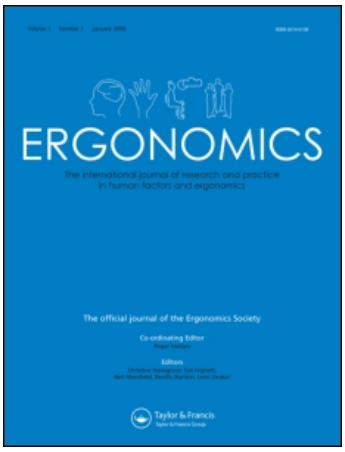

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Risk of musculoskeletal disorders among females and males in repetitive/constrained work

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This paper combines epidemiological data on musculoskeletal morbidity in 40 female and 15 male occupational groups (questionnaire data 3720 females, 1241 males, physical examination data 1762 females, 915 males) in order to calculate risk for neck and upper limb disorders in repetitive/constrained vs. varied/mobile work and further to compare prevalence among office, industrial and non-office/non-industrial settings, as well as among jobs within these. Further, the paper aims to compare the risk of musculoskeletal disorders from repetitive/constrained work between females and males. Prevalence ratios (PR) for repetitive/constrained vs. varied/mobile work were in neck/shoulders: 12-month complaints females 1.2, males 1.1, diagnoses at the physical examination 2.3 and 2.3. In elbows/hands PRs for complaints were 1.7 and 1.6, for diagnoses 3.0 and 3.4. Tension neck syndrome, cervicalgia, shoulder tendonitis, acromioclavicular syndrome, medial epicondylitis and carpal tunnel syndrome showed PRs > 2. In neck/shoulders PRs were similar across office, industrial and non-office/non-industrial settings, in elbows/hands, especially among males, somewhat higher in industrial work. There was a heterogeneity within the different settings (estimated by bootstrapping), indicating higher PRs for some groups. As in most studies, musculoskeletal disorders were more prevalent among females than among males. Interestingly, though, the PRs for repetitive/constrained work vs. varied/mobile were for most measures approximately the same for both genders. In conclusion, repetitive/constrained work showed elevated risks when compared to varied/mobile work in all settings. Females and males showed similar risk elevations. This article enables comparison of risk of musculoskeletal disorders among many different occupations in industrial, office and other settings, when using standardised case definitions. It confirms that repetitive/constrained work is harmful not only in industrial but also in office and non-office/non-industrial settings. The reported data can be used for comparison with future studies.

Keywords: physical examination; questionnaire; tension neck syndrome; shoulder; upper limb

1. Introduction

Musculoskeletal disorders of the neck and upper limbs are widespread in the populations of industrialised countries, leading to individual suffering and large costs (Buckle and Devereux 2002). Several studies have shown relationships between physical and psychosocial risk factors at work and such disorders (Bernard 1997, National Research Council 2001, Östergren *et al.* 2005); therefore, there should be a substantial potential for prevention (Melhorn and Gardner 2004).

Risk factors described include repetitive movements and constrained postures (Walker-Bone and Cooper 2005), often in combination since work tasks that demand repetitive hand motions also imply constrained neck postures due to visual demands. Although numerous studies concerning work-related musculoskeletal disorders have been published, limited evidence for causality exists. For example, a recent systematic review (Palmer and Smedley 2007) found only moderate evidence for a causal relationship between repetitive shoulder movements and chronic neck pain. Thus, further research is still needed.

Traditionally, industrial repetitive tasks have been associated with musculoskeletal disorders of the upper extremity (Chung *et al.* 2005). Many jobs outside of the industrial sector can also be described as repetitive (such as cleaning and hairdressing) or constrained (such as dentistry) and elevated risks have been reported (Leino *et al.* 1999, Åkesson *et al.* 2000, Gamperiene *et al.* 2003). A growing concern is computerised office work, leading to pain and discomfort in the neck and upper limb (Wahlström 2005). It is not clear, however, whether such jobs are as riskful as the repetitive industrial ones. As reported data on disorder prevalence in specific work tasks or exposures have used different definitions for case ascertainment, the estimated risks within and among different occupational settings cannot be adequately compared using current evidence (Kuorinka *et al.*

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1987, Ohlsson *et al*. 1994b, Palmer *et al*. 2000, Sluiter *et al*. 2001, Andersen *et al*. 2007).

Upper extremity musculoskeletal disorders are more prevalent among females than among males, even when adjusting for some work factors (Treaster and Burr 2004). There is however a lack of data on possible differences in the relative risk of repetitive/constrained work tasks between genders, which may influence gender musculoskeletal disorders differences.

An often used method for assessment of musculoskeletal complaints is the Nordic Questionnaire (Kuorinka *et al*. 1987, Descatha *et al*. 2007). This research group has used this as well as a standardised physical examination method with pre-defined criteria for diagnoses (Ohlsson *et al*. 1994a) in many different occupational groups. By combining data from previous studies, there is now a database that can be used to describe differences among jobs based on consistent case definitions.

This paper aims to combine data on musculoskeletal morbidity, assessed by questionnaire as well as by a physical examination, in different occupational groups, in order to calculate the risk for musculoskeletal disorders among workers with repetitive/constrained work as compared to workers with varied mobile work. Further, the paper aims to compare the prevalence of disorders among office, industrial and non-office/non-industrial settings, as well as among different jobs within these settings and finally to compare the risk of musculoskeletal disorders from repetitive/constrained work between females and males.

2. Materials and methods

2.1. Occupational groups

The study base comprised all workers in all occupational groups who have been screened for musculoskeletal disorders by the current research group or, in some cases, by other research groups in cooperation with the present group. The groups have each been recruited for separate epidemiological studies. All occupational groups that consisted of at least 30 male or 30 female workers with homogeneous work tasks, in total 43 groups, were included (Table 1). A total of 12 groups had both female and male workers, 28 had female workers only and three had male workers only. All surveys were cross-sectional.

The groups were examined between 1986 and 2005 (Table 1). Most of the individual studies have already been published elsewhere in separate publications, see Table 1 for references. For the rest, a short presentation is given below:

Group 7: These males mixed rubber chemicals for rubber production. Their work was mostly performed standing and walking and involved some heavy lifting. They had a varied pattern of motion with frequent pauses.

Group 15: Among the males in this group, 124 were examined in 1990 and have been described earlier (Nordander *et al*. 1999). The remaining 32 caretakers were examined in 2004 and since they had the same kind of work tasks they were added to the group.

Groups 16 and 19: Female nurses in a psychiatric and an orthopaedic ward respectively. Due to the differences in patients admitted, the latter ones had more heavy lifting.

Group 18: Among the females in this group, 71 were examined in 1990 and have been described earlier (Ohlsson *et al*. 1994b, Nordander *et al*. 1999). The remaining 44 day nursery workers were examined in 2004 and, since they had the same kind of work tasks, they were added to the group.

Group 22: These males spent their entire working days standing at a table, cutting up pork shoulders or pork hams.

Group 32: In addition to the workers described by Juul-Khristensen *et al*. (2001, 2002), the group included 25 Swedish female poultry-processing workers with the same work tasks.

Group 43: Traditional hairdressing.

Group 38: Male and female dentists with ordinary dentistry work.

Group 40: Diagnostic ultrasound examinations of patients by hand-held sonographic devices.

Group 42: Dentistry hygienists. The work tasks in the group examined in 2005 are more constrained than was the case in 1986 (group 39), involving more grinding and harder materials.

The groups were divided into two categories, namely, repetitive/constrained and varied/mobile work. Repetitive work was defined according to Silverstein *et al*. (1986); a cycle time <30 s or $>50\%$ of the cycle time involved the same fundamental cycle. Constrained work implied that $>50\%$ of working time involved prolonged awkward postures. Often, work was repetitive for the hands and constrained for the neck.

