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Gender differences in the relations between work-related physical and psychosocial risk factors and musculoskeletal complaints

by Wendela E Hooftman, MSc,[1,2] Mireille NM van Poppel, PhD,[1,2] Allard J van der Beek, PhD,[1,2] Paulien M Bongers, PhD,[2,3] Willem van Mechelen, PhD[1,2]

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Gender differences in the prevalence of musculoskeletal complaints might be explained by differences in the effect of exposure to work-related physical and psychosocial risk factors. A systematic review was conducted to examine gender differences in the relations between these risk factors and musculoskeletal complaints. Several electronic databases were searched. The strength of the evidence was determined on the basis of the methodological quality and consistency of the study results. For lifting, strong evidence was found that men have a higher risk of back complaints than women. The same was found for the relation between hand–arm vibration and neck–shoulder complaints. For arm posture, strong evidence was found that women have a higher risk of neck–shoulder complaints than men. For social support, no evidence of a gender difference was found for either neck–shoulder or back complaints. For hand–wrist and lower-extremity complaints, inconclusive evidence was found due to a lack of high-quality studies.

Key terms back, literature study, lower extremities, neck, occupational, physical load, psychosocial load, sex factors, systematic review, upper extremities.

Many studies have reported gender differences in the prevalence of musculoskeletal complaints. For example, in a large population-based study in The Netherlands, 79.3% of the women and 71.5% of the men reported one or more musculoskeletal complaints in the past year (1). The one-year prevalence of self-reported spinal pain (including lower back, upper back, and neck) in a sample of 35- to 45-year-old Swedish residents was 69.5% for women and 63.2% for men (2). In the United States the prevalence of chronic joint symptoms in 2001 was 37.3% for women and 28.4% for men (3).

This gender difference seems to be more distinct for neck and upper-extremity complaints than for back complaints. The prevalences of neck and upper-extremity complaints has been found to be consistently higher for women than for men (1, 4, 5), while the prevalence of back complaints has been shown to be markedly higher for women (6) or slightly higher for women (1, 4) and also slightly higher for men (7).

Several explanations have been proposed for the gender difference in prevalence (8–11). First, it has been proposed that men and women have different exposure to risk factors, either because of differences in exposures outside work or because of differences in work exposure due to the sex segregation of the labor market. This last factor has been suggested to be the most important explanation for the sex difference in the prevalence of musculoskeletal complaints. However, the difference in prevalence remains when men and women from the same occupational class (12), or with the same work tasks (13) are compared. Second, it is claimed that women are more prone to express pain and symptoms, either because they have a lower threshold for detecting pain and symptoms or because they are more willing to express their feelings than men, who are taught not to complain (14). If this were true, one would expect that the gender difference in the prevalence of self-reported pain or symptoms would be larger than for objectively

1 Department of Public and Occupational Health, Institute for Research in Extramural Medicine, VU University Medical Center, Amsterdam, The Netherlands.
2 Body@Work, Research Center Physical Activity, Work and Health, TNO VUmc (Netherlands' Organisation for Applied Scientific Research, VU University Medical Center), The Netherlands.
3 TNO Work and Employment, Hoofddorp, The Netherlands.

Correspondence to: Dr Allard van der Beek, Department of Public and Occupational Health, Institute for Research in Extramural Medicine, Van de Boechorststraat 7, NL-1081 BT Amsterdam, The Netherlands. [E-mail: a.vanderbeek@vumc.nl]

measured problems. Yet, Punnett & Herbert (8), who reported that some of the largest gender differences were found in studies in which objective measures were used, did not show this result. The third explanation to be suggested is that the same risk factors may have a different effect on men and women. In this respect, it has been pointed out that joint laxity seems to be influenced by sex hormones (15, 16), women therefore being more vulnerable for musculoskeletal pain. In addition, women, on the average, have smaller body dimensions, lower muscle force, and a lower aerobic capacity. Therefore tasks performed with the same (absolute) exposure will, in most cases, result in a higher relative workload for women (8, 17, 18), which could lead to more complaints. Finally, men and women have been found to use different coping strategies for dealing with occupational stressors (19), and this difference could result in different outcomes.

In this review we focus on gender differences in the effect of risk factors. The aim was to determine whether there are gender differences in the relations between work-related physical and psychosocial risk factors and musculoskeletal complaints of the back, neck–shoulder, hand–wrist, and lower extremities.

Methods

Selction of the literature

Several electronic databases, MEDLINE (1966-December 2002), CINAHL (1982-December 2002), Psychinfo (1887-December 2002), CisDoc, NIOSHtic2, HSEline, RILOSH (1977-February 2002), and Biological Abstracts (1990-January 2002), were checked in order to identify relevant studies. The databases were searched with the following search string: (risk factor OR predictor OR determinant or causality OR (a)etiology OR causal factor) AND (gender (difference) OR sex (difference)) AND (work(–)(related) OR work environment OR job OR employment OR workplace OR occupation(al)) AND (back (pain) OR musculoskeletal (disorder) OR upper extremity (disorder) OR lower extremity (disorder) OR shoulder OR wrist OR elbow OR neck OR knee OR RSI OR repetitive strain injury OR cumulative strain disorder OR hand OR arm OR leg OR foot OR feet). In addition, a snowball search was performed, and the references of some recent reviews (20–25) were checked for relevant publications. Finally, articles from personal databases were included.

Articles were included if they met the following criteria: (i) the study design was cohort, case–control or cross-sectional, (ii) the study population included both men and women who came from a working or community-based population, (iii) the study addressed a musculoskeletal complaint, (iv) the exposure to relevant risk factors was measured separately for men and women and, for example, not based on job title or a job exposure matrix, (v) separate analyses were performed for men and women or an interaction effect for gender was calculated, and (vi) the study was published in a peer-reviewed journal in English. Two reviewers (WH and MP) read the titles and abstracts of all the studies to decide whether the inclusion criteria were met. If no abstract was present or if, based on title and abstract, it still was unclear whether an article should be included or excluded, the complete article was retrieved and checked.

Quality assessment

The quality of the studies was assessed using a quality assessment list (table 1), based on lists used in earlier reviews of observational studies (22, 25). The items on the list were rated as + (minimal requirements met), – (minimal requirements not met) or ? (unclear whether the minimal requirements were met). For all the studies, the number of positive items was calculated. Studies were rated as high in quality if they scored positive on at least 50% of the relevant items. Two reviewers (WH and MP) separately evaluated the quality of the studies. A consensus meeting was arranged to sort out differences between the reviewers.

Data extraction

From all the studies, information on design, population, response rate, exposure, outcome, and the risk estimates [relative risk (RR), odds ratio (OR)] were extracted for the men and women. When risk estimates were not presented, but enough data were given, the risk estimates were calculated. When multiple outcome measures were presented, for example, pain and sick leave, the outcome closest to the complaint level was used in the analysis.

When it is being determined whether there was a gender difference for a risk factor, it is not sufficient for a risk estimate to be statistically significant in one group and not in another. It is also not correct to say that, if confidence intervals overlap, the risk estimates are not significantly different (26). Therefore, we divided the risk for women by the risk for men in order to calculate a gender ratio. A ratio higher than 1.25 (ie, women had a higher risk) or lower than 0.75 (ie, women had a lower risk) was regarded as a relevant gender difference.

It was anticipated that a wide variety of risk factors would be found in the various studies. Therefore, on the basis of the results of several recent reviews (20–24, 27–32), we selected certain risk factors and used them in the analysis. The following tasks and job characteristics were considered physical risk factors: (i) lifting, manual materials handling, patient handling, awkward posture, bending and twisting, heavy physical workload, and whole-body vibration for the back; (ii) repetition, hand–arm vibration, arm posture, arm force, and head posture for the neck–shoulder region; (iii) repetition, vibration, wrist posture, and use of force for the hand–wrist region; and (iv) heavy physical work, kneeling or squatting, walking, and climbing for the lower extremities. Job demands, job control, social support, and job satisfaction were considered psychosocial risk factors for all the regions of the body under study.

Levels of evidence

Based on the reviews of Ariëns et al (22) and Hoogendoorn et al (25), the following four levels of evidence were constructed to determine the strength of evidence for a gender difference: (i) strong evidence, comprised of consistent gender differences in multiple high-quality cohort or case–control studies; (ii) moderate evidence, consistent gender differences found in one high-quality cohort or case–control study and at least one low-quality cohort or case–control study or consistent gender differences found in multiple low-quality cohort or case–control studies or consistent gender differences found in multiple high-quality cross-sectional studies; (iii) inconclusive evidence, consistent gender differences found in multiple low-quality cross-sectional studies or inconsistent results found in multiple studies or results based on one study; and (iv) no evidence of a difference, consistently no gender differences found. The results were regarded as consistent if at least 75% of the results were in the same direction.

