were based on the consistency of results, study design, and methodological quality. The procedure and rating of the methodological quality had a considerable influence on the establishment of the level of evidence, indicating that changes in this procedure may have a large impact on the results.

All items on the methodological quality list were given the same weighting factor on the assumption that all items are equally important. One disadvantage of this method is that a single critical mistake in a study will lead to a negative score on this critical quality item. If that same study scores positively on all other items, this critical flaw in the study has little or no influence on the total quality score.

Of the 37 cross-sectional studies that investigated physical risk factors for neck pain, only 4 were rated as high-quality studies (17—20). The mean total quality score for the cross-sectional studies was 4.3. Compared with the cut-off value of at least 7 for classification as a high-quality study, this value is low. The items on the standardization of the exposure and outcome measures were given the lowest scores. Only 1 study (20) presented data on the standardization of the exposure measures, and only 2 studies presented such data for the outcome measures (20, 21). Many studies reported that they used standardized questionnaires, but presented no data to confirm this. It is clear that the 3 items concerning the standardization of exposure and outcome measures did not discriminate between high- or low-quality studies, since hardly any of the studies scored positively on these items. This outcome is not surprising because it was a very strict item. Not only should exposure and outcome assessment

be standardized, but data to confirm the standardization should also be presented. When these 3 standardization items on the methodological quality list were not taken into account, the number of high-quality studies increased from 5 to 13 (2, 17—20, 22, 41, 42, 45, 47, 50, 52, 53). Two of the three longitudinal studies were classified as high-quality studies (2, 22). The results of this sensitivity analysis lead to the conclusion that there is some evidence that neck flexion, arm force, arm posture, duration of (fixed) sedentary work posture, twisting or bending of the trunk, hand-arm vibration, and workplace design factors are risk factors for neck pain. Inconclusive evidence was found for neck extension, neck rotation, driving a vehicle, and sports and exercise. These results are more in line with the results of the reviews carried out by Kuorinka & Forcier (4) and Bernard (5).

Concluding remarks

According to this systematic review, there is some evidence for a positive relationship between the duration of (fixed) sedentary posture at work and neck pain, and there is some evidence for a positive relationship between twisting or bending of the trunk at work and neck pain. It is clear that the low methodological quality of most of the studies described in this review was the main reason behind the inconclusive evidence for risk factors that would be expected to be related to neck pain. A sensitivity analysis showed that a change in the quality assessment list resulted in a different conclusion, namely, that there is some evidence for a positive relationship between neck pain and neck flexion, arm force, arm posture, duration of (fixed) sedentary posture, twisting or bending of the trunk, hand-arm vibration, and workplace design factors.

In contrast to reviews on the effectiveness of different types of intervention, methodological guidelines on the systematic review of observational studies are not available. The systematic review of observational studies on risk factors for musculoskeletal disorders is still in a very experimental stage. It is challenging to capture the wide range of possible biases that threaten the validity of the results of observational studies. However, there is much to gain from a systematic transparent method for the review process of observational epidemiologic studies.