Of course, there is no sharp demarcation line between these categories. In two cases, grouping was not obvious (groups 5, air traffic control and 6, information service, telephone), These were categorised as varied/mobile. The categorisation into repetitive/constrained or varied/mobile work was for most groups performed prior to the data collection, since they were each selected for epidemiological studies. Hence, care was taken that the assessors were not aware of the disorder prevalences when categorising the groups. Further, within each category the groups were divided according to their occupational settings (office, industrial and non-office/non-industrial).

Table 1. Description of the different occupational groups including type of work, gender (F = female, M = male), number of participating subjects (N), participation rate* (Part), age (mean and SD), employment (Empl) time (mean and SD), assessment method for disorders (disorders: Nordic Questionnaire† (Q), 3720 females and 1241 males; physical examination (E), 1762 females and 915 males), year of examination and references to earlier publications.

Group	Type of work	Gender	N	Part (%)	Age		Empl time		Disorders	Year	References
					Mean	SD	Mean	SD			
Varied/mobile											
Office											
1	Varied office work	F	32	100	44	10	11	10	QE	1987	1, 2, 3
2	Varied office work	F	93	100	44	11	15	8	QE	1990	4, 5
3	Partly VDU work	F	186	89	45	10	16	9	QE	1995	6, 7, 8, 9
		M	122	88	46	9	18	10	QE	1995	6, 7, 8, 9
4	Varied office work	F	33	100	38	9	12	9	QE	1992	10
		M	41	100	43	10	16	12	QE	1992	
5	Air traffic control	F	90	100	37	8	10	8	QE	2002	11
		M	97	100	41	10	13	10	QE	2002	11
6	Information service, telephone Industrial	F	67	76	45	11	21	13	Q	1989	12
7	Rubber mixing	M	77	100	41	13	16	14	QE	2001	
8	Varied industrial work	F	35	100	34	12	9	8	QE	1992	10
		M	31	100	36	12	9	10	QE	1992	
Non-office/non-industrial											
9	Various work	F	60	97	38	8	9	6	Q	1986	13
10	Farming	F	108	65	44	10	16	11	Q	1992	14
11	Nursing work	F	152	79	40	11	13	8	Q	1992	14
12	Nursing work	F	30	100	42	11	8	8	Q	1987	15
13	Caring of children and elderly	F	255	86	42	11	8	7	Q	1990	1, 3
14	Grocery store work	F	32	100	40	11	10	6	QE	1987	1, 2, 3
15	Caretaker work	M	156	99	44	12	12	10	QE	2004	
16	Nursing, psychiatry	F	155	77	41	12	15	11	Q	2002	
17	Home-help service	F	42	100	37	14	6	6	QE	1990	4, 5
18	Day nursery work	F	115	99	39	12	11	10	QE	2004	
19	Nursing, orthopaedics	F	73	83	36	11	12	11	Q	2002	
Repetitive/constrained											
Office											
20	Data entry, giroform Industrial	F	146	80	44	13	17	9	Q	1989	12
21	Spot-welding, car manufacturing	F	42	74	31	7	1	1	Q	1997	16
		M	137	81	31	9	1	1	Q	1997	
22	Meat cutting	M	90	99	36	9	12	8	QE	2005	
23	Mink fur sorting	F	58	94	35	10	3	3	Q	1989	12
		M	86	85	34	11	3	3	Q	1989	12
24	Light assembly, thermoset	F	147	100	35	13	5	6	Q	1986	1, 3, 17, 18
25	Parquet slats sorting	F	151	100	38	11	10	8	QE	1998	19, 20, 21
26	Light assembly, ceramics	F	82	100	46	12	19	10	QE	1987	1, 2, 3
27	Fish processing	F	206	87	39	14	6	6	QE	1990	4, 5
		M	116	92	41	14	9	9	QE	1990	5
28	Injection moulding, rubber	F	83	92	42	12	14	11	QE	2001	22
		M	37	99	41	12	11	11	QE	2001	22
29	Light assembly, thermoset	F	32	100	42	10	15	7	QE	1997	
30	Forceful assembly, brakes	F	90	98	41	10	11	7	QE	2003	22
		M	67	97	33	10	6	6	QE	2003	22
31	Laminate production	F	87	100	40	13	11	9	QE	1992	10, 23
		M	89	100	39	12	12	10	QE	1992	
32	Poultry processing	F	59	..	35	6	6	5	Q	1997	24, 25
Non-office/non-industrial											
33	Dentistry, nurses	F	115	95	37	9	14	8	Q	1986	13
34	Milking, tethering	F	162	80	44	12	18	13	Q	1992	14, 26, 27
35	Hairdressing	F	166	54	31	9	8	9	Q	2004	28
36	Dentistry, dentists	F	33	97	37	8	11	8	Q	1986	13, 29
		M	39	95	37	9	10	9	Q	1986	13
37	Cleaning, extended organisation	F	111	95	44	11	14	8	QE	1994	30
38	Dentistry, dentists	F	65	100	47	11	15	12	Q	2003	
		M	56	100	52	14	18	12	Q	2003	

(*continued*)

Table 1. (*Continued*).

Group	Type of work	Gender	N	Part (%)	Age Mean	Age SD	Empl time Mean	Empl time SD	Disorders	Year	References
39	Dentistry, hygienists	F	30	100	41	7	7	4	Q	1987	15
40	Medical ultrasonic work	F	33	100	47	9	13	9	Q	2005	
41	Cleaning, traditional organisation	F	135	89	45	9	15	6	QE	1994	30
42	Dentistry, hygienists	F	51	100	45	11	14	10	QE	2005	
43	Hairdressing	F	78	93	43	12	24	14	QE	2005	

*For some of the groups, the original study bases were larger, but some subjects could not be reached or refrained from participation. Not known for group 32.

†Two females in group 3, two males in group 15 and six males in group 27 answered the questionnaire but did not participate in the physical examination.

1 = Pålsson *et al*. 1997; 2 = Ohlsson *et al*. 1995; 3 = Norlund *et al*. 2000; 4 = Ohlsson *et al*. 1994b; 5 = Nordander *et al*. 1999; 6 = Hansson *et al*. 2000b; 7 = Hansson *et al*. 2001; 8 = Nordander *et al*. 2000; 9 = Balogh *et al*. 2004; 10 = Hansson *et al*. 2000a; 11 = Arvidsson *et al*. 2006; 12 = Hansson and Mikkelsen 1997; 13 = Åkesson *et al*. 2000; 14 = Stål *et al*. 1996; 15 = Åkesson *et al*. 1999; 16 = Byström *et al*. 2004; 17 = Ohlsson *et al*. 1988; 18 = Ohlsson *et al*. 1989; 19 = Persson *et al*. 2003; 20 = Garde *et al*. 2003; 21 = Balogh *et al*. 2006; 22 = Nordander *et al*. 2008; 23 = Balogh *et al*. 1999; 24 = Juul-Kristensen *et al*. 2001; 25 = Juul-Kristensen *et al*. 2002; 26 = Stål and Hansson 1999; 27 = Stål *et al*. 2000; 28 = Veiersted *et al*. 2008; 29 = Åkesson *et al*. 1997; 30 = Unge *et al*. 2007).

2.2. *Subjects*

The study population comprised all subjects in the 43 different occupational groups who were presently employed when each study was performed (including those on sick leave). A questionnaire survey was performed in all these groups, answered by 3720 female (participation rate 87%) and 1241 male (95%) workers (Table 1). In 23 of the groups, a physical examination was performed on all workers. All together, 1762 females (98%) and 915 males (97%) participated.

The mean age for females with repetitive/constrained work was 40 years and the mean employment time was 12 years. Males in this category had a mean age of 37 years and a mean employment time of 8 years. Corresponding figures for varied/mobile work was 41 years and 12 years for females, 43 years and 14 years for males.