Results

Selection of the literature

The search resulted in a total of 1653 articles. After the exclusion of doubles, 1473 titles and abstracts were reviewed for their relevance. Initially, there was a 7% disagreement between the reviewers about whether a paper met the inclusion criteria. After these disagreements were resolved, the full text of 185 articles was retrieved. On the basis of the full text, we included 31 studies. Another nine studies were included on the basis of the snowball search, the reference check, and perusal of personal databases.

Eight studies (33–40) were excluded after the data extraction because they did not present a risk estimate or there were not enough data to calculate one. Two studies (41, 42) were excluded because they did not

Table 1. Items used for scoring methodological quality. (ICC = intraclass correlation)

	Cohort	Case–control	Cross-sectional
Design			
1. Participation rate at baseline at least 80% or not selective	✓	✓	✓
Population			
2. Cases and controls drawn from the same population and clear definition of cases and controls stated		✓	
3. Response after 1-year follow-up at least 80% or the nonresponse not selective	✓		
Exposure assessment			
4. Data on physical load at work collected and used in the analysis	✓	✓	✓
5. Data on physical load collected using standardized methods of acceptable quality [a]	✓	✓	✓
6. Data on psychosocial load at work collected and used in the analysis	✓	✓	✓
7. Data on psychosocial load collected using standardized methods of acceptable quality [a]	✓	✓	✓
8. Data on historical exposure at work collected and used in the analysis [b]	✓	✓	✓
9. Data on physical load during leisure time collected and used in the analysis	✓	✓	✓
10. Data on psychosocial load during leisure time collected and used in the analysis	✓	✓	✓
11. Exposure assessment blinded with respect to disease status		✓	✓
12. Exposure measured in an identical way for the cases and controls		✓	
13. Exposure assessed prior to the occurrence of the outcome		✓	
14. Data on history of (relevant) musculoskeletal complaints collected and used in the analysis	✓	✓	✓
Outcome assessment			
15. Data on outcome collected with standardized methods of acceptable quality [c]	✓	✓	✓
16. Incident cases used		✓	
17. Data on outcome collected for at least 1 year	✓		
18. Data on outcome collected at least every 3 months or from a continuous registration system	✓		
Analysis			
19. Statistical model appropriate for the outcome studied and a measure of association (including confidence intervals) presented	✓	✓	✓
20. Study controlled for confounding [d]	✓	✓	✓
21. Number of cases in the multivariate analysis at least 10 times the number of independent variables	✓	✓	✓
Maximum score	16	18	14

[a] Information in article of reference: direct measurements: ICC >0.6 or kappa >0.4; observations: ICC >0.6 or kappa >0.4 for inter- or intraobserver reliability; self report: ICC >0.6 or kappa >0.4 for inter- or intraobserver reliability.
[b] Only years of employment in current job not enough. At least several jobs or exposure in a certain time period should have been given.
[c] Self report: ICC >0.6 or kappa >0.4 for test-retest reliability; registration system: data should show a valid and reliable system. Physical examination: ICC >0.6 or kappa >0.4 for inter- or intraobserver reliability.
[d] At least corrected for age and (if applicable) different worksites.

report musculoskeletal complaints for a specific region. Finally, four studies (43–46) that met all the inclusion criteria and presented their data in a usable way could not be used in the analysis because they did not report findings in respect to any of the predetermined risk factors. Therefore, 14 studies (47–60) on back complaints, 9 studies (58–66) on neck–shoulder complaints, 4 studies (65–68) on hand–wrist complaints and 4 studies (69–72) on lower-extremity complaints were used. A description of the studies that were used is given in the appendix. Only relevant outcome and exposure measures are presented.

Quality assessment

The overall agreement between the two reviewers was 86% (kappa 0.76), and the agreement for the individual items ranged from 50% (item 18) to 100% (item 6, 14, and 19). All disagreements were resolved in the consensus meeting. In table 2 an overview of the scoring

Table 2. Scoring used for the methodological quality of the studies included in this review. See table 1 for a description of the items. (+ = study described the item and met the minimum requirements, – = study described the item but did not meet the minimum requirements, ? = the item was not clearly described or it was not clear whether the minimum requirements were met; · = not applicable)

Study	Item																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	Score
Bildt-Thorbjörnsson et al, 1998 (59); Köster et al, 1999 (79); Fredriksson et al, 1999 (80, 81); Bildt-Thorbjörnsson et al, 2000 (82); Torgen et al 1997 (83); Bildt-Thorbjörnsson et al, 1999 (84)																						
Cohort study	+	·	–	+	+	+	+	–	+	+	·	·	·	+	+	·	+	–	+	+	+	81
Case–control study	+	+	·	+	+	+	+	–	+	–	–	+	–	–	+	+	·	·	+	+	+	72
Vingard et al, 1999 (60); Tornqvist et al, 2001 (85); Vingard et al, 2000 (86); Wiktorin et al, 1996 (87); Waldenstrom et al, 1998 (88); Wiktrorin et al, 1996 (89); Wiktorin et al, 1999 (90); Torgén et al, 1999 (91); Mortimer et al, 1998 (92)	?	+	·	+	+	+	+	+	+	–	–	+	–	+	+	+	·	·	+	+	+	78
Mäkelä et al, 1991 (64); Mäkelä et al, 1999 (93)	+	·	·	+	+	+	+	–	–	–	–	·	·	+	+	·	·	·	+	+	+	71
Cassou et al, 2002 (61)	+	·	+	+	?	+	?	+	–	–	·	·	·	+	?	·	+	–	+	+	+	63
Cole et al, 2001 (48); Dollard & Winefield, 1998 (94)	+	·	·	+	?	+	+	–	+	–	–	·	·	–	?	·	·	·	+	+	+	57
Hemingway et al, 1997 (51)	–	·	–	–	–	+	+	–	+	–	·	·	·	+	?	·	+	+	+	+	+	56
Alcouffe et al, 1999 (47)	+	·	·	+	?	–	–	–	+	–	–	·	·	+	?	·	·	·	+	+	+	50
Barnekow-Bergkvist et al, 1998 (58)	?	·	?	+	?	+	+	–	+	–	·	·	·	–	+	·	+	–	+	+	–	50
Walsh et al, 1989 (56)	+	·	·	+	?	–	–	+	–	–	–	·	·	+	?	·	·	·	+	+	+	50
Coggon et al, 2000 (69)	–	+	·	+	?	–	–	+	–	–	–	+	–	+	?	–	·	·	+	+	+	44
Heliövaara, 1987 (50)	?	+	·	+	?	–	–	–	–	–	+	+	+	–	?	+	·	·	–	+	+	44
Manninen et al, 2002 (72)	–	+	·	+	–	–	–	+	+	–	–	+	–	+	?	–	·	·	+	–	+	44
Macfarlane et al, 1997 (54); Croft et al, 1999 (95); Papageorgiou et al, 1997 (96); Papageorgiou et al, 1995 (97)	–	·	–	+	?	+	?	+	–	–	·	·	·	?	?	·	+	–	+	+	+	44
Foppa & Noach, 1996 (49)	+	·	·	+	?	+	?	–	–	+	–	·	·	–	?	·	·	·	+	–	+	43
Walsh et al, 1991 (57)	–	·	·	+	?	–	–	+	–	–	–	·	·	+	?	·	·	·	+	+	+	43
Coggon et al, 1998 (70)	–	+	·	+	?	–	–	+	–	–	–	+	–	+	?	–	·	·	+	–	+	39
Lau et al, 2000 (71); Cooper et al, 1994 (98)	?	–	·	+	?	–	–	–	+	–	–	+	–	+	?	–	·	·	+	+	+	39
Jensen et al, 2002 (65);, 99)	–	·	·	+	?	+	?	–	–	–	–	·	·	–	?	·	·	·	+	+	+	36
Matsui et al, 1997 (55)	+	·	·	+	?	–	–	–	–	–	–	·	·	?	?	·	·	·	+	+	+	36
Tanaka et al, 1995 (68); Tanaka et al, 2001 (100); Tanaka et al, 1997 (101)	+	·	·	+	?	–	–	–	–	–	–	·	·	–	?	·	·	·	+	+	+	36
Palmer et al, 2001 (62); Palmer et al, 2000 (75)	–	·	·	+	?	+	?	–	–	–	–	·	·	–	?	·	·	·	+	+	+	36
Fransson-Hall et al, 1995 (67)	+	·	·	+	?	+	?	–	–	–	–	·	·	–	?	·	·	·	–	+	+	36
Karlqvist et al, 2002 (66)	+	·	·	+	?	+	?	–	–	–	–	·	·	–	?	·	·	·	+	–	–	29
Latza et al, 2000 (53); Michel et al, 1997 (102)	–	·	·	+	?	–	–	–	–	–	–	·	·	–	?	·	·	·	+	+	+	29
Pope et al, 1997 (63) [a]	–	·	·	+	?	+	?	+	–	–	–	·	·	–	?	·	·	·	+	–	–	29
Kelsey, 1975 (52, 103); Kelsey & Hardy, 1997 (104)	–	+	·	+	?	–	–	–	–	–	–	+	–	–	?	+	·	·	–	+	–	28

[a] The article stated a case–control design, but since we found the matching procedure questionable, the study was regarded as cross-sectional.

of the individual studies is given. Three out of seven cohort studies were regarded as high in quality. For the case–control studies, again, three out of seven studies were of high quality. The study of Bildt-Thorbjörnsson et al (59), which consisted of a cohort and a case-control part, was regarded as high in quality for both designs. Only 4 of the 15 cross-sectional studies were of high quality.