References

1. Bovim G, Schrader H, Sand T. Neck pain in the general population. Spine 1994;19:1307—9.
2. Skov T, Borg V, Ørhede E. Psychosocial and physical risk factors for musculoskeletal disorders of the neck, shoulders, and lower back in salespeople. Occup Environ Med 1996; 53:351—6.
3. Koningsveld EAP, Mossink JCM, editors. Kerncijfers maatschappelijke kosten van arbeidsomstandigheden in Nederland [Socio-economic costs of occupational safety and health in The Netherlands]. 's Gravenhage: Ministerie van Sociale Zaken en Werkgelegenheid, VUGA Uitgeverij BV, 1997.
4. Kuorinka I, Forcier L, editors. Work related musculoskeletal disorders (WMSD): a reference book for prevention. London: Taylor & Francis Ltd, 1995;17—137.
5. Bernard BP, editor. Musculoskeletal disorders (MSDs) and workplace factors. Cincinnati (OH): US Department of Health and Human Services, 1997.
6. Stock SR. Workplace ergonomic factors and the development of musculoskeletal disorders of the neck and upper limb: a meta-analysis. Am J Ind Med 1991;19:87—107.
7. Hagberg M, Wegman DH. Prevalence rates and odds ratios of shoulder-neck diseases in different occupational groups. Br J Ind Med 1987;44:602—10.
8. Borghouts JAJ, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. Pain 1998;77:1—13.
9. Van Tulder MW, Assendelft WJJ, Koes BW, Bouter LM. Method guidelines for systematic reviews in the Cochrane Collaboration back review group for spinal disorders. Spine 1997;20:2323—30.
10. Bergqvist U. Visual display terminal work a A perspective on long-term changes and discomforts. Int J Ind Ergon 1995; 16:201—9.
11. Bjelle A, Hagberg M, Michaelson G. Work-related shoulder-neck complaints in industry: a pilot study. Br J Rheumatol 1987;26:365—9.
12. Engels JA, van der Gulden JWJ, Senden TF, Hertog CAWM, Kolk JJ, Binkhorst RA. Physical work load and its assessment among the nursing staff in nursing homes. J Occup Med 1994; 36:338—45.
13. Hägg GM, Åstrom A. Load pattern and pressure pain threshold in the upper trapezius muscle and psychosocial factors in medical secretaries with and without shoulder/neck disorders. Int Arch Occup Health 1997;69:423—32.
14. Hasvold T, Johnsen R, Førde OH. Non-migrainous headache, neck or shoulder pain, and migraine — differences in association with background factors in a city population. Scand J Prim Health Care 1996;14:92—9.
15. Veiersted KB, Westgaard RH. Development of trapezius myalgia among female workers performing light manual work. Scand J Work Environ Health 1993;19:277—83.
16. Westgaard RH, Jensen C, Hansen K. Individual and work-related risk factors associated with symptoms of musculoskeletal complaints. Int Arch Environ Health 1993;64:405—13.
17. Bernard B, Sauter S, Fine L, Petersen M, Hales T. Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. Scand J Work Environ Health 1994;20:417—26.
18. Hales TR, Sauter SL, Peterson MR, Fine LJ, Putz-Anderson V, Schleifer LR et al. Musculoskeletal disorders among visual display terminal users in a telecommunication company. Ergonomics 1994;37:1603—21.
19. Kamwendo K, Linton SJ, Moritz U. Neck and shoulder disorders in medical secretaries. Scand J Rehabil Med 1991; 23:127—33.
20. Mäkelä M, Heliövaara M, Sievers K, Impivaara O, Knekt P, Aromaa A. Prevalence, determinants, and consequences of chronic neck pain in Finland. Am J Epidemiol 1991; 134:1356—67.
21. Bru E, Mykletun RJ, Svebak S. Work-related stress and mus-

