

REVIEW

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Review of the factors associated with musculoskeletal problems in epidemiological studies

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Abstract Objectives: To review systematically all epidemiological studies of the past 15 years concerning the factors associated with musculoskeletal disorders (MSDs) or complaints of the neck and upper limbs. **Methods:** Fifty-seven cross-sectional and seven longitudinal studies were reviewed. A list was made of all personal, occupational, extra-occupational and psycho-organisational factors taken into consideration in each study, and of those that were found in association with MSDs. MSDs of the neck-shoulder region (NSs) and hand-wrist (HWs) were considered separately. About 70 different factors are listed. **Results:** This inventory identifies the factors or categories of factors that were generally taken into consideration. It makes it possible also to evaluate the strength of the association with a given factor, in considering the number of studies finding an association, and those that did not consider this factor. Based on this review, some factors taken into consideration (such as weight or hobbies) could be excluded in further studies, and replaced by more specific psycho-organisational factors.

Key words Upper limb disorders · Risk factor · Review

Introduction

The first field studies concerning the association between musculoskeletal disorders (MSDs) and risk factors took into consideration mainly the occupational factors and some confounding factors or “co-factors” such as age, seniority, gender, sports, smoking habits, etc. The role

played by efforts, repetitiveness, and postures are now well-known, and the majority of the authors agree that these are the biomechanical risk factors to take into account for prevention at the workplace.

Approximately 10 years ago, researchers started looking also at some psycho-organisational and stress factors, and, in some cases, the psychological characteristics of the workers (mainly personality and behaviour).

Hagberg et al. (1995) defined the psycho-organisational factors as “the worker’s subjective perceptions of organisational factors, which in turn are the objective aspects of how the work is organised, supervised and carried out”. Stress would occur when the person is not able to cope with the work demands (Bongers et al. 1993) and may lead to adverse health effects (hypertension, sleep disorders, gastrointestinal problems), and to the development and/or the persistence of MSDs (Sauter and Swanson 1996; Smith and Carayon 1996).

In a large review of the literature, Bongers et al. (1993) reviewed the psycho-organisational and personality factors associated with MSDs of the back and the neck. These authors concluded that monotonous work, a high workload, time pressures, lack of control and social support were associated with MSDs. In the recent review on the musculoskeletal disorders of the back and the upper limbs, Bernard (1997) reached similar conclusions.

To our knowledge, such a review was never made specifically concerning hand and wrist disorders.

The present article ambitions to review all the factors considered in the literature in studies of associations with MSDs of the neck and shoulders [that will be noted neck-shoulder region (NSs)] or of the hands and wrists [designated by hand-wrist (HWs)]. While most of the review studies focus on a single category of factors, the paper will consider all individual, psycho-organisational, personal, occupational and extra-occupational factors. The review will present, on the one hand, the inventory of the factors studied by the different authors and, on the other hand, the inventory of the factors that were shown to be statistically associated with the NSs or HWs in these studies.

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Methodology

An extensive review of the literature was performed to identify the studies carried out in the field with the participation of active workers and searching an association between musculoskeletal disorders of occupational origin and some risk factors, whatever their origin (occupational, psycho-organisational, personal). Articles of review, epidemiological studies on the general population, and laboratory researches were not included. A bibliographical research was performed on the major international databases. The majority of the selected studies were found in international publications primarily in ergonomics, and mostly in English.

The review was orientated towards the cervicobrachial region and the hand and wrist region. Papers dealing with MSDs of the upper limbs as a whole were not retained, so that we were able to differentiate between these two regions.

Studies orientated towards the neck and/or shoulders were considered together, as few studies actually dealt separately with the two zones. It is to be noted also that the majority of the field studies were conducted using questionnaires filled in by the workers who had problems distinguishing between the neck and shoulders.

The musculoskeletal disorders of the HWs were also considered together, as was done in most studies.

No distinction was attempted between the studies based on complaints expressed by the workers and those based on clinical examinations: the number of studies of the two types will however be discussed.

Potential risk factors were grouped into four categories:

- Occupational risk factors
- Medical history
- Personal factors: age, weight, personality and extra-occupational activities
- Psycho-organisational factors linked to the work and human support and stress symptoms

Each category included several factors. We will only report the factors considered in more than one study, except when significantly associated with MSDs, and will discuss particularly the factors found statistically associated with MSDs in more than 50% of these studies.

Publications using "global indices" for the psycho-organisational factors, stress or personal factors were disregarded.

Since questionnaires and terminologies were not standardised, grouping and interpretation had to be made for some factors.

The results are presented in the form of tables giving the references of the studies, which took into consideration a given factor, as well as, among those, the references of the studies reporting an association with MSDs.