Back complaints

A summary of the determination of the levels of evidence for back complaints can be found in table 3. Eight studies (47, 52–54, 56–58, 60) concerned lifting. The high-quality cohort study (58) found a gender ratio of 0.18, while, in the high-quality case–control study (60), gender ratios of 0.57 and 0.80 were found for heavy lifting and manual materials handling, respectively. The low-quality cohort and case–control studies (52, 54) and a high-quality cross-sectional study (47) found gender ratios between 1.35 and 2.27. The second high-quality cross-sectional study (56) and a low-quality cross-sectional study (57) found no difference between men and women, while, in another low-quality cross-sectional study (53), a ratio of 0.55 was found. On the basis of the results of the high-quality cohort and case–control studies, we concluded that there is strong evidence that men have a higher risk of back complaints due to lifting than women do.

Posture was investigated in four studies (47, 53, 58, 60). The high-quality cohort study (58) and the

Table 3. Summary of the determination of levels of evidence for back complaints. (MQ = methodological quality, HQ = high quality, LQ = low quality)

Risk factor	MQ	Direction of the difference						Level of evidence
		Male>female		Male=female		Female>male		
		Case–control or cohort	Cross-sectional	Case–control or cohort	Cross-sectional	Case–control or cohort	Cross-sectional	
Lifting	HQ	Vingard et al (60); Barnekow-Bergkvist et al (58)	·	Walsh et al (56)	·	·	Alcouffe et al (47)	Strong evidence, male greater than female
	LQ	·	Latza et al (53)	·	Walsh et al (57)	Kelsey (52); Macfarlane et al (54)	·	·
Awkward postures	HQ	Vingard et al (60)	·	Barnekow-Bergkvist et al (58)	Alcouffe et al (47)	·	·	Inconclusive evidence
	LQ	·	Latza et al (53)	·	·	·	·	·
Heavy physical work	HQ	·	·	Bildt-Thorbjörnsson et al (59)	Barnekow-Bergkvist et al (58)	Vingard et al (60)	·	Inconclusive evidence
	LQ	·	·	·	Foppa & Noach (49)	Heliövaara (50); Matsui et al (55)	·	·
Whole-body vibration	HQ	Barnekow-Bergkvist et al (58)	Walsh et al (56)	·	·	Vingard et al (60)	Walsh et al (56)	Inconclusive evidence
	LQ	·	·	Kelsey (52); Macfarlane et al (54)	·	·	Walsh et al (57)	·
Job demands	HQ	·	·	Hemingway et al (51); Bildt-Thorbjörnsson et al (59)	·	Barnekow-Bergkvist et al (58)	Cole et al (48)	Inconclusive evidence
	LQ	·	·	·	Foppa & Noach (49)	·	·	·
Job control	HQ	Hemingway et al (51)	·	Vingard et al (60)	Alcouffe et al (47); Cole et al (48)	Barnekow-Bergkvist et al (58)	·	Inconclusive evidence
	LQ	·	·	·	·	·	·	·
Job satisfaction	HQ	Vingard et al (60)	·	Hemingway et al (51); Barnekow-Bergkvist et al (58)	·	·	·	Inconclusive evidence
	LQ	·	·	·	Foppa & Noach (49)	·	·	·
Social support	HQ	·	·	Hemingway et al (51); Bildt-Thorbjörnsson et al (59); Vingard et al (60)	Cole et al (48)	Barnekow-Bergkvist et al (58)	·	No evidence of a difference
	LQ	·	·	·	·	·	·	·

high-quality cross-sectional study (47) found no difference between men and women. The high-quality case–control study (60) and the low-quality cross-sectional study (53) showed risk ratios of 0.67 and 0.40, respectively. Since the results of the high-quality cohort and case–control studies were not consistent, there is inconclusive evidence for a gender difference for posture.

Four case–control (50, 55, 59, 60) and two cross-sectional (48, 49) studies reported on heavy physical work as a risk factor for back pain. One high-quality (60) and two low-quality case–control (50, 55) studies found a larger risk for women (gender ratios ranging from 1.36 to 3.43). No difference in the risk estimate between men and women was found in the other high-quality case–control study (59) and the cross-sectional studies (48, 49). Since these results were not consistent, there is inconclusive evidence for a gender difference for heavy physical workload.

Whole-body vibration, measured as vibration or driving, was investigated in six studies (52, 54, 56–58, 60). The high-quality case–control (60) and the low-quality cross-sectional (57) studies found gender ratios of 3.11 and 1.40, respectively. However, the high-quality cohort study (58) found a gender ratio of 0.58. In the high-quality cross-sectional study (56), gender ratios of 0.24–0.67 for driving, and a gender ratio of 3.80 for exposure to vibration machinery, were found. Finally, the low-quality cohort (54) and case–control (52) studies did not find a gender difference. Since these results were not consistent, there is inconsistent evidence of a gender difference for whole-body vibration.

Job demands were assessed in five studies (48, 49, 51, 58, 59). One high-quality cohort study (58) and one high-quality cross-sectional study (48) found gender ratios of 1.90 and 1.35 respectively. The second high-quality cohort study (51), the high-quality case–control study (59), and a low-quality cross-sectional study (49) did not find a gender difference. Due to the inconsistency of these results there is inconclusive evidence of a gender difference for job demands.

Five high-quality studies (47, 48, 51, 58, 60) examined job control. One cohort study (58) found a gender ratio of 1.35, while, for the other cohort study (51), a gender ratio of 0.70 was calculated. The case–control study (60) and both cross-sectional studies (47, 48) did not find a gender difference. Because of the inconsistency of these results, there is inconclusive evidence for a gender difference for job control.

A gender ratio of 1.41 for social support as a risk factor was found in a high-quality cohort study (58). However, the other high-quality cohort study (51), both high-quality case–control studies (59, 60), and the high-quality cross-sectional study (48) did not find a gender difference. The conclusion, therefore, is that there is no evidence of a gender difference.

A gender difference in the relation between job satisfaction and back pain was only found in one high-quality case–control study (60), with a gender ratio of 0.33. No gender difference was found in two high-quality cohort studies (51, 58) and one low-quality cross-sectional study (49). Due to the inconsistency in the high-quality studies, there is inconclusive evidence for a gender difference for job satisfaction.

Neck-shoulder complaints

Table 4 provides an overview of the determination of the levels of evidence for neck–shoulder complaints. A total of five studies (59–61, 63) assessed the relation between repetition and neck–shoulder complaints. One high-quality case–control study (60) found a gender ratio of 1.33, while the second high-quality case–control study (59) did not find a gender difference. The high-quality cohort study (61) found a gender ratio of 1.44 for the exposure at baseline, but no difference for exposure before baseline. The results of the low-quality cross-sectional studies (63, 65) were not consistent either, with gender ratios of 0.53–2.34, depending on the exact outcome and exposure. Because of these inconsistent results, there is inconclusive evidence for a gender difference for repetition.

The relation between hand-arm vibration and neck–shoulder complaints was measured in four studies (59, 60, 62, 63). Both high-quality case–control studies (59, 60) and one low-quality cross-sectional study (63) found a larger risk for men (gender ratios 0.50, 0.54 and 0.73, respectively). The second low-quality cross-sectional study (62) found a gender ratio of 0.22 for pain in the past 7 days, but no difference for pain in the past 12 months. Because the case–control studies (59, 60) consistently showed a higher risk estimate for men, it is concluded that there is strong evidence that exposure to hand–arm vibration is a larger risk for men.

Arm posture was investigated in one high-quality cohort study (58), one high-quality case–control study (60), and three low-quality cross-sectional studies (62, 63, 66). The cohort and case–control studies found larger risk estimates for women, with gender ratios of 6.39 (58) and 1.44 (60). The cross-sectional studies found no difference between men and women (62, 66) or a larger risk for men (63). The results of the cohort (58) and case–control (60) studies indicate that there is strong evidence that exposure to awkward arm postures is a larger risk factor for women than for men.