culoskeletal pain among female hospital staff. Work Stress 1996;10:309—21.
22. Viikari-Juntura E, Riihimäki H, Tola S, Videman T, Mutanen P. Neck trouble in machine operating, dynamic physical waork and sedentary work: a prospective study on occupational and individual risk factors. J Clin Epidemiol 1994;47:1411—22.
23. Mundt DJ, Kelsey JL, Golden AL, Panjabi MM, Pastides H, Berg AT, et al. An epidemiologic study of sports and weight lifting as possible risk factors for herniated lumbar and cervical discs. Am J Sports Med 1993;21:854—60.
24. Chang WS, Bejjani FJ, Chyan D, Bellegarde M. Occupational musculoskeletal disorders of visual artists: a questionnaire and video analysis. Ergonomics 1987;30:33—46.
25. Hünting W, Läubli T, Grandjean E. Postural and visual loads at VDT workplaces, I: constrained postures. Ergonomics 1981;24:917—31.
26. Ingelgård A, Karlsson H, Nonås K, Örtengren R. Psychosocial and physical work environment factors at three workplaces dealing with materials handling. Int J Ind Ergon 1996; 17:209—20.
27. Jacobsson L, Lindgärde F, Manthorpe R, Ohlsson K. Effect of education, occupation and some lifestyle factors on common rheumatic complaints in a Swedish group aged 50—70 years. Ann Rheum Dis 1992;51:835—43.
28. Ohlsson K, Attewell R, Skerving S. Self-reported symptoms in the neck and upper limbs of female assembly workers: impact of length on employment, work pace and selection. Scand J Work Environ Health 1989;15:75—80.
29. Pocekay D, McCurdy SA, Samuels SJ, Hammond SK, Schenker MB. A cross-sectional study of musculoskeletal symptoms and risk factors in semiconductor workers. Am J Ind Med 1995;28:861—71.
30. Rosecrance JC, Cook TM, Wadsworth CT. Prevalence of musculoskeletal disorders and related job factors in 900 newspaper workers. Adv Ind Ergon Safety 1992;IV:141—6.
31. Westgaard RH, Jansen T. Individual and work related factors associated with symptoms of musculoskeletal complaints, II: different risk factors among sewing machine operators. Br J Ind Med 1992;49:154—62.
32. Starr SJ, Shute SJ, Thompson CR. Relating posture to discomfort in VDT use. J Occup Med 1985;27:269—71.
33. MacKay Rossignol A, Pechter Morse E, Summers VM, Pagnotto LD. Video display terminal use and reported health symptoms among Massachusetts clerical workers. J Occup Med 1987;29(2):112—8.
34. Hünting W, Grandjean E, Maeda K. Constrained postures in accounting machine operators. Appl Ergon 1980;11:145—9.
35. Kajland A, Lindvall T, Nilsson T. Occupational medical aspects of the dental profession. Work Environ Health 1974; 11:100—7.
36. Rundcrantz B-L, Johnsson B, Moritz U. Cervical pain and discomfort among dentists: epidemiological, clinical and therapeutic aspects, part 1: a survey of pain and discomfort. Swed Dent J 1989;14:71—80.
37. Johansson JÅ, Kadefors R, Rubenowitz S, Klingenstierna U, Lindström I, Engström T, et al. Musculoskeletal symptoms, ergonomic aspects and psychosocial factors in two different truck assembly concepts. Int J Ind Ergon 1993;12:35—48.
38. Johansson JÅ. Psychosocial an physical working conditions and associated musculoskeletal symptoms among operators in five plants using arc welding in robot stations. Int J Hum Factors Manu 1994;4:191—204.
39. Rundcrantz B-L, Johnsson B, Moritz U. Pain and discomfort in the musculoskeletal system among dentists: a prospective study. Swed Dent J 1991;15:219—28.
40. Andersen JH, Gaardboe O. Prevalence of persistent neck and upper limb pain in a historical cohort of sewing machine operators. Am J Ind Med 1993;24:677—87.
41. Bergqvist U, Wolgast E, Nilsson B, Voss M. The influence of VDT work on musculoskeletal disorders. Ergonomics 1995; 38:754—62.
42. Bovenzi M, Zadini A, Franzinelli A, Borgogni F. Occupational musculoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. Ergonomics 1991;34:547—62.
43. Dartiques JF, Henry P, Puymirat E, Commenges D, Peytour P, Gagnon M. Prevalence and risk factors of recurrent cervical pain syndrome in a working population. Neuroepidemiology 1988;7:99—105.
44. Dimberg L, Olafsson A, Stefansson E, Aagaard H, Odén A, Andersson GBJ, et al. The correlation between work environment and the occurrence of cervicobrachial symptoms. J Occup Med 1989;31:447—53.
45. Ignatius YTS, Yee TY, Yan LT. Self-reported musculoskeletal problems amongst typist and possible risk factors. J Hum Ergol 1993;22:83—93.
46. Johansson JC, Rubenowitz S. Risk indicators in the psychosocial and physical work environment for work-related neck, shoulder and low back symptoms: a study among blue- and white-collar workers in eight companies. Scand J Rehabil Med 1994;26:131—42.
47. Johansson JÅ. Psychosocial work factors, physical work load and associated musculoskeletal symptoms among home care workers. Scand J Psychol 1995;36:113—29.
48. Kilbom Å, Persson J, Jonsson BG. Disorders of the cervicobrachial region among female workers in the electronics industry. Int J Ind Ergon 1986;1:37—47.
49. Lau EMC, Sham A, Wong KC. The prevalence of and risk factors for neck pain in Hong Kong. J Public Health Med 1996;18:396—9.
50. Linton SJ. Risk factors for neck and back pain in a working population in Sweden. Work Stress 1990;4(1):41—9.
51. Musson Y, Burdorf A, van Drimmelen D. Exposure to shock and vibration and symptoms in workers using impact power tools. Ann Occup Hyg 1989;33:85—96.
52. Schibye B, Skov T, Ekner D, Christiansen JU, Sjøgaard G. Musculoskeletal symptoms among sewing machine operators. Scand J Work Environ Health 1995;21:427—34.
53. Tharr D. Evaluation of work-related musculoskeletal disorders and job stress among teleservice center representatives. Appl Occup Environ Hyg 1995;10:812—6.
54. Wells JA, Zipp JF, Scheutte PT, McEleney J. Musculoskeletal disorders among letter carriers: a comparison of weight carrying, walking and sedentary occupations. J Occup Med 1983;25:814—20.
55. Yu ITS, Wong TW. Musculoskeletal problems among VDU workers in a Hong Kong bank. Occup Med 1996;46:275—80.
56. Winkel J, Mathiassen SE. Assessmentof physical work load in epidemiologic studies: concepts, issues and operational considerations. Ergonomics 1994;37:979—88.