For studies including both univariate and multivariate statistical analyses, preference was given to the results of the multivariate analysis.

Results

Generalities

Fifty-seven cross-sectional and seven longitudinal studies met the criteria described above. The majority (44) concerned a mixed population; 16 were specifically designed for women and four for men. Fifty-one studies concerned more than 100 subjects and 11 more than 1,000 workers. Thirty considered only blue-collar workers and 17 white-collar workers.

Twenty-five were concerned with the cervicobrachial region, 18 with the hand/wrist region and 21 with both.

The occurrence of MSDs was assessed either through clinical examination (40%), interviews (20%), or self-administered questionnaires (40%).

Some researches dealt with specific factors (such as stress) or a specific type of risk factors (occupational factors, psycho-organisational factors). The numbers of factors considered varied from 1 to 19. The statistical analyses were essentially multivariate (73%).

Most of the selected studies dated from the 1990s, with some remarkable exceptions (Silverstein et al. 1986, 1987).

For reason of simplicity and readability, we will use hereunder the code "n/N" to designate the fact that "N" studies considered a given factor and "n" of them found a significant association.

Occupational factors

Occupational factors are listed in Table 1.

Musculoskeletal disorders of the neck-shoulder region

The factors most frequently studied are seniority at the workplace, physical workload or force, awkward postures and repetitiveness. In view of the results, these factors appear to be associated with NSs in the majority of the studies. However, the percentage of studies having found a significant relationship does not generally exceed 50%.

Three factors are statistically significant in more than 50% of the studies that took them into consideration: repetitiveness (8/11), static efforts (4/8) and workload in the previous job (4/4). This last factor, however, was investigated in four studies only. Clearly, the association with vibration is not established (1/5).

Only five prospective studies considered the cervicobrachial region (Kilbom and Persson 1987; Jonsson et al. 1988; Takala et al. 1991; Leino and Magni 1993; Fredrikson et al. 1999). In the first two, the association between NSs and static efforts was significant, and the other associated factors were awkward postures (Kilbom and Persson 1987) and the number of cycles per hour (Jonsson et al. 1988).

Musculoskeletal disorders of the hand-wrist

The factors studied most frequently are again seniority, physical workload, awkward postures and repetitiveness, this last factor being this time more systematically considered. Only repetitiveness (10/16) and physical workload (10/18) were found associated significantly in more than 50% of the studies. The type of grip was found an associated factor in few studies (2/5). The number of working hours was associated with HWs in 50% (4/8) of these studies.

Table 1 Occupational factors (numbers refer to the reference list)

Factors	Neck and shoulders		Wrists and hands	
	Studied	Associated	Studied	Associated
Seniority	[1, 6, 10, 13, 16, 22, 26, 29, 30, 31, 34, 35, 36, 37, 39, 51, 52, 53, 55, 59, 66, 73]	[1, 6, 26, 30, 37, 39, 51, 53, 73]	[1, 6, 10, 13, 14, 16, 24, 27, 31, 32, 34, 35, 44, 48, 49, 51, 55, 56, 59, 60, 61, 72, 73]	[14, 32, 49, 51, 59, 73]
Number of hours	[16, 22, 34, 35, 36, 37, 39, 52, 62]	[34]	[16, 24, 32, 34, 35, 47, 49, 50]	[32, 34, 49, 50]
Physical workload	[10, 13, 15, 16, 17, 18, 20, 25, 26, 34, 35, 39, 59, 62, 69]	[15, 16, 26, 35, 59, 69]	[5, 10, 13, 15, 16, 19, 20, 24, 25, 34, 35, 47, 48, 56, 59, 60, 61, 64]	[10, 13, 15, 20, 24, 25, 56, 59, 60, 61]
Awkward postures	[3, 13, 17, 18, 20, 22, 26, 33, 34, 35, 40, 52, 53, 54, 66, 70]	[17, 26, 33, 40, 52, 66, 70]	[13, 19, 20, 24, 27, 32, 33, 34, 35, 44, 47, 56, 61, 64]	[19, 24, 32, 35]
Repetitiveness	[3, 10, 15, 17, 18, 19, 26, 35, 52, 53, 54]	[3, 15, 17, 18, 26, 52, 53, 54]	[2, 10, 14, 15, 19, 24, 27, 32, 35, 43, 44, 48, 56, 59, 61, 64]	[2, 10, 19, 24, 32, 35, 43, 56, 59, 61]
Static efforts	[7, 18, 19, 20, 36, 38, 39, 40]	[7, 36, 39, 40]	[13, 20, 35]	[35]
Vibration	[10, 16, 25, 54, 70]	[16]	[10, 14, 16, 25, 44, 56, 61]	[10, 14]
Grip type	[19]		[19, 24, 32, 33, 61]	[19, 33]
Precision	[18]	[18]	[24, 35]	[24]
Overtime hours	[3, 25, 31, 36, 39]		[25, 31]	
Task rotation	[19, 31, 36, 39, 52]		[31]	
Number of cycles/hour	[7, 36, 39, 40]	[36]	[44]	
Rate of movement	[7, 36, 39, 40, 52]	[40]		
Number of breaks	[3, 6, 22, 30, 31, 36, 39, 40, 59]	[30]	[6, 31, 56, 59]	[56]
Heavy physical load at previous jobs	[10, 13, 36, 40]	[10, 13, 36, 40]	[10, 13, 56]	