2.3. *Questionnaire*

Pain or discomfort in the different body regions during the past 12 months, as well as the past 7 d, was recorded in all groups by the Nordic Questionnaire (Kuorinka *et al*. 1987, Descatha *et al*. 2007). For all groups that participated in the physical examination, the questionnaire was filled out during an interview, for the rest it was administered as a mailed questionnaire.

2.4. *Physical examination*

All workers in groups 1–5, 7, 8, 14, 15, 17, 18, 22, 25–31, 37 and 41–43 were examined by a standardised physical examination of the neck and upper limb (Ohlsson *et al*. 1994a), immediately after the interview. Diagnoses were set according to predefined criteria (Table 2). To increase sensitivity for diagnosing peripheral nerve entrapments, the criteria have been revised since the original publication, in accordance with a recommended standardised method of examination (Sluiter *et al*. 2001, Nordander *et al*. 2008). As all findings have been saved, recalculation of the prevalences in earlier studies has been made according to this. In groups 1, 14 and 26 some diagnoses could not be redefined because the original examination scheme was too short. Hence, these groups lack data on elbows/hands diagnoses. The inter-examiner reproducibility of the method has been shown to be generally good (Nordander 2004). Data on separate shoulder, elbows and hand diagnosis will be presented for the right side.

2.5. *Statistical methods*

The mean prevalences for the subjects with repetitive/constrained and varied/mobile work respectively, as well as the prevalence ratios (PRs) for repetitive/constrained vs. varied/mobile work, for complaints and diagnoses, were calculated.

For repetitive/constrained work, data were also presented as mean prevalences among office, industrial and non-office/non-industrial settings. Further, to evaluate differences among groups within occupational settings with repetitive/constrained work, in settings with at least four groups of the same gender, the chi-squared test was used to see if the prevalence of complaints or diagnoses was similar across studies. In order to quantify the heterogeneity across a set of studies, the studies were ordered with regard to their observed prevalence of complaints. The estimated slope should approximately reflect the absolute change

Table 2. Criteria for the 19 predefined diagnoses of disorders of the neck and upper limbs.

Diagnosis	Criteria
Tension neck syndrome	Neck pain; sense of fatigue or stiffness in the neck; pain radiating from the neck to the back of the head; tightness of muscles (in at least two out of four possible); tender spots in the muscles (in at least three out of eight possible localisations).
Cervical syndrome	Pain radiating from the neck to the upper extremity; limited neck movement; radiating pain provoked by test movements; decreased sensibility in hands/fingers; muscle weakness of the upper limb.
Cervicalgia	Neck pain; limited mobility (in at least four out of six possible directions). Diagnosis only if tension neck syndrome or cervical syndrome is not present.
Thoracic outlet syndrome	Pain radiating of the upper extremity, in the distribution of the ulnar nerve; paresthesia in the distribution of the ulnar nerve; positive Roos' test (increase of the subjective symptoms, not only fatigue); intense tenderness over the brachial plexus. Diagnosis only if tension neck syndrome or cervical syndrome is not present.
Frozen shoulder	Shoulder pain; progressive stiffness of the shoulder during the last 3–4 months; limited outward rotation and abduction.
Supraspinatus tendonitis	Shoulder pain; local tenderness over the tendon insertion; pain at resisted isometric abduction.
Infraspinatus tendonitis	Shoulder pain; local tenderness over the tendon insertion; pain at resisted isometric outward rotation.
Bicipital tendonitis	Shoulder pain; local tenderness over the tendon(s); pain at resisted isometric elevation of the arm (straight and elevated 90°) and/or resisted isometric flexion of the elbow (flexed 90° and hand supinated).
Acromioclavicular syndrome	Shoulder (epaulet) pain; palpable tenderness of the joint; pain provoked by horizontal adduction and/or by outward rotation of the arm (90° abducted, with flexed elbow).
Lateral epicondylitis	Elbow pain; palpable tenderness of the lateral epicondyle; pain at resisted isometric extension of the wrist; pain and/or weakness in gripping.
Medial epicondylitis	Elbow pain; palpable tenderness of the medial epicondyle; pain at resisted isometric flexion of the wrist.
De Quervain's disease	Wrist pain; palpable tenderness of the tendons of the first dorsal compartment of the wrist; positive Finkelstein's test.
Peritendinitis/tenosynovitis	Wrist pain; palpable tenderness of the tendon(s); local swelling; redness or heat.
Overused hand syndrome	Hand pain; palpable tenderness of the thenar, hypothenar and interossei muscles, and of the wrist capsule.
Carpal tunnel syndrome	Nocturnal numbness of the hand; paresthesia in the distribution of the median nerve; positive Tinel's sign over the carpal tunnel and/or positive Phalen's test and/or decreased sensibility in the distribution of median nerve and/or decreased strength in opposition of the thumb.
Pronator teres syndrome	Pain of the medial/proximal part of the forearm; local tenderness over the edge of m. pronator teres; pain and decreased in pronation and/or decreased flexion strength of the wrist and/or of the distal phalanxes of the fingers I-II.
Radial tunnel syndrome	Pain in the elbow during rest; pain of the proximal, lateral part of the forearm; tenderness about 5–8 cm distally of the lateral epicondyle and pain at resisted isometric supination.
Ulnar nerve entrapment at the elbow	Pain and paresthesia or numbness in the distribution of the ulnar nerve; positive Tinel's sign over the cubital tunnel.
Ulnar nerve entrapment at the wrist	Pain and paresthesia or numbness in the distribution of the ulnar nerve; decreased sensibility of the fingers IV-V and/or positive Tinel's sign over Guyon's tunnel (volar/ulnar at the wrist) and/or decreased strength in spreading the fingers.

Note: All symptoms and findings were required.

in prevalence across a set of k studies (the study with the lowest prevalence was coded as 0, the following studies were coded as $1/(k\text{-}1)$, $2/(k\text{-}1)$ and so on, until the study with the highest prevalence, which hence was coded as 1, taking into account outcome data from all studies. The slope estimate should be fairly similar to the difference between the highest and lowest prevalence. Clearly, also when the prevalence is assumed to be homogeneous across the studies, one should expect a positive change in prevalence across studies that are ordered with regard to prevalence. Under the homogeneity assumption, the expected change was set to the median of 1000 slopes obtained by bootstrap simulations (see below). The excess absolute change in prevalence (EAC) across a set of studies was calculated by subtracting the expected change under the homogeneity assumption from the estimated slope based on the observed data. By bootstrap simulations, subjects within each study were re-sampled with replacement in order to assess the number of subjects with complaints (Efron and Tibshirani 1993). Based on a simulated dataset, the studies were ordered according to prevalence and a new slope was estimated by a weighted linear

regression analysis (the number of study subjects as the study weight). A corresponding procedure was employed under the homogeneity assumption; with the exception that subjects were randomly allocated to the studies (the total number of subjects in each study should not vary, however). The 95% CI for the EAC corresponds to the 2.5th and 97.5th percentiles of the distribution of the the slopes minus the expected change obtained from 1000 bootstrap simulations.

To enable comparisons between genders, all results were presented separately for females and males.

3. Results

3.1. Repetitive/constrained vs. varied/mobile work

In total, 52% of the females and 32% of the males with repetitive/constrained work reported last 7 d complaints in the neck/shoulder region, yielding PR about 1.5 for females, around one for males when compared to varied/mobile work (Table 3, Figure 1a). Complaints in elbows/hands were less common (females 38%, males 25%) while the difference between the categories was larger than for neck/shoulders; PR was about two for females and 1.5 for males. The 12 month complaint prevalence was about 60% for neck/shoulders in the groups with varied/mobile work, for females as well as males. Although it was higher for repetitive/constrained work, the PRs were only slightly above 1. In contrast, for elbows/hands, lower 'background prevalences' for 12-month complaints and larger PRs were shown.