Arm force, measured as lifting, was measured in one high-quality cohort study (58), one high-quality case–control study (60), and two low-quality cross-sectional studies (62, 63). The case–control study (60) and one of the cross-sectional studies (63) found a larger risk for men (gender ratios from 0.20 to 0.67). No gender

Table 4. Summary of the determination of levels of evidence for neck-shoulder complaints. (MQ = methodological quality score, HQ = high quality, LQ = low quality)

Risk factor	MQ	Direction of the difference						Level of evidence
		Male>female		Male=female		Female>male		
		Case–control/ cohort	Cross-sectional	Case–control/ cohort	Cross-sectional	Case–control/ cohort	Cross-sectional	
Repetition	HQ	·	·	Cassou et al (61) [a]; Bildt-Thorbjörnsson et al (59)	·	Vingart et al (60); Cassou et al (61) [b]	·	Inconclusive evidence
	LQ	·	Pope et al (63) [d]	·	Jensen et al (65) [e]; Pope et al (63) [c]	·	Jensen et al (65) [f]	·
Hand–arm vibration	HQ	Bildt-Thorbjörnsson et al (59); Vingard et al (60)	·	·	·	·	·	Strong evidence, male greater than female
	LQ	·	Pope et al (63)	·	Palmer et al (62)	·	·	
Arm posture	HQ	·	·	·	·	Barnekow-Bergkvist et al (58); Vingard et al (60)	·	Strong evidence, female greater than male
	LQ	·	Pope et al (63)	·	Palmer et al (62); Karlqvist (66)	·	·	·
Arm force	HQ	Vingard et al (60)	·	Barnekow-Bergkvist et al (58)	·	·	·	Inconclusive evidence
	LQ	·	Pope et al (63)	·	Palmer et al (62)	·	·	
Job demands	HQ	Barnekow-Bergkvist et al (58)	·	Cassou et al (61)	Mäkelä et al (64)	Bildt-Thorbjörnsson et al (59); Vingard et al (60)	·	Inconclusive evidence
	LQ	·	·	·	Jensen et al (65); Karlqvist (66)	·	·	·
Job control	HQ	·	·	Vingard et al (60)	·	Barnekow-Bergkvist et al (58); Bildt-Thorbjörnsson et al (59)	·	Inconclusive evidence
	LQ	·	·	·	·	·	·	·
Social support	HQ	·	·	Barnekow-Bergkvist et al (58); Vingard et al (60)	·	·	·	No evidence for a difference
	LQ	·	·	·	Karlqvist (66)	·	·	·

[a] For exposure at baseline. [b] Exposure before baseline. [c] For using the wrist repetitively. [d] For using the arm repetitively.
[e] For neck pain. [f] For shoulder pain.

difference was found in the second cross-sectional study (62) and the cohort study (58), in which men and women with a heavy lift index had a lower risk of neck–shoulder complaints. Therefore, the evidence is inconclusive.

Job demands were investigated in seven studies (58–61, 64–66). One high-quality cohort study (58) found a gender ratio of 0.64, but the two high-quality case–control studies (59, 60) found gender ratios from 1.57 to 4.50. No gender difference was found in the second high-quality cohort study (61) and the cross-sectional studies (64–66). Since these results were not consistent, there is inconclusive evidence of a gender difference for job demands.

Three high-quality studies (58–60) measured job control. One case–control study (60) found no gender difference, but the second case–control study (59) found a gender ratio of 5.0. The gender ratio in the cohort study (58) was 1.33. Due to the inconsistency of the results, there is inconclusive for a gender difference for job control.

One high-quality cohort (58), one high-quality case–control (60), and one low-quality cross-sectional (66) study concerned social support. Since none of them found differences between men and women, it is concluded that there is no evidence for a gender difference.

Hand–wrist complaints

Two low-quality cross-sectional studies (65, 67) concerned repetitive movements. Since only one of them (67) found a gender difference (gender ratio 1.29), there is inconclusive evidence for a gender difference.

One study (68) focused on the relation between vibration and hand–wrist complaints (gender ratio 0.49), but, since this was a low-quality cross-sectional study, there is inconclusive evidence of a gender difference.

Three cross-sectional studies (66–68) concentrated on wrist postures. One of them (67) found gender differences, with ratios of 0.71 and 1.29 depending on the exact exposure, but the other two studies found no gender differences. Since these results were inconsistent and the studies were low in quality, there is inconclusive evidence for a gender difference.

Job demands were measured in two studies (65, 66), but only one of them (66) found a gender difference. Due to the inconsistency and the low quality of the studies, there is inconclusive evidence of a gender difference.

One low-quality cross-sectional study (66) reported the relation between social support and hand–wrist complaints. No gender difference was found, but, since the results were based on only one study, there is inconclusive evidence for a gender difference.

Lower-extremity complaints

Only one low-quality study (72) reported a relation between heavy physical workload and lower-extremity complaints. This study found a gender ratio of 1.33. With only one study, there is inconclusive evidence of a gender difference.

Four low-quality case–control studies (69–72) reported on kneeling or squatting. Two studies (69, 72) used exposures that combined kneeling and squatting. Neither study found a gender difference. Two studies (70, 71) found a gender difference for kneeling (gender ratio 0.33–0.64), and, in one study (69), a gender ratio of 1.27 was found for squatting. Since the results of these studies were not consistent, there is inconclusive evidence for a gender difference for kneeling or squatting.

Much walking was a larger risk factor for men in two out of four low-quality case–control studies (71, 72), with gender ratios from 0.36 to 0.72. The third study showed no difference between men and women, while, in the fourth, gender ratios of 1.36 and 1.88 were found. Due to the inconsistency of the results, there is inconclusive evidence for a gender difference for walking.

Climbing was measured in four low-quality case–control studies (69–72). Two studies (69–72) found a larger risk for men (gender ratios 0.30–0.54). In one study (71) the direction of the gender difference depended on the outcome (gender ratio 0.18 for hip complaints and 2.04 for knee complaints), and in one study (70) the direction was dependent on the duration of the exposure (gender ratios 0.57–1.28). Since these results were not consistent, there is inconclusive evidence of a gender difference for climbing.

Discussion

The purpose of this review was to examine gender differences in the effect of exposure to work-related physical and psychosocial risk factors. Considering the gender differences in prevalence, we expected that women would have higher risks. The results show evidence of a gender difference for a few risk factors, but in most cases men had the higher risk.

Back complaints

Before the study, we presumed that women would have a higher risk of back complaints due to lifting than men, but we found strong evidence that men have a higher risk. However, it could be argued that, since the weight of the average larger male torso has to be added to the weight of the lifted object, men in fact have a higher exposure than women when lifting an equal object. This difference may be one factor leading to a higher risk of back complaints among men. Several studies (18, 73, 74) indeed found that men have a greater absolute exposure, due to their greater body mass. However, these same studies also showed that women are not merely scaled-down versions of men, but, in fact, use different techniques while lifting. In the end, this difference resulted in a greater relative workload for women and, therefore, in a greater risk of complaints. Another remarkable point is that Vingard et al (60) found a (not significant) relative risk of 0.8 for women, while Barnekow-Bergkvist et al (58) found odds ratios of <1 for both men and women. This evidence is clearly in contrast to the generally accepted view that lifting is a risk factor for back pain (23, 32). It should be mentioned, however, that the study population in this last study was relatively young [mean age 34 (SD 0.74) years]. Together with the possible selection bias of this study, the young age may explain the unexpected result. Finally, although the high-quality cohort and case–control studies found gender ratios below 0.75, the low-quality cohort and case–control studies consistently found ratios above 1.25. Therefore, the conclusion that men have a higher risk than women due to lifting should be considered with due caution.

Neck-shoulder complaints

As for back complaints, it was expected that women would have a higher risk. This was indeed the case for arm posture, but for hand–arm vibration men had the higher risk. The studies in our review used a rather low cut-off point for exposure (30 minutes and 16% of the time); hence a large range of exposures within the highest exposure category was possible. Total daily exposure to vibration has been found to be much higher for men than for women (75), and, therefore, men may still have had a higher exposure than women within the same exposure category. Furthermore, the effect of vibration on complaints may be rather small for women, since the 1-week prevalence of exposure was found to be only 6% for working women, but 32% for working men (75).

Hand–wrist complaints

Very few studies on hand–wrist complaints were found. Although initially nine studies were identified, four were excluded because they did not report findings for the selected risk factors. Three studies (44, 65, 66) considered the duration of computer use as a risk factor, but the results were not consistent. While, in the study by Blatter et al (44), the risk was larger for women (gender ratios ranging from 1.05 to 1.38), Jensen et al (65) and Karlqvist et al (66) found larger risks for men (ratios ranging from 0.55 to 0.99). Nevertheless, only a few studies reported risk factors for men and women separately, and the reason for the inconclusiveness should primarily be sought in the lack of (high-quality) studies. Furthermore, since all these studies were cross-sectional, no causal relation could be established. It is recommended that more, preferably prospective, studies on hand–wrist complaints make separate analyses for men and women.