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Appendix I

Methodological quality scores

Scores for items of quality assessment for all the studies in this review. The column headings correspond with the letters in front of the item definitions in table 1 of the text. As can be seen in this table, not all the items were used in all 3 of the methodological quality assessment lists.

Reference	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	Total[a]
Andersen & Gaarboe, 1993 (40)	+	+	-	.	.	-	-	-	-	+	+	-	-	.	.	?	.	.	.	+	+	+	5
Bergqvist et al, 1995 (41)	+	?	+	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	+	+	+	6
Bernard et al, 1994 (17)	+	+	+	.	.	+	?	+	?	-	+	-	+	.	.	?	.	.	.	+	+	?	7
Bovenzi et al, 1991 (42)	+	+	?	.	.	+	?	-	-	-	+	-	+	.	.	?	.	.	.	+	+	+	6
Bru et al, 1996 (21)	+	+	+	.	.	+	?	+	?	-	-	-	-	.	.	+	.	.	.	-	+	?	5
Chang et al, 1987 (24)	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Dartigues et al, 1988 (43)	+	+	?	.	.	+	?	+	?	+	-	?	-	.	.	?	.	.	.	+	+	?	5
Dimberg et al, 1989 (44)	+	-	+	.	.	+	?	?	?	+	+	-	-	.	.	?	.	.	.	-	+	?	5
Hales et al, 1994 (18)	+	+	+	.	.	+	?	+	?	+	+	-	-	.	.	?	.	.	.	+	+	-	7
Hünting et al, 1980 (34)	+	+	?	.	.	+	?	-	-	-	-	-	?	.	.	?	.	.	.	-	-	-	1
Hünting et al, 1981 (25)	-	+	?	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	1
Ignatius et al, 1993 (45)	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	6
Ingelgård et al, 1996 (26)	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Jacobsson et al, 1992 (27)	+	+	?	.	.	+	-	-	-	-	-	-	-	.	.	?	.	.	.	+	+	-	3
Johansson et al, 1993	+	+	?	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Johansson, 1994 (38)	+	+	?	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Johansson & Rubenowitz, 1994 (46)	+	-	+	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	+	+	5
Johansson, 1995 (47)	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	6
Kajland et al, 1974 (35)	+	+	+	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Kamwendo et al, 1991 (19)	+	+	+	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	7
Kilbom et al, 1986 (48)	+	+	-	.	.	+	?	+	?	+	+	-	-	.	.	?	.	.	.	-	+	?	5
Lau et al, 1996 (49)	+	+	-	.	.	-	-	-	-	+	-	+	-	.	.	?	.	.	.	+	+	+	5
Linton, 1990 (50)	+	+	?	.	.	+	?	+	?	+	-	-	-	.	.	?	.	.	.	+	+	+	6
MacKay Rossignol et al, 1987 (33)	+	+	+	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Mäkelä et al, 1991 (20)	+	+	+	.	.	+	+	+	+	-	-	?	-	.	.	+	.	.	.	+	+	+	9
Mundt et al, 1993 (23)	+	+	?	+	.	-	-	-	-	+	-	-	-	+	-	?	-	.	.	+	+	+	6
Musson et al, 1989 (51)	+	-	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	+	+	-	4
Ohlsson et al, 1989 (28)	+	+	?	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	?	3
Pocekay et al, 1995 (29)	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	+	?	3
Rosecrance et al, 1992 (30)	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Rundcrantz et al, 1989 (36)	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Rundcrantz et al, 1991 (39)	+	+	+	.	+	+	?	-	-	-	+	-	.	.	.	?	.	+	-	-	-	-	5
Schibye et al, 1995 (52)	+	+	+	.	.	+	-	-	-	-	+	-	?	.	.	?	.	.	.	+	+	?	5
Skov et al, 1996 (2)	+	+	-	.	.	+	?	+	?	+	-	-	-	.	.	?	.	.	.	+	+	+	6
Starr et al, 1985 (32)	+	+	?	.	.	+	?	-	-	-	-	-	?	.	.	?	.	.	.	-	-	-	1
Tharr, 1995 (53)	+	+	+	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	?	6
Viikari-Juntura et al, 1994 (22)	+	+	-	.	+	+	?	+	?	+	+	?		.	.	?	.	+	-	+	+	+	9
Wells et al, 1983 (54)	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	-	4
Westgaard & Jansen, 1992 (31)	+	-	?	.	.	-	-	-	-	+	-	+	-	.	.	?	.	.	.	-	+	?	3
Yu & Wong, 1996 (55)	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	-	4

[a] Total score calculated by counting the number of positive validity or precision items.