Neck/shoulder diagnoses prevalences were 38% in females and 22% in males with repetitive/constrained work, which for both genders was more than two-fold as common as in varied/mobile work (Table 3, Figure 2a). A similar pattern for elbows/hands was found with PRs around 3.

The most common diagnosis was tension neck syndrome (Table 4). Although also quite prevalent in varied/mobile work, it was 2.6 times as common for females and almost four times as common for males with repetitive/constrained work. Elevated PRs (all above 2) were also shown for repetitive/constrained work, as compared to varied/mobile work for cervicalgia (females only) and for right-sided shoulder tendonitis, acromioclavicular syndrome, medial epicondylitis and carpal tunnel syndrome.

In general, much higher prevalences were shown for complaints and diagnoses in neck/shoulders than in elbows/hands (Table 3, Table 4). Groups with a high prevalence of elbows/hands diagnoses consistently also showed a high prevalence of neck/shoulder diagnoses, with one exception, group 22 (male meat cutters, Figure 3). There was no obvious difference in this pattern between females and males or between repetitive/constrained and varied/mobile work.

In shoulders as well as in elbows/hands, right-sided complaints and diagnoses were more prevalent than left-sided ones (not shown in table).

Table 3. Prevalence of complaints during the last 12 months and last 7 d (Nordic Questionnaire; NQ), as well as at least one diagnosis (physical examination; PE). Number of subjects examined in each occupational setting (N). Prevalence ratios (PR), with 95% CI, for subjects with repetitive/constrained work in office*, industrial and non-office/non-industrial (NO/NI) work, as well as all three combined, vs. all subjects with varied/mobile work†.

	Females						Males				
	Repetitive/constrained				Varied/		Repetitive/constrained			Varied/	
	Office	Industrial	NO/NI	All	mobile		Industrial	NO/NI	All	mobile	
NQ (N)	146	1037	979	2162	1558		622	95	717	524	
PE (N)	–	731	375	1106	656		393	–	393	522	
	%	%	%	%	%	PR (CI)	%	%	%	%	PR (CI)
Neck/shoulders											
Complaints:											
12 months	77	73	72	73	61	**1.2 (1.1–1.3)**	62	66	63	56	**1.1 (1.0–1.2)**
7 d	58	52	46	52	34	**1.5 (1.4–1.7)**	32	34	32	29	1.1 (0.9–1.3)
Diagnosis		37	40	38	17	**2.3 (1.9–2.8)**	22		22	9.8	**2.3 (1.7–3.2)**
Elbows/hands											
Complaints:											
12 months	59	63	54	58	35	**1.7 (1.6–1.8)**	56	33	51	33	**1.6 (1.4–1.8)**
7 d	38	44	31	38	19	**2.0 (1.8–2.3)**	27	8	25	17	**1.5 (1.2–1.9)**
Diagnosis		12	17	14	4.6	**3.0 (2.1–4.5)**	9		9.2	2.7	**3.4 (1.9–6.2)**

Questionnaire data from 3720 females and 1241 males, physical examination from 1762 females and 915 males‡.

*Females only since no data on male subjects with repetitive/constrained office work were available.

†Results shown in bold face statistically significant, 95% CI exceeds 1.0.

‡Data on elbows/hands diagnoses lacking on 146 females since the original dataset did not allow redefinition of diagnoses with the revised critera.

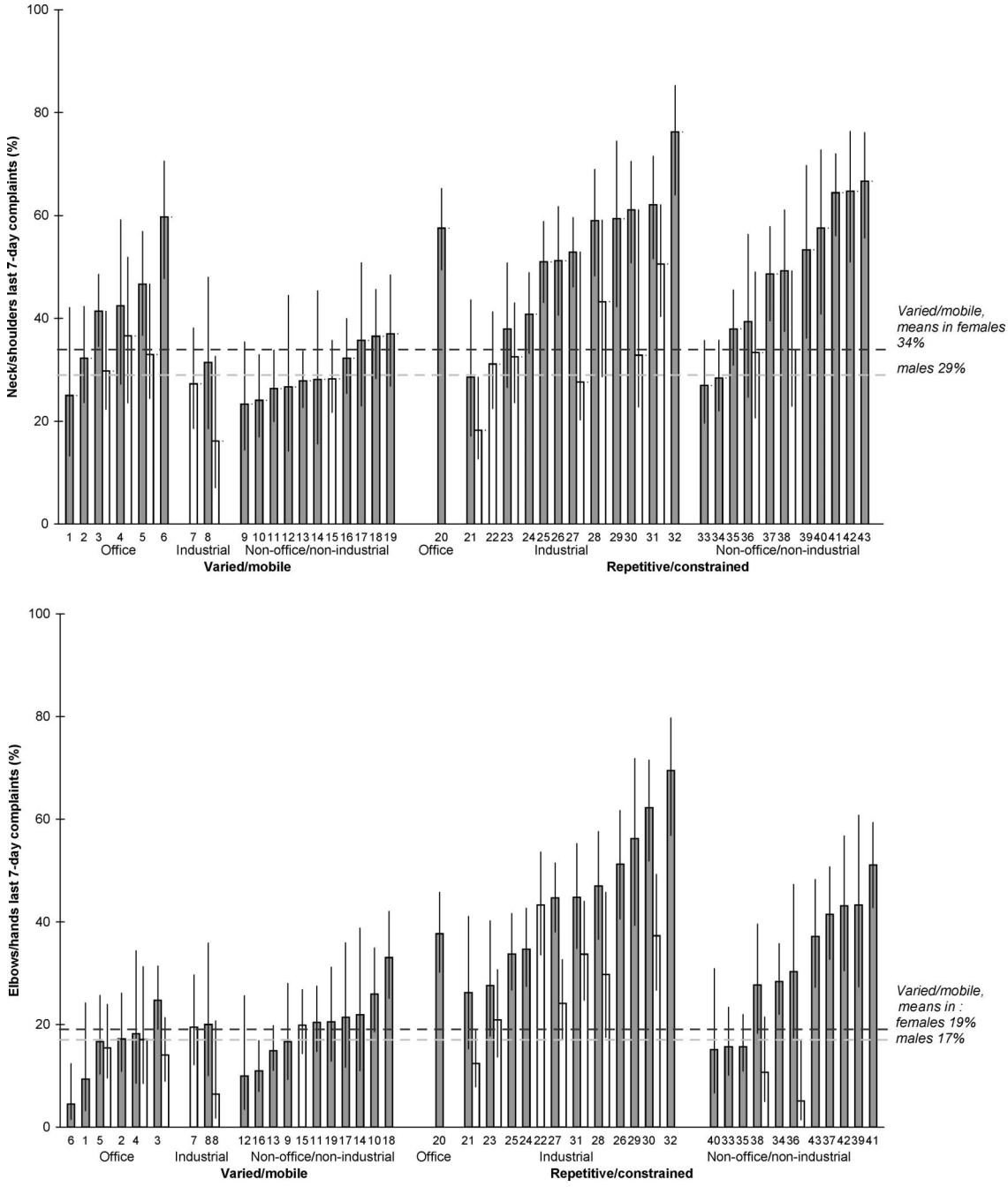

Figure 1. Prevalence of complaints during the last 7 d in neck/shoulders (a) and elbows/hands (b) in 43 different occupational groups (see Table 1 for description), assessed by the Nordic Questionnaire in 3720 females (grey columns) and 1241 males (white columns). The 95% CI for the prevalence in each group is indicated by a line. The mean prevalences for males and females in the varied/mobile groups are indicated by dotted lines.