Lower-extremity complaints

Due to the inconsistency and the small number of low-quality studies, inconclusive evidence was found for all the risk factors for lower-extremity complaints. As for hand–wrist complaints, we would like to emphasize the need for more (high-quality) studies.

Selection of the literature

To our knowledge this is the first review that systematically examined gender differences in the relation between work-related risk factors and musculoskeletal complaints. In spite of our extensive literature search, it is likely that both selection and publication bias influenced the results. Most studies on risk factors do not aim at examining gender differences and do not use key words referring to such differences. By including the terms gender (difference) and sex (difference) in the search string, we may have missed these studies. Another potential source of bias is publication bias. While some studies tested for all possible interactions or made separate analyses for all risk factors, most of the studies only did this for a few variables. It could very well be that such an approach was only used because (significant) gender differences were found for these risk factors. The results of this review may therefore overestimate gender differences.

Analysis

We chose to use a percentage difference in risk estimates rather than an absolute number or a significant difference to identify relevant differences. However, we could not find theoretical grounds for the point of cut-off. By using the percentage difference, we had to exclude studies that did not present risk estimates and those which only reported a nonsignificant difference. Four of these studies did mention that there was no difference between men and women, or no significant interaction with gender was found (37–40). One study (37) assessed the relation between lifting and back complaints, three studies concerned job demands and neck–shoulder complaints (38–40), while job control, social support, and work with hands above shoulder level were each assessed in one study (39, 40). Considering these studies did not change the strength of the evidence.

Methodological quality and levels of evidence

The combination of a quality scale and levels of evidence is often used, but not without criticism (76, 77). Our quality list was very similar to lists used earlier (20, 22, 23, 25). One of these lists (22) was rated by West et al (78), and it scored positive on six and partially positive on one out of nine domains for assessing study quality. A point of criticism on this and similar lists is that all the items have the same weight, and studies that have only a few, but very important, flaws can still be regarded as high in quality (21, 22). In our review, the three studies with the highest quality (59 ,60, 64) scored positive on all items regarding validity of outcome and exposure measures. Another three high-quality studies (48, 51, 58) scored positive on at least one of these items, while none of the low-quality studies scored positive on these items. Therefore, these items are important in discriminating between high- and low-quality studies. Another point of criticism is that, when different levels of evidence are compared, their agreement is poor and may result in differences in the conclusion (76). Unfortunately, to our knowledge, no other levels of evidence for observational studies have been published, and no comparison can be made with our levels.

Concluding remarks

Strong evidence of a gender difference was found for only three risk factors, but for two out of three factors the difference was not in the expected direction. These findings seemed fairly insensitive to the limitations of our study, but are likely to be an overestimation of gender differences. Therefore, the results should be interpreted with some caution. For hand–wrist and lower-extremity complaints only a few low-quality studies were found, and it is recommended that more studies make separate analyses for men and women.

Since gender differences in the effect of risk factors do not seem to provide an explanation for the higher prevalence of musculoskeletal complaints among women, alternative explanations have to be considered, such as gender differences in the number of workers exposed, in exposure within the same exposure category, or the expression of pain (8–11). In terms of prevention, until more clarity is achieved, the focus should remain on the reduction of exposure among female workers.

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Appendix

Description of the studies included in the analyses

Table 1. Description of the studies on back complaints. (CC = case–control, CH = cohort, CS = cross-sectional, HLD = herniated lumbar intevertebral disc, MQ = methodological quality score, OR = odds ratio, PR = prevalence ratio, RR = relative risk, TWA MET = time-weighted average of the metabolic rate, 95% CI = 95% confidence interval)

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association: Female OR, RR or PR	Female 95%CI	Male OR, RR or PR	Male 95% CI	Gender ratio [b]
Bildt-Thorbjörnsson et al, 1998 (59); Köster et al, 1999 (79); Bildt-Thorbjörnsson et al, 1999 (84)	CH	81	Working persons 18–34 years of age (N=2579)	Low-back pain in previous 12 months	High mental load	PR 1.1	0.7–1.8	PR 1.1	0.6–1.8	1.00
					High physical load	PR 1.0	0.9–1.5	PR 1.1	0.8–1.6	0.91
					Monotonous work	PR 0.9	0.5–1.5	PR 1.5	0.9–2.4	0.60
					Overtime work	PR 1.0	0.7–2.1	PR 0.6	0.3–1.3	1.67
					Poor social support	PR 1.2	0.8–1.9	PR 1.1	0.6–1.8	1.09
Hemingway et al, 1997 (51)	CH	56	Nonindustrial civil servants 35–55 years of age (N=6894 men, N=3414 women)	Sickness absence <7 days due to back pain	Job satisfaction (low versus high)	RR 1.15	0.83–1.58	RR 1.17	0.92–1.48	0.98
					Job satisfaction (medium versus high)	RR 1.08	0.78–1.5	RR 1.04	0.8–1.33	1.04
					Social support (low versus high)	RR 0.87	0.63–1.19	RR 1.12	0.89–1.41	0.78
					Social support (medium versus high)	RR 0.81	0.58–1.14	RR 1.01	0.8–1.27	0.80
					Work control (low versus high)	RR 1.01	0.7–1.47	RR 1.44	1.11–1.85	0.70
					Work control (medium versus high)	RR 1.04	0.71–1.53	RR 1.31	1.04–1.64	0.79
					Workpace (medium versus high)	RR 1.5	1.05–2.15	RR 1.21	0.96–1.54	1.24
					Workpace (low versus high)	RR 1.42	0.98–2.07	RR 1.79	1.39–2.31	0.79
Barnekow-Bergkvist et al, 1998 (58)	CH	50	Students 16 years of age at baseline (N=220 men, N=205 women)	Back symptoms in previous 12 months	High decision latitude	OR 1.35	0.34–5.39	OR 1.00	0.22–4.48	1.35
					High demand index	OR 1.2	0.31–4.71	OR 0.63	0.18–2.13	1.90
					High job satisfaction	OR 0.95	0.37–2.32	OR 0.83	0.37–1.99	1.14
					Lift index (heavy)	OR 0.17	0.02–1.37	OR 0.94	0.24–3.6	0.18
					Posture work index (monotonous)	OR 6.39	1.25–32.7	OR 5.45	1.07–27.9	1.17
					Social support index (high)	OR 1.91	0.47–7.78	1.35	0.38–4.74	1.41
					Vibration	OR 1.90	0.47–7.69	OR 3.29	1.34–8.08	0.58
Macfarlane et al, 1997 (54); Croft et al, 1999 (95); Papageorgiou et al, 1997 (96); Papageorgiou et al 1995 (97)	CH	44	Adults with 2 general practices (N=1884 men, N=2617 women)	Low-back pain, no consultation with general practitioners	Driving a car in current or previous job	OR 1.4	0.3–5.9	OR 1.3	0.7–2.4	1.08
					Driving a truck in current or previous job	OR 0		OR 1.2	0.5–3.1	0.00
					Lift >/ 25 lbs [c]	OR 2.5	1.5–4.1	OR 1.1	0.7–1.7	2.27

(continued)

Table 1. Continued.