3.2. Differences among and within occupational settings

Among females with repetitive/constrained work, PR for neck/shoulder complaints for last 7 d in office work was 1.7 (95% CI 1.5–2.0; derived from Table 3), in industrial work 1.6 (1.4–1.7) and in non-office/non-industrial work 1.4 (1.2–1.5). Among males, PR for repetitive/constrained industrial work was 1.1 (0.9–1.3); non-office/non-industrial work 1.2 (0.8–1.6). Further, concerning PR for diagnoses, females in repetitive constrained industrial work was 2.2

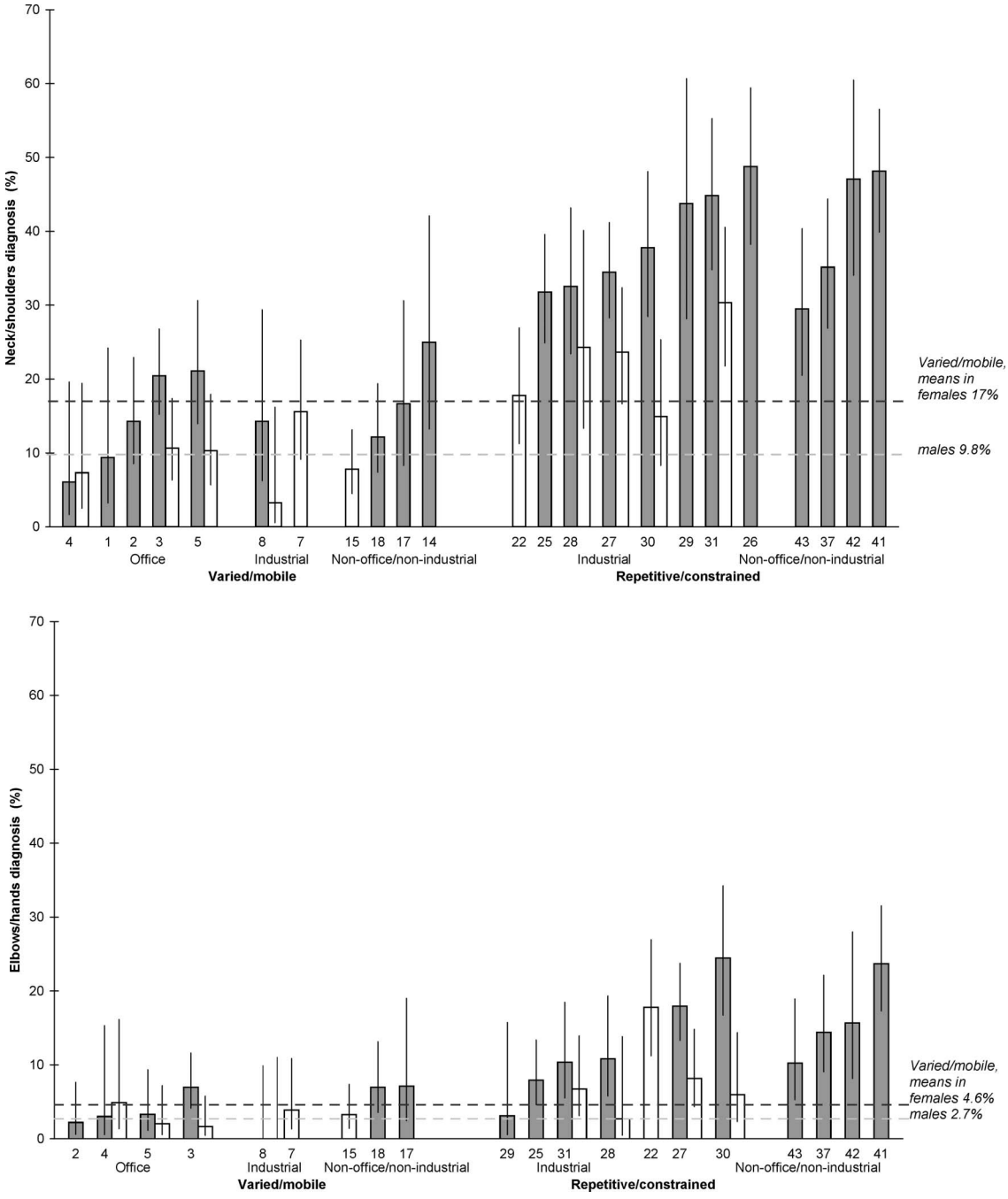

Figure 2. Prevalence of at least one diagnosis in neck/shoulders (a) or elbows/hands (b), in 23 different occupational groups (see Table 1 for description), from a physical examination of 1758 females (grey columns) and 915 males (white columns). The 95% CI for the prevalence in each group is indicated by a line. The mean prevalences for males and females in the varied/mobile groups are indicated by dotted lines.

(1.8–2.7); in non-office/non-industrial work 2.4 (2.0–3.0). Hence, their PRs for repetitive/constrained work vs. varied/mobile work among the different settings showed similar levels. In elbows/hands, PRs were somewhat higher for repetitive/constrained industrial work than for the other settings, especially among males.

The PRs for each group with repetitive/constrained work as compared to mean levels for varied/mobile work can be derived from Figures 1 and 2. Within several of the settings, considerable differences were shown among the different working groups. Concerning neck/shoulder last 7 d complaints in repetitive/constrained work, homogeneity test yielded

Table 4. Prevalence of defined diagnoses on the right side (physical examination). Prevalence ratio (PR), with 95% CI for subjects with repetitive/constrained vs. varied/mobile work*.

	Females			Males		
	Repetitive/constrained N = 1106 %	Varied/mobile N = 656 %	PR (CI)	Repetitive/constrained N = 393 %	Varied/mobile N = 522 %	PR (CI)
Neck-shoulders						
Tension neck syndrome	26	10	**2.6 (2.0–3.3)**	11	2.9	**3.9 (2.2–6.9)**
Cervicalgia	6.2	3.1	**2.4 (1.4–4.2)**	3.3	2.3	1.4 (0.7–3.1)
Cervical syndrome	1.0	0.2	6.5 (0.8–50)	0.3	0.4	0.7 (0.1–7.3)
Thoracic outlet syndrome	0.7	0.5	1.6 (0.4–5.9)	0.3	0.2	1.5 (0.1–21)
Supraspinatus tendonitis	6.1	2.5	**2.5 (1.4–4.2)**	5.6	2.1	**2.7 (1.3–5.4)**
Infraspinatus tendonitis	4.3	1.4	**3.1 (1.6–6.4)**	4.6	1.1	**4.0 (1.6–9.9)**
Bicipital tendonitis	5.9	2.5	**2.4 (1.4–4.1)**	3.8	1.1	**3.3 (1.3–8.5)**
Acromioclavicular syndrome	7.0	2.8	**2.5 (1.5–4.2)**	6.4	1.1	**5.5 (2.3–13)**
Frozen shoulder	0.7	0.3	2.4 (0.5–11)	0.0	0.2	0.0 (–)
Elbows-hands						
Lateral epicondylitis	3.3	1.7	1.9 (1.0–3.8)	1.5	1.5	1.0 (0.3–2.8)
Medial epicondylitis	1.6	0.5	**3.5 (1.0–12)**	2.3	0.6	**4.0 (1.1–15)**
Pronator syndrome	0.6	0.2	3.4 (0.4–29)	0.3	0.0	–
Cubital tunnel syndrome	1.0	0.0	–	0.5	0.0	–
Radial tunnel syndrome	1.2	0.3	3.4 (0.8–15)	0.3	0.2	1.3 (0.1–21)
Peritendinitis/tenosynvitis	1.0	0.5	2.2 (0.6–7.7)	0.3	0.0	–
De Quervains' disease	0.8	0.2	4.6 (0.6–37)	0.3	0.0	–
Carpal tunnel syndrome	6.1	1.8	**3.3 (1.8–6.1)**	3.8	0.0	–
Guyon's canal syndrome	0.8	0.5	1.8 (0.5–6.5)	0.5	0.0	–
Over-used hand syndrome	1.3	0.2	7.5 (1.0–57)	0.5	0.2	2.7 (0.2–29)

Data from 1762 females and 915 males[†].