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association: Female OR, RR or PR	Female 95%CI	Male OR, RR or PR	Male 95% CI	Gender ratio [b]
Vingart et al, 1999 (60); Tornqvist et al, 2001 (85); Vingard et al, 2000 (86); Wiktorin et al, 1996 (97, 89); Waldestrom et al, 1998 (88); Wiktorin et al, 1999 (90); Torgén et al, 1999 (91); Mortimer et al, 1998 (92)(91); Mortimer et al, 1998 (92)	CC	78	Persons 20–59 years of age (cases: N=315 men, N=380 women, controls: N=610 men, N=813 women)	Seeking treatment for low-back pain	Bend >60 minutes/day	RR 1.2	0.7–1.8	RR 1.8	1.1–3.1	0.67
					Drive >240 minutes/day	RR 2.8	1.8–8.5	RR 0.9	0.6–1.5	3.11
					Heavy lifting	RR 0.8	0.6–1.2	RR 1.4	1.0–2.0	0.57
					Low influence over work	RR 1.0	0.7–1.5	RR 1.0	0.6–1.6	1.00
					Manual materials handling	RR 1.2	0.7–2	RR 1.5	0.8–2.9	0.80
					Medium influence over work	RR 1.2	0.9–1.6	RR 1.6	1.2–2.2	0.75
					No social support at work	RR 0.9	0.6–1.3	RR 1.0	0.7–1.4	0.90
					Poor job satisfaction	RR 0.7	0.3–1.7	RR 2.1	0.9–5.2	0.33
					TWA MET >3.0	RR 1.9	1.2–2.8	RR 1.4	1.0–2.0	1.36
					TWA MET >3.5	RR 1.5	1.4–4.6	RR 1.1	0.8–1.7	1.36
Heliövaara, 1987 (50)	CC	44	Persons discharged from hospital due to HLD (cases: N=212 men, N=124 women; controls: N=767 men, N=454 women)	HLD	Work strenuousness (heavy versus light)	RR 2.4		RR 0.7		3.43
					Work strenuousness (normal versus light)	RR 3.8		RR 0.7		5.43
			Persons discharged from hospital due to sciatica (cases: N=364 men, N=228 women; controls N=1298 men, 842 women)	HLD or sciata	Work strenuousness (heavy versus light)	RR 2.5		RR 1.1		2.27
					Work strenuousness (normal versus light)	RR 2.0		RR 0.9		2.22
Kelsey, 1975 (52, 103); Kelsey & Hardy, 1975 (104)	CC	28	Persons 20–64 years of age	HLD	Driving a car	OR 1.92	1.18–3.11	OR 2.46	1.03–5.87	0.78
					Lifting	RR 1.73		RR 1.17		1.48
Cole et al, 2001 (48); Dollard & Winefield, 1998 (94)	CS	57	Persons 18–64 years of age (N=4230 men, N=4043 women)	Back problems (excluding arthritis) expected to last >6 months	Decision latitude (high versus low)	RR 1.00	0.77–1.29	RR 0.87	0.69–1.11	1.15
					Psychological demands (high versus low)	RR 1.63	1.26–2.1	RR 1.21	0.96–1.53	1.35
					Work physical exertion (high versus low)	RR 1.58	1.08–2.3	RR 1.37	1.1–1.72	1.15
					Work social support (high versus low)	RR 1.08	0.85–1.38	RR 1.21	0.96–1.51	0.89
Alcouffe et al, 1999 (47)	CS	50	Random sample of workers (N=1342 men, N=3168 women)	Low-back pain in the previous month	Manual lifting 10 kg every day	OR 1.69	1.27–2.25	OR 1.27	1.06–1.53	1.33
					Manual lifting 10 kg <1 time per week	OR 1.35	1.04–1.75	OR 1.23	1.01–1.53	1.10
					Manual lifting 10 kg ≥1 time per week	OR 1.62	1.25–2.1	OR 1.20	10.1–1.44	1.35
					No means to achieve good quality work	OR 1.38	1.15–1.65	OR 1.39	1.19–1.63	0.99
					No uncomfortable work postures	OR 0.49	0.41–0.59	OR 0.54	0.46–1.6	0.91
Walsh et al, 1989 (56)	CS	50	Persons 20–70 years of age (N=436)	Low-back pain ever	Driving car or van >4 hours (at birthday prior to onset)	RR 0.4	0.1–3.2	RR 1.7	1–2.9	0.24
					Driving car or van >4 hours (lifetime)	RR 0.8	0.1–7.1	RR 1.2	0.5–2.8	0.67
					Driving truck, tractor or digger (at birthday prior to onset)	RR 0.6	0.1–5.2	RR 0.7	0.4–1.4	0.86
					Driving truck, tractor or digger (lifetime)	RR 1.6	0.1–16.6	RR 0.5	0.2–1	3.20
					Lifting or moving >25 kg by hand (at birthday prior to onset)	RR 2.0	1.1–3.7	RR 2.0	1.3–3.1	1.00
					Lifting or moving > 25 kg by hand (lifetime)	RR 1.1	0.5–2.4	RR 1.5	1.0–2.4	0.73
					Using vibrating machinery (at birthday prior to onset)	RR 1.1	0.1–9.4	RR 1.3	0.7–2.4	0.85
					Using vibrating machinery (lifetime)	RR 5.7	1.1–29.3	RR 1.5	0.7–3.1	3.80
Foppa & Noach, 1996 (49)	CS	43	Workers (N=623 men, N=227 women)	Severe–moderate back pain during previous 4 months	High responsibility	RR 0.87	0.43–1.78	RR 0.99	0.78–1.26	0.88
					Job demands	RR 1.56	1.16–2.09	RR 1.63	1.23–2.06	0.96
					Low job satisfaction	RR 1.16	0.85–1.58	RR 1.40	1.1–1.77	0.83
					Physically demanding job	RR 1.37	1.02–1.84	RR 1.37	1.08–1.74	1.00
					Subjective workload	RR 1.39	1.04–1.88	RR 1.36	1.07–1.73	1.02
					Time pressure	RR 1.39	1.02–1.9	RR 0.90	0.7–1.15	1.54

(continued)

Table 1. Continued.

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association: Female OR, RR or PR	Female 95%CI	Male OR, RR or PR	Male 95% CI	Gender ratio [b]
Walsh et al, 1991 (57)	CS	43	Persons from general practitioners offices (N=1172 men, N=1495 women)	Low-back pain lasting >1 day	Driving car or van >4 hours (at birthday prior to onset)	RR 1.4	0.2–8.2	RR 1.0	0.6–1.8	1.40
					Driving truck, tractor or digger (at birthday prior to onset)	RR 4.5	0.3–65	RR .1	0.7–1.7	4.09
					Lifting or moving >25 kg by hand at birthday prior to onset	RR 2.2	1.3–3.5	RR 2.0	1.4–2.8	1.10
					Using vibrating machinery at birthday prior to onset	RR 2.7	0.6–12.8	RR 0.8	0.5–1.3	3.38
Matsui et al, 1997 (55)	CS	36	Workers of a manufacturing company (N=517 men, N=525 women)	Low-back pain at time of interview	Physical work demands (light versus sedentary)	RR 1.2	0.4–3.4	RR 1.5	1.1–1.9	0.80
					Physical work demands (moderate versus sedentary)	RR 3.5	1.1–10.8	RR 3.2	1.9–5.2	1.09
				Low -back pain ever	Heavy physical work demands	RR 1.38	1.09–1.74	RR 0.68	0.6–0.78	2.03
Latza et al, 2000 (53); Michel et al, 1997 (102)	CS	29	Persons from the general population 25–74 years of age (N=459)	Low-back pain, grade II/III	Working in bent position	RR 0.75	0.41–1.37	RR 1.89	1.03–3.46	0.40
				Unremitting low-back pain	Driving truck, tractor or digger (lifetime)	RR 1.1	0.1–13.2	RR 1.4	0.4–5.1	0.79
					Lifting or moving >25 kg by hand (lifetime)	RR 2.9	0.8–10.2	RR 5.3	1.3–20.9	0.55
					Using vibrating machinery (lifetime)	RR 3.3	0.3–41	RR 1.3	0.3–5.3	2.54

[a] For references see the general reference list of the review.
[b] Ratio of the risk of women to the risk of men (female/male).
[c] 1 lbs = 0.4536 kg.

Table 2. Description of the studies on neck–shoulder complaints. (CC = case–control, CH = cohort, CS = cross-sectional, OR = odds ratio, PR = prevalence ratio, RR = relative risk, 95%CI = 95% confidence interval)