*Results shown in bold are statistically significant, 95% CI exceeds 1.0.

[†]Data on elbows/hands diagnoses lacking on 146 females since the original dataset did not allow redefinition of diagnoses with the revised critera.

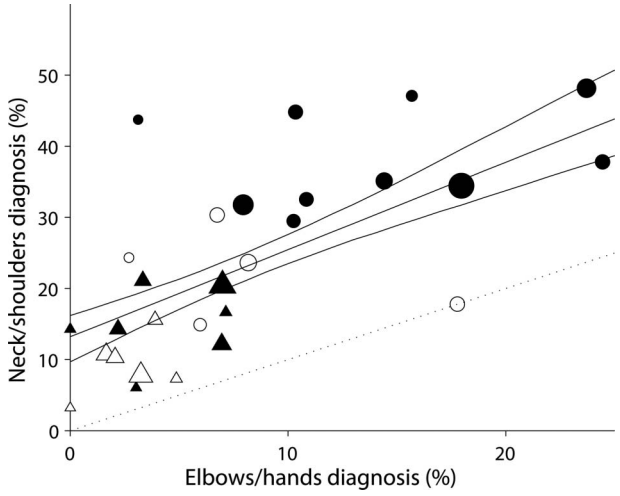

Figure 3. Prevalence of at least one neck/shoulders vs. at least one elbows/hands diagnosis, as assessed by a standardised physical examination (see Table 1 for description). The linear regression line with 95% CI was obtained by bootstrap simulation (continuous lines). Also, the line of identity (dotted line) is shown. The sizes of the symbols are proportional to the number of subjects in each group. *Varied/mobile, females (six groups); †varied/mobile, males (six groups); ‡repetitive/constrained, females (10 groups); §repetitive/constrained, males (five groups).

$p < 0.001$ and EAC was 22 (CI 13–34)% for females and $p < 0.001$, EAC 16 (CI 8.6–29)% for males, in industrial work, and $p < 0.001$, EAC 25 (CI 21–40)% for females in non-office/non-industrial work. For elbows/hands complaints, corresponding figures were $p < 0.001$, EAC 27 (CI 16–39)% for females and $p = 0.001$, EAC 16 (CI 10–30)% for males in industrial work. For females with non-office/non-industrial work, $p < 0.001$ and EAC 22 (CI 17–37)% was shown.

A similar pattern was found for diagnoses. Thus, in neck/shoulders homogeneity test yielded $p < 0.001$, EAC 5.8 (CI–0.8–20)% for females, and $p = 0.16$, EAC 4.5 (CI–2.2–20)% for males, in industrial work, and $p = 0.03$, EAC 9.8 (CI–0.1–27)% for females in non-office/non-industrial work. In elbows/hands, for females $p = 0.001$, EAC 13 (CI 4.2–21)%, for males $p = 0.02$, EAC 8.5 (CI 0.5–16)% in industrial work. Finally, for females in non-office/non-industrial work $p = 0.06$, EAC 5.5 (CI–1.0–16)%.

3.3. *Females vs. males*

In most groups that included both genders, females showed a higher prevalence of disorders (Figure 1a,b, Figure 2a,b). The mean differences between females and males were larger in repetitive/constrained than in varied/mobile work. However, the PRs for repetitive/constrained work vs. varied/mobile were for most measures as high for males as for females.

4. Discussion

Substantially increased risks of musculoskeletal disorders in the neck and upper limbs were shown for repetitive/constrained work, especially for diagnoses.

PRs for complaints assessed by the Nordic Questionnaire were in neck/shoulders only slightly above 1. In fact, as about 60% of subjects with varied/mobile work reported complaints during the last 12 months, PR above 2 for this measure was impossible. In elbows/hands, where the prevalence in the referent group was lower, PRs for complaints were higher, between 1.5 and 2.0 for females as well as males.

On the other hand, PRs for at least one diagnosis (assessed by the physical examination) were >2.0 for both genders, in neck/shoulders as well as in elbows/hands. The risks shown for at least one diagnosis were mainly explained by a few specific diagnoses, each with even higher risk estimates than the aggregated ones. The by far most common diagnosis was tension neck syndrome, which Palmer and Smedley (2007) recently concluded had a causal relationship (PR $\geq$1.7) with physical factors (repeated shoulder movements, neck flexion and static load, especially in combination), as well as with psychosocial factors (high job demands, low control over work and low social support at work). The present data emphasise this, yielding PRs considerably higher than their estimate.

High risks were also shown for shoulder tendonitis. In the present groups, this was probably not because of the well-known risk factor work above shoulder level (Svendsen *et al*. 2004), but instead due to repeated shoulder movements, earlier reported but not as well established (Frost *et al*. 2002). Further, there was an increased risk of acromioclavicular syndrome, most obvious for males, seldom focused on before (Stenlund *et al*. 1992). In the present study, PRs well above 2 were found for medial epicondylitis in both genders, in accordance with Shiri *et al*. (2006). For lateral epicondylitis the risk was elevated in females. The risk factors for these disorders are most likely the same, namely, repetitive and forceful wrist movements. Finally, in accordance with Palmer *et al*. (2007b), relative risks with PRs exceeding 2 were found for carpal tunnel syndrome (prolonged or repetitive wrist flexion or extension, especially in combination with high hand-force demands, being well known risk factors).

The PR, i.e. the relative risk, is important in judging whether or not a disorder in an exposed affected worker has been caused by a certain occupational exposure or by other causes. A reasonable approach is to make such a decision when the literature shows an attributable fraction in the exposed group of $>50\%$, i.e. when the relative risk is

above 2 (Palmer *et al*. 2007a). As discussed above, in the present study, for repetitive/constrained work, tension neck syndrome, supraspinatus-, infraspinatus- and bicipital tendonitis, acromiclavicular syndrome, medial epicondylitis and carpal tunnel syndrome all showed PRs >2 in females and in males.

Repetitive work often implies a combination of repeated motion in the hands, static loading of the neck and shoulders and low decision latitude (MacDonald *et al*. 2008). Constrained work involves prolonged awkward postures and muscular contractions and may involve high mental demands; thus, both physical and psychosocial factors may be relevant. However, in the present material complaints and diagnoses were generally more frequent in the right than in the left arm, which suggests physical workload as the main causal factor (Shiri *et al*. 2007).

Groups with a high risk of elbow/hand disorders also had an increased risk of neck/shoulder ones. Hence, actions to prevent elbow/hand disorders may also protect the neck/shoulders.

The risk of repetitive/constrained work was not only shown for industrial work, it was almost as high for office and non-office/non-industrial settings. Further, there was heterogeneity in disorder prevalence between groups within the different occupational settings with repetitive/constrained work. Hence for some of the groups, the PRs were much higher than the average. It is likely that these heterogeneities are explained by underlying large differences concerning physical and/or psychosocial risk factors among the different groups in the same setting (Andersen *et al*. 2002). Hence, for some of the groups, the PRs were much higher than the average.

As in most studies, musculoskeletal disorders were more prevalent among females than among males (Roquelaure *et al*. 2006), even within the same workplace. Interestingly, though, the PRs for repetitive/constrained work vs. varied/mobile were for most measures approximately the same for both genders.

4.1. Limitations

Since the present analysis is based on cross-sectional studies, one cannot draw firm conclusions on causality. It is possible that subjects with musculoskeletal disorders in the neck/upper extremity more often than others choose employments characterised by repetitive/constrained work. However, this is considered to be highly unlikely. Instead, there is a risk of a healthy worker selection, i.e. affected workers leaving work, which would falsely reduce the risk estimates (Ohlsson *et al*. 1989, 1994b, Nordander *et al*. 1999, 2008, Hansson *et al*. 2000a).

The response rate was generally high (except for a few groups with questionnaire data only); thus, any selection bias should be of minor importance.

The employment time varied among the groups and subjects with short employment time may not yet have developed disorders. For example, two groups (group 21, spot welding and 23, mink fur sorting) with highly repetitive work had low employment times and low prevalences of disorders. In addition, the latter group only had seasonal work (about 6 months per year). Therefore, the EAC might be too large.

Since the data collection occurred over several years, working conditions have changed for many occupations. The categorisation into repetitive/constrained and varied/mobile is, however, still valid.

The physical examinations were made by a few examiners individually, but in very close cooperation. Since the interviews and physical examinations were performed in the workplaces, it was not possible to blind the examiners to the exposure. Due to the high degree of standardisation of the method, it is, however, unlikely that this has influenced the results in any significant way.

The prevalence of musculoskeletal disorders in the general population increases with age (Roquelaure *et al*. 2006). Subjects in repetitive/constrained work were, on average, younger than those in varied/mobile work. Hence, confounding by age could not explain the excess risk for the former.

In some studies, smoking has been reported to predict neck/shoulder problems with odds ratios between 1.1 and 1.8 (Viikari-Juntura *et al*. 2001, Feveile *et al*. 2002, Palmer and Smedley 2007). Unfortunately, for most groups, data on smoking were not at hand, but it is plausible that smoking was more common among workers with repetitive/constrained work tasks than among those with varied/mobile such. Indeed, 52% of the female fish-processing workers, but only 26% of the female referents in that study, were smokers (Nordander *et al*. 1999). Among the male workers in the same study, there was no difference in smoking habits. However, in that study, adjusting for smoking in a multivariate analysis did not affect the prevalence odds ratios (PORs) for fish-processing workers vs. referents as concerns musculoskeletal disorders.

For females in the present study, calculations were performed under the assumption that there was a large difference in smoking habits between the categories. If 50% of the females with repetitive/constrained work were smokers but only 25% of those with varied mobile, and if the true PR for smoking is as high as 1.5, the expected smoking-adjusted PR for at least one diagnosis in neck/shoulders would be reduced from 2.3 to 2.0.

An increased risk of musculoskeletal disorders has also been shown for a high BMI (relative risk 1.3 for subjects with BMI above 29) (Viikari-Juntura *et al*.

2001). The material does not include data on BMI, but even if there was a systematic difference between the groups concerning this condition, the influence on the reported PRs can only be minor, in accordance with smoking.

The present criteria for diagnoses are very close to those suggested by others (Palmer *et al*. 2000, Sluiter *et al*. 2001). However, diagnoses were included for two regional pain syndromes, tension neck syndrome and overused hand syndrome. In fact, tension neck syndrome was by far the most common diagnosis both in repetitive/constrained and in varied/mobile work. Several authors have argued that the signs and symptoms defining this diagnosis are non-specific, thus excluding it from examination schedules (Palmer *et al*. 2000, Sluiter *et al*. 2001). However, with the present strict criteria (Waris *et al*. 1979), the PR for repetitive/constrained work was about three-fold, affecting as many as one-fourth of the females in such work. Tension neck syndrome is a common reason for suffering, change of work, long-term sick leave or disability pensioning and is therefore of great importance.

4.2. Conclusion

Repetitive/constrained work showed elevated risks when compared to varied/mobile work in all settings. Females and males showed similar risk elevations. Diagnoses set at the physical examination yielded much higher risk estimates than those attained by the Nordic Questionnaire, with PRs above 2 for several defined diagnoses.

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References

Åkesson, I., *et al*., 1997. Quantifying work load in neck, shoulders and wrists in female dentists. *International Archives of Occupational and Environmental Health*, 69 (6), 461–474.

Åkesson, I., *et al*., 1999. Musculoskeletal disorders among female dental personnel—clinical examination and a 5-year follow-up study of symptoms. *International Archives of Occupational and Environmental Health*, 72 (6), 395–403.

Åkesson, I., *et al*., 2000. Musculoskeletal symptoms among dental personnel; – lack of association with mercury and selenium status, overweight and smoking. *Swedish Dental Journal*, 24 (1–2), 23–38.

Andersen, J.H., Haahr, J.P., and Frost, P., 2007. Risk factors for more severe regional musculoskeletal symptoms: a two-year prospective study of a general working population. *Arthritis and Rheumatism*, 56 (4), 1355–1364.

Andersen, J.H., *et al*., 2002. Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. *Spine*, 27 (6), 660–667.

Arvidsson, I., *et al*., 2006. Musculoskeletal disorders among female and male air traffic controllers performing identical and demanding computer work. *Ergonomics*, 49 (11), 1052–1067.

Balogh, I., *et al*., 1999. Interindividual variation of physical load in a work task. *Scandinavian Journal of Work Environment and Health*, 25 (1), 57–66.

Balogh, I., *et al*., 2004. Self-assessed and directly measured occupational physical activities – influence of musculoskeletal complaints, age and gender. *Applied Ergonomics*, 35 (1), 49–56.

Balogh, I., *et al*., 2006. Increasing the degree of automation in a production system: Consequences for the physical workload. *International Journal of Industrial Ergonomics*, 36 (4), 353–365.

Bernard, B.P., 1997. *Musculoskeletal disorders and workplace factors. A critical review of epidemiological evidence for work-related musculoskeletal disorders of the neck, upper extremity and low back*. Cincinnati, OH: National Institute of Occupational Safety and Health.

Buckle, P.W. and Devereux, J.J., 2002. The nature of work-related neck and upper limb musculoskeletal disorders. *Applied Ergonomics*, 33 (3), 207–217.

Byström, P., Hanse, J.J., and Kjellberg, A., 2004. Appraised psychological workload, musculoskeletal symptoms, and the mediating effect of fatigue: a structural equation modeling approach. *Scandinavian Journal of Psychology*, 45 (4), 331–341.

Chung, M.K., Lee, I., and Kee, D., 2005. Quantitative postural load assessment for whole body manual tasks based on perceived discomfort. *Ergonomics*, 48 (5), 492–505.

Descatha, A., *et al*., 2007. Validity of Nordic-style questionnaires in the surveillance of upper-limb work-related musculoskeletal disorders. *Scandinavian Journal of Work Environment and Health*, 33 (1), 58–65.

Efron, B. and Tibshirani, R., 1993. *An introduction to the bootstrap*. New York: Chapman & Hall.

Feveile, H., Jensen, C., and Burr, H., 2002. Risk factors for neck-shoulder and wrist-hand symptoms in a 5-year follow-up study of 3,990 employees in Denmark. *International Archives of Occupational and Environmental Health*, 75 (4), 243–251.

Frost, P., *et al*., 2002. Risk of shoulder tendonitis in relation to shoulder loads in monotonous repetitive work. *American Journal of Industrial Medicine*, 41 (1), 11–18.

Gamperiene, M., *et al*., 2003. Duration of employment is not a predictor of disability of cleaners: a longitudinal study. *Scandinavian Journal of Public Health*, 31 (1), 63–68.