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association: Female OR, RR or PR	Female 95%CI	Male OR, RR or PR	Male 95% CI	Gender ratio [b]
Bildt-Thorbjörnsson et al, 1998 (59); Köster et al, 1999 (79), Fredriksson et al, 2000 (80); Fredriksson et al, 1999 (81); Thorbjörnsson et al, 2000 (82); Torgen et al, 1997 (83); Bildt-Thorbjörnsson et al, 1999 (84)	CH CC	81 72	Working people 18–34 years of age (N=2579)	Consultation with physician, symptom or sick leave for neck, shoulder or neck and shoulder	High mental load at work	PR 1.1	0.2–4.9	PR 1.5	0.5–5.1	0.73
					High mental load	PR 1.2	0.3–4.4	PR 1.7	0.6–4.9	0.71
					Frequent hand or finger movement	PR 1.5	1.0–2.3	PR 1.6	0.9–2.8	0.94
					Handheld vibrating tools	PR 0.7	0.2–2.4	PR 1.3	0.7–2.1	0.54
					High perceived workload	PR 1.6	0.9–2.6	PR 0.9	0.4–1.8	1.78
					Influence over work index (low)	PR 1.2	0.7–1.9	PR 0.9	0.5–1.7	1.33
					Time pressure	PR 0.9	0.5–1.8	PR 0.3	0.1–1.0	3.00
Cassou et al, 2002 (61)	CH	63	Random selection of workers (N=9787 men, N=7163 women)	Chronic neck and shoulder pain	Repetitive work under time constraints at baseline	OR 1.3	1.0–1.6	OR 0.9	0.7–1.2	1.44
					Repetitive work under time constraints before baseline	OR 1.2	1.0–1.5	OR 1.3	1.0–1.7	0.92
					High job demands	OR 1.2	1.0–1.4	OR 1.2	1.0–1.4	1.00
Barnekow-Bergkvist et al, 1998 (58)	CH	50	Students 16 years of age at baseline (N=220 males, N=205 females)	Neck–shoulder symptoms in previous 12 months	Decision latitude (high)	OR 3.80	1.00–14.4	OR 0.76	0.22–2.57	5.00
					Demand index (high)	OR 0.49	0.13–1.84	OR 0.76	0.23–2.48	0.64
					Lift index (heavy)	OR 0.20	0.05–0.85	OR 0.26	0.08–0.87	0.77
					Posture work index (monotonous)	OR 5.88	1.52–22.8	OR 0.92	0.29–2.94	6.39
					Social support index (high)	OR 0.91	0.27–3.07	OR 1.11	0.39–3.22	0.82
Vingard et al, 1999 (60); Tornqvist et al, 2001 (85); Vingard et al, 2000 (86); Wiktorin et al, 1996 (87, 89); Waldenstrom et al, 1998 (88); Wiktorin et al, 1999 (90); Torgén et al, 1999 (91); Mortimer et al, 1998 (92)	CC	78	Persons 20–59 years of age (cases: N=118 men, N=274 women; controls: N=662 men, N=849 women)	Seeking treatment for neck–shoulder pain	Hand above shoulder >30 minutes per day	RR 1.3	0.9–2.0	RR 0.9	0.6–1.4	1.44
					High creativity and low routine	RR 0.9	0.7–1.3	RR 0.6	0.4–1.0	1.50
					High demands in relation to competence	RR 0.8	0.5–1.1	RR 0.9	0.6–1.5	0.89
					High psychosocial demands	RR 1.1	0.8–1.5	RR 0.7	0.4–1.0	1.57
					High quantitative demands	RR 0.9	0.5–1.5	RR 0.2	0.1–0.9	4.50
					High routine and low creativity	RR 1.1	0.7–1.5	RR 1.2	0.7–1.8	0.92
					High time pressure	RR 1.3	0.9–1.8	RR 0.5	0.3–1.0	2.60
					Job strain	RR 1.4	1.1–2.0	RR 1.1	0.7–1.9	1.27

(continued)

Table 2. Continued.

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association				Gender ratio [b]
						Female		Male		
						OR, RR or PR	95%CI	OR, RR or PR	95% CI	
					Decision latitude (low)	RR 1.2	0.9–1.6	RR 1.3	0.8–1.9	0.92
					Demands in relation to competence (low)	RR 1.0	0.7–1.4	RR 1.5	1.0–2.4	0.67
					Participation & demands in planning (low)	RR 1.2	0.7–2.1	RR 0.9	0.4–2.2	1.33
					Manual materials handling (>50N >60 minutes per day)	RR 0.8	0.4–1.5	RR 1.2	0.7–2.0	0.67
					Poor general support at work	RR 1.2	0.9–1.6	RR 1.3	0.9–1.9	0.92
					Repetitive movements	RR 1.6	1.2–2.2	RR 1.2	0.8–1.8	1.33
					Vibrating tools >30 minutes/ day	RR 0.8	0.4–2.0	RR 1.6	1.0–2.3	0.50
Mäkelä et al, 1991 (64); Mäkelä et al, 1999 (93)	CS	71	Persons from the general population (N=7217)	Chronic neck syndrome	Mental stress index (high versus other)	RR 1.78	0.48–2.13	RR 1.63	1.29–2.07	1.09
					Physical work index (high versus other)	RR 1.90	1.62–2.21	RR 1.95	1.58–2.39	0.97
Jensen et al, 2002 (65, 99)	CS	50	Workers using a computer at work (N=7125 men, N=821 women)	Musculoskeletal symptoms in the neck in the past year	Repetitive movements	OR 1.26		OR 1.27		0.99
					Repetitive movements and tasks	OR 1.59		OR 1.86		0.85
					Quantitative demands and development possibilities (low-low)	OR 1.37		OR 1.24		1.10
					Quantitative demands and development possibilities (high-high)	OR 1.28		OR 1.17		1.09
					Quantitative demands and development possibilities (high-low)	OR 2.21		OR 2.05		1.08
				Musculoskeletal symptoms in the shoulder in the past year	Repetitive movements	OR 1.71		OR 1.20		1.43
					Repetitive movements & tasks	OR 1.78		OR 0.76		2.34
					Quantitative demands (medium low)	OR 0.94		OR 1.39		0.68
					Quantitative demands (medium high)	OR 1.27		OR 1.31		0.97
					Quantitative demands (high)	OR 1.60		OR 1.50		1.07
Palmer et al, 2001 (62); Palmer et al, 2000 (75)	CS	36	Persons 16–64 years of age (N=9368)	Neck pain during previous 12 months	Hand above shoulder >1 hour	PR 1.4	1.2–1.6	PR 1.3	1.1–1.4	1.08
					Hand–arm vibration	PR 1.2	1–1.4	PR 1.0	0.9–1.1	1.20
					Lift 10–25 kg by hand	PR 1.1	1–1.3	PR 1.0	0.9–1.1	1.10
					Lift >25 kg by hand	PR 1.1	0.9–1.3	PR 1.1	1.0–1.2	1.00
				Neck pain during previous 7 days	Hand above shoulder >1 hour	PR 1.7	1.3–2.1	PR 1.4	1.2–1.6	1.21
					Hand–arm vibration	PR 0.2	0.9–1.5	PR 0.9	0.8–1.1	0.22
					Lift 10–25 kg by hand	PR 1.1	0.9–1.3	PR 0.9	0.7–1.0	1.22
					Lift >25 kg by hand	PR 1.1	0.9–1.4	PR 1.1	1.0–1.3	1.00
Karlqvist, 2002 (66)	CS	29	Workers from 46 worksites (N=489 men, N=785 women)	Reported symptoms in the neck/ shoulders during the previous 3 months	Position of nonkeyboard input device (nonoptimal)	PR 1.1	1.0–1.3	PR 1.3	1.0–1.7	0.85
					Medium & high job strain	PR 1.3	1.1–1.6	PR 1.2	0.8–1.8	1.08
					Demands not in relation to competence	PR 1.1	1.0–1.2	PR 1.4	1.1–1.8	0.79
					Probability of meeting time limits & quality demands (less good–low versus high)	PR 1.1	1.0–1.2	PR 1.1	0.8–1.4	1.00
					Social support (medium–low versus high)	PR 1.1	0.9–1.2	PR 0.9	0.7–1.2	1.22
					Supervisory social support (medium–low versus high)	PR 1.0	0.9–1.2	PR 1.1	0.8–1.4	0.91
				Reported symptoms in the shoulder joint or upper arm during the previous 3 months	Position of nonkeyboard input device (nonoptimal)	PR 1.0	0.80–1.20	PR 1.2	0.8–1.9	0.83
					Medium & high job strain	PR 1.5	1.0–2.3	PR 0.9	0.6–1.5	1.67
					Demands not in relation to competence	PR 0.9	0.7–1.1	PR 0.8	0.5–1.2	1.13
					Probability of meeting time limits & quality demands (less good–low versus high)	PR 1.3	1.1–1.6	PR 0.6	0.4–1.0	2.17
					Social support (medium–low versus high)	PR 1.1	0.9–1.3	PR 1.1	0.7–1.6	1.00
					Supervisory social support (medium–low versus high)	PR 1.3	1.0–1.7	PR 1.0	0.7–1.6	1.30

(continued)

Table 2. Continued.

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association				Gender ratio [b]
						Female		Male		
						OR, RR or PR	95%CI	OR, RR or PR	95% CI	
Pope et al, 1997 (63)	CS	29	Persons from a general practice (cases: N=16 men, N=23 women; controls: N=79 men, N=100 women	Shoulder pain	Carrying on one shoulder	RR 1.1	0.1–8.1	RR 5.5	1.8–17.4	0.20
					Lifting or carrying >25 lbs [c]	RR 0.8	0.3–2.2	RR 1.2	0.1–3.5	0.67
					Stretching to reach below knee	RR 1.4	0.6–3.3	RR 2.0	0.7–5.7	0.70
					Using arms in repetitive way	RR 0.9	0.4–2.1	RR 1.7	0.6–4.8	0.53
					Using vibrating machinery	RR 0.8	0.2–2.7	RR 1.1	0.4–3.6	0.73
					Using wrist in repetitive way	RR 2.0	0.9–4.6	RR 2.0	0.7–5.9	1.00

[a] For references see the general reference list of the review.
[b] Ratio of the risk of women to the risk of men (female/male).
[c] 1 lbs = 0.4536 kg.

Table 3. Description of the studies on hand–wrist complaints. (CC = case-control, CH = cohort, CS = cross-sectional, OR = odds ratio, PR = prevalence ratio, RR =relative risk, 95% CI = 95% confidence interval)

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association				Gender ratio [b]
						Female		Male		
						OR, RR or PR	95%CI	OR, RR or PR	95% CI	
Jensen et al, 2002 (65, 99)	CS	50	Workers using a computer at work (N=7125 men, N=821 women)	Musculoskeletal symptoms in hand–wrist in past year	Repetitive movements	OR 1.35		OR 1.59		0.85
					Repetitive movements & tasks	OR 1.58		OR 1.88		0.84
					Quantitative demands (medium–low)	OR 0.91		OR 1.16		0.78
					Quantitative demands (medium–high)	OR 1.02		OR 1.45		0.70
					Quantitative demands (high)	OR 1.76		OR 1.27		1.39
Tanaka et al, 1995 (68); Tanaka et al, 2001 (100); Tanaka et al, 1997 (101)	CS	36	Workers from a household survey (N=15 427 men, N=14 627 women)	Carpal tunnel syndrome in last 12 months	Bending–twisting	RR 2.91	2.25–3.76	RR 3.66	2.52–5.32	0.80
					Vibration	RR 1.38	0.96–2.0	RR 2.80	1.08–3.77	0.49
Fransson-Hall et al, 1995 (67)	CS	36	Workers randomly selected from assembly line workers at a Swedish automobile factory (N=521)	Pain, ache or discomfort during last 7 days in the elbow, forearm, wrist, hand or fingers	Wrist extension & ulnar deviation	PR 1.3	0.9–1.9	PR 1.6	1.1–2.3	0.81
					Wrist extension & radial deviation	PR 1.2	0.8–1.8	PR 1.7	1.2–2.4	0.71
					Wrist flexion & ulnar deviation	PR 1.4	1.0–2.0	PR 1.5	1.1–2.2	0.93
					Wrist flexion & radial deviation	PR 1.4	1.0–2.0	PR 1.5	1.1–2.2	0.93
					Wrist ulnar deviation, repetitive movements & precision movements	PR 1.7	1.2–2.4	PR 1.5	0.9–2.3	1.13
					Wrist radial deviation, repetitive movements & precision movements	PR 1.8	1.3–2.5	PR 1.4	0.8–2.2	1.29
					Wrist ulnar–radial deviation, extension–flexion & repetitive movements & precision movements	PR 1.8	1.2–2.6	PR 1.6	1.0–2.6	1.13
Karlqvist, 2002 (66)	CS	29	Employees from 46 worksites (N=489 men, N=785 women)	Reported symptoms in the elbow, forearm, or hands during previous 3 months	Position of nonkeyboard input device (nonoptimal)	PR 1.1	0.9–1.4	PR 1.2	0.8 –1.7	0.92
					Medium & high job strain	PR 1.7	1.1–2.6	PR 1.2	0.7–1.9	1.42
					Demands not in relation to competence	PR 1.1	0.9–1.3	PR 1.4	1.0–1.9	0.79
					Less good–low probability of meeting time limits & quality demands	PR 1.1	0.9–1.3	PR 0.9	0.6–1.3	1.22
					Medium–low social support	PR 1.1	0.9–1.3	PR 1.3	0.8–1.9	0.85
					Medium–low supervisory social support	PR 1.1	0.9–1.3	PR 1.2	0.8–1.8	0.92

[a] For references see the general reference list of the review.
[b] Ratio of the risk of women to the risk of men (female/male).

Table 4. Description of the studies on lower-extremity complaints. (CC = case-control, CH = cohort, CS = cross-sectional, OR = odds ratio, PR = prevalence ratio, 95% CI = 95% confidence interval)

Study [a]	Design	MQ (%)	Population	Outcome	Exposure	Association: Female OR, RR or PR	Female 95%CI	Male OR, RR or PR	Male 95% CI	Gender ratio [b]
Coggon et al, 2000 (69)	CC	44	Persons living in 3 health districts (cases: N=675; controls N=667)	On waiting list for knee surgery due to osteoarthritis	Climbing ladder or stairs >30 times/day	0.7	0.3–1.6	2.3	1.3–4.0	0.30
					Geting up from kneeling or squatting >30 times/day	1.8	1.0–3.2	2.0	1.1–3.5	0.90
					Kneeling or squatting >1 hour/day	2.1	1.2–3.6	2.0	1.1–3.6	1.05
					Kneeling >2 hours/day	2.0	1.1–3.5	1.7	1.0–3.0	1.18
					Squatting >1 hour/day	2.8	1.1–7.2	2.2	1.0–4.9	1.27
					Standing or walk >2 hours/day	0.5	0.8–2.9	4.1	0.3–65.5	0.12
					Walking >2 miles/day [c]	2.1	1.4–3.2	1.7	0.8–3.6	1.24
Manninen et al, 2002 (72)	CC	44	Persons 55–75 years of age (N=194 men, N=640 women)	Knee surgery due to primary osteo-arthritis	Heavy physical workload (medium versus low)	1.60	0.83–3.06	2.23	0.64–7.72	0.72
					Heavy physical workload (high versus low)	2.03	1.03–3.99	1.53	0.42–5.56	1.33
					Kneeling or squatting <2 hours	0.97	0.59–1.59	0.58	0.21–1.64	1.67
					Kneeling or squatting >2 hours	1.81	1.11–2.95	1.68	0.66–4.28	1.08
					Climbing (medium versus low level)	1.08	0.71–1.63	3.06	1.25–7.46	0.35
					Climbing (high versus low level)	1.50	0.81–2.77	2.79	0.96–8.16	0.54
					Walking (medium versus low level)	0.89	0.56–1.42	2.07	0.73–5.89	0.43
					Walking (high versus low level)	1.06	0.64–1.76	1.47	0.55–3.89	0.72
Coggon et al, 1998 (70)	CC	39	Persons living in 2 health districts (N=420 men, N=802 women)	On waiting list due to hip osteo-arthritis	Kneeling >1 hour (0.1–9.9 years) [d]	0.9	0.6–1.4	0.8	0.4–1.4	1.13
					Kneeling >1 hour (10–19.9 years) [d]	0.7	0.4–1.3	2.0	0.8–4.7	0.35
					Kneeling >1 hour (>20 years) [d]	1.2	0.5–3.0	1.0	0.6–1.7	1.20
					Squatting >1 hour (0.1–9.9 years) [d]	1.1	0.6–1.9	0.9	0.5–1.6	1.22
					Squatting >1 hour (10–19.9 years) [d]	1.5	0.6–3.4	1.4	0.5–3.6	1.07
					Squatting >1 hour (>20 years) [d]	0.7	0.3–1.8	0.9	0.5–1.6	0.78
					Walking >2 miles [c] (0.1–9.9 years) [d]	1.5	1.0–2.3	0.8	0.4–1.9	1.88
					Walking >2 miles [c] (10–19.9 years) [d]	1.5	1.0–2.0	1.1	0.4–2.5	1.36
					Walking >2 miles [c] (>20 years) [d]	1.3	0.8–2.0	1.2	0.6–2.5	1.08
					Climbing >30 flights of stairs (0.1–9.9 years) [d]	1.4	0.8–2.0	1.3	0.7–2.5	1.08
					Climbing >30 flights of stairs (10–19.9 years) [d]	1.3	0.4–4.0	2.3	1.1–4.9	0.57
					Climbing >30 flights of stairs (>20 years) [d]	2.3	0.8–6.3	1.8	0.9–3.4	1.28
Lau et al, 2000 (71); Cooper et al, 1994 (98)	CC	39	Hip (cases [e]: N=30 men, N=108 women; controls [f]: N=90 men, N=324 women)	Osteoarthritis of hip, grade III / IV	Climbing	2.3	0.6–8.1	12.5	1.5–104.3	0.18
					Kneeling	1.3	0.7–2.5	3.9	1.1–14.2	0.33
					Squatting >1 hour/day	1.6	1.0–2.8	1.3	0.5–3.2	1.23
					Walking	1.4	0.9–2.3	3.9	1.3–12.1	0.36
					Walking	0.8	0.5–1.1	1.0	0.5–2.1	0.80
			Knee (cases [e]: N=166 men, N=492 women; controls [f]: N=166 men, N=492 women)	Osteoarthritis of knee, grade III/ IV	Climbing	5.1	2.5–10.2	2.5	1.0–6.4	2.04
					Kneeling	0.9	0.6–1.3	1.4	0.7–3.0	0.64
					Squatting >1 hour/day	1.1	0.8–1.5	1.2	0.7–2.0	0.92

[a] For references see the general reference list of the review.
[b] Ratio of the risk of women to the risk of men (female/male).
[c] 1 mile = approximately 1.6 km.
[d] Exposure up to 10 years before the study.
[e] Patients with osteoarthritis of hip and knee.
[f] Consecutive patients of 8 general practices.