Garde, A.H., *et al*., 2003. The influence of production systems on physiological responses measured in urine and saliva. *Stress and Health*, 19 (5), 297–306.
Hansson, G.-Å. and Mikkelsen, S., 1997. Kinematic evaluation of occupational work. *Advances in Occupational Medicine and Rehabilitation*, 3, 57–69.
Hansson, G.-Å., *et al*., 2000a. Impact of physical exposure on neck and upper limb disorders in female workers. *Applied Ergonomics*, 31 (3), 301–310.
Hansson, G.-Å., *et al*., 2000b. Sensitivity of trapezius electromyography to differences between work tasks – influence of gap definition and normalisation methods. *Journal of Electromyography and Kinesiology*, 10 (2), 103–115.
Hansson, G.-Å., *et al*., 2001. Questionnaire vs. direct technical measurements in assessing postures and movements of the head, upper back, arms and hands. *Scandinavian Journal of Work Environment and Health*, 27 (1), 30–40.
Juul-Kristensen, B., *et al*., 2001. Assessment of work postures and movements using a video-based observation method and direct technical measurements. *Applied Ergonomics*, 32 (5), 517–524.
Juul-Kristensen, B., *et al*., 2002. Physical workload during manual and mechanical deboning of poultry. *International Journal of Industrial Ergonomics*, 29 (2), 107–115.
Kuorinka, I., *et al*., 1987. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics*, 18 (3), 233–237.
Leino, T., *et al*., 1999. Health reasons for leaving the profession as determined among Finnish hairdressers in 1980–1995. *International Archives of Occupational and Environmental Health*, 72 (1), 56–59.
MacDonald, L., *et al*., 2008. Incorporating work organisation into occupational health research: an invitation for dialogue. *Occupational and Environmental Medicine*, 65 (1), 1–3.
Melhorn, J.M. and Gardner, P., 2004. How we prevent prevention of musculoskeletal disorders in the workplace. *Clinical Orthopaedics and Related Research*, 419, 285–296.
Nordander, C., 2004. *Work-related musculoskeletal disorders – exposure assessment and gender aspects*. Thesis (PhD). Lund University.
Nordander, C., *et al*., 1999. Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. *Occupational and Environmental Medicine*, 56 (4), 256–264.
Nordander, C., *et al*., 2000. Muscular rest and gap frequency as EMG measures of physical exposure: the impact of work tasks and individual related factors. *Ergonomics*, 43 (11), 1904–1919.
Nordander, C., *et al*., 2008. Gender differences in workers with identical repetitive industrial tasks: exposure and musculoskeletal disorders. *International Archives of Occupational and Environmental Health*, 81 (8), 939–947.
Norlund, A., *et al*., 2000. Economic consequences of occupational disorders in women with repetitive industrial work. *The European Journal of Public Health*, 10, 127–132.
National Research Council, 2001. *Musculoskeletal disorders in the workplace: Low back and upper extremities*. Panel on Musculoskeletal Disorders in the Workplace. Commission on Behavioral and Social Sciences and Education. Washington, DC: National Academy Press.
Ohlsson, K., Attewell, R., and Skerfving, S., 1989. Self-reported symptoms in the neck and upper limbs of female assembly workers. Impact of length of employment, work pace, and selection. *Scandinavian Journal of Work Environment and Health*, 15 (1), 75–80.
Ohlsson, K., *et al*., 1988. Selenium status in females with occupational cervico-brachial complaints. *International Archives of Occupational and Environmental Health*, 61 (3), 167–169.
Ohlsson, K., *et al*., 1994a. An assessment of neck and upper extremity disorders by questionnaire and clinical examination. *Ergonomics*, 37 (5), 891–897.
Ohlsson, K., *et al*., 1994b. Disorders of the neck and upper limbs in women in the fish processing industry. *Occupational and Environmental Medicine*, 51 (12), 826–832.
Ohlsson, K., *et al*., 1995. Repetitive industrial work and neck and upper limb disorders in females. *American Journal of Industrial Medicine*, 27 (5), 731–747.
Östergren, P.O., *et al*., 2005. Incidence of shoulder and neck pain in a working population – effect modification between mechanical and psychosocial exposures at work. *Journal of Epidemiology and Community Health*, 59 (9), 721–728.
Palmer, K.T. and Smedley, J., 2007. Work relatedness of chronic neck pain with physical findings – a systematic review. *Scandinavian Journal of Work Environment and Health*, 33 (3), 165–191.
Palmer, K., *et al*., 2000. The Southampton examination schedule for the diagnosis of musculoskeletal disorders of the neck and upper limb. *Annals of the Rheumatic Diseases*, 59, 5–11.
Palmer, K.T., Harris, E.C., and Coggon, D., 2007a. Compensating occupationally related tenosynovitis and epicondylitis: a literature review. *Occupational Medicine (London)*, 57 (1), 67–74.
Palmer, K.T., Harris, E.C., and Coggon, D., 2007b. Carpal tunnel syndrome and its relation to occupation: a systematic literature review. *Occupational Medicine (London)*, 57 (1), 57–66.
Persson, R., *et al*., 2003. The influence of production systems on self-reported arousal, sleepiness, physical exertion and fatigue – consequences of increasing mechanization. *Stress and Health*, 19 (3), 163–171.
Pålsson, B., *et al*., 1997. Sick-leave and disability pensions among female assembly workers. *European Journal of Public Health*, 7 (2), 162–168.
Roquelaure, Y., *et al*., 2006. Epidemiologic surveillance of upper-extremity musculoskeletal disorders in the working population. *Arthritis and Rheumatism*, 55 (5), 765–778.
Shiri, R., *et al*., 2006. Prevalence and determinants of lateral and medial epicondylitis: a population study. *American Journal of Epidemiology*, 164 (11), 1065–1074.
Shiri, R., *et al*., 2007. Hand dominance in upper extremity musculoskeletal disorders. *The Journal of Rheumatology*, 34 (5), 1076–1082.
Silverstein, B.A., Fine, L.J., and Armstrong, T.J., 1986. Hand wrist cumulative trauma disorders in industry. *British Journal of Industrial Medicine*, 43 (11), 779–784.
Sluiter, J.K., Rest, K.M., and Frings-Dresen, M.H., 2001. Criteria document for evaluating the work-related disorders. *Scandinavian Journal of Work Environment and Health*, 27 (Suppl. 1), 1–102.

Stål, M. and Hansson, G.-Å., 1999. Wrist positions and movements as possible risk factors during machine milking. *Applied Ergonomics*, 30 (6), 527–534.

Stål, M., Hansson, G.-Å., and Moritz, U., 2000. Upper extremity muscular load during machine milking. *International Journal of Industrial Ergonomics*, 26 (1), 9–17.

Stål, M., *et al*., 1996. Milking is a high-risk job for young females. *Scandinavian Journal of Rehabilitation Medicine*, 28 (2), 95–104.

Stenlund, B., *et al*., 1992. Radiographic osteoarthrosis in the acromioclavicular joint resulting from manual work or exposure to vibration. *British Journal of Industrial Medicine*, 49 (8), 588–593.

Svendsen, S.W., *et al*., 2004. Work above shoulder level and degenerative alterations of the rotator cuff tendons: a magnetic resonance imaging study. *Arthritis and Rheumatism*, 50 (10), 3314–3322.

Treaster, D.E. and Burr, D., 2004. Gender differences in prevalence of upper extremity musculoskeletal disorders. *Ergonomics*, (47), 495–526.

Unge, J., *et al*., 2007. Differences in physical workload, psychosocial factors and musculoskeletal disorders between two groups of female hospital cleaners with two diverse organizational models. *International Archives of Occupational and Environmental Health*, 81 (2), 209–220.

Wahlström, J., 2005. Ergonomics, musculoskeletal disorders and computer work. *Occupational Medicine (London)*, 55 (3), 168–176.

Walker-Bone, K. and Cooper, C., 2005. Hard work never hurt anyone: or did it? A review of occupational associations with soft tissue musculoskeletal disorders of the neck and upper limb. *Annals of the Rheumatic Diseases*, 64 (10), 1391–1396.

Waris, P., *et al*., 1979. Epidemiologic screening of occupational neck and upper limb disorders. Methods and criteria. *Scandinavian Journal of Work Environment and Health*, 5 (Suppl. 3), 25–38.

Veiersted, K.B., *et al*., 2008. Effect of an intervention addressing working technique on the biomechanical load of the neck and shoulders among hairdressers. *Applied Ergonomics*, 39 (2), 183–190.

Viikari-Juntura, E., *et al*., 2001. Longitudinal study on work related and individual risk factors affecting radiating neck pain. *Occupational and Environmental Medicine*, 58 (5), 345–352.