Vibration was considered as a secondary risk factor in many researches orientated towards MSDs: the authors rarely quantify it and simply record the use or not of vibrating tools. A positive association was found in 2/7, but no conclusion can be drawn, as postures and efforts are usually strongly correlated with vibration, and the vibration association or lack of association might therefore translate another relationship.

Medical history

Details of medical history are displayed in Table 2.

Musculoskeletal disorders of the neck-shoulder region

The association was systematic (3/5) for only one factor – the general health. The other factors do not appear to be relevant.

None of the factors linked to the medical history were significantly in association in the two prospective studies (Jonsson et al. 1988; Kilbom and Persson 1987).

Musculoskeletal disorders of the hand-wrist

Many studies considered the medical history and in particular the occurrence of chronic diseases, hormonal

disturbances and upper limb accidents. None of these parameters appeared to be associated with HWs in more than 50% of the studies.

Personal factors

Personal factors are shown in Table 2.

Musculoskeletal disorders of the neck-shoulder region

The factors in this category can be subdivided in three types:

- Individual characteristics such as age, weight, height, gender, smoking habits. . .
- Extra-occupational factors, such as sports practice, spare time activities. . .
- Personality

In the first category, only gender appeared associated with NSs (more frequently for women) in more than 50% (10/19) of the studies. It is remarkable to notice that weight, height and smoking habits, conventionally investigated, were almost never found associated with NSs. Age was found an associated factor in 40% (14/36) of the studies only.

The maximum voluntary force was associated positively in 2/7 and negatively in 1/7.

Table 2 Personal factors and medical history

Factors	Neck and shoulders		Wrists and hands	
	Studied	Associated	Studied	Associated
Individual characteristics				
Age	[1, 3, 6, 7, 10, 13, 15, 16, 17, 18, 19, 22, 23, 26, 29, 30, 31, 33, 34, 35, 36, 37, 39, 42, 45, 52, 53, 54, 55, 59, 62, 65, 66, 70, 71, 73]	[3, 10, 16, 29, 33, 37, 42, 45, 52, 53, 54, 55, 65, 66]	[1, 2, 6, 10, 13, 14, 15, 16, 19, 27, 31, 32, 33, 34, 35, 42, 43, 44, 47, 48, 49, 50, 55, 56, 59, 60, 61, 64, 72, 73]	[19, 27, 42, 43, 47, 49, 50, 55]
Height	[6, 7, 10, 13, 16, 19, 22, 30, 35, 39, 62, 69, 70, 71, 73]	[16, 30, 39, 71]	[6, 10, 13, 16, 19, 24, 35, 48, 56, 64, 72, 73]	[10, 16, 19, 24]
Weight	[7, 10, 13, 16, 19, 22, 30, 35, 62, 69, 70, 71, 73]	[16, 71]	[10, 13, 14, 16, 19, 24, 35, 44, 48, 56, 64, 72, 73]	[16, 19, 24, 44]
Gender	[3, 6, 10, 15, 16, 17, 18, 19, 22, 26, 29, 31, 34, 35, 54, 59, 62, 68, 73]	[3, 6, 10, 16, 17, 18, 34, 62, 68, 73]	[2, 6, 10, 14, 15, 16, 19, 27, 31, 34, 35, 38, 43, 44, 47, 48, 56, 59, 60, 61, 64, 72, 73]	[6, 15, 19, 34, 35, 43, 48, 60, 72]
Dominant hand			[19, 24, 56]	
Driving distance	[19, 62, 66]	[62]	[19]	
Smoking	[1, 3, 10, 16, 17, 18, 26, 33, 42, 53, 59, 62, 65, 50, 73]	[17, 62, 73]	[1, 10, 16, 27, 33, 42, 43, 48, 56, 59, 72, 73]	[72]
Alcohol	[54, 69]		[48, 55, 56]	
Education	[29, 66]	[66]	[43]	
Number of children	[1, 17, 18]	[1, 56]	[56]	
Maximum voluntary force	[7, 36, 39, 40, 69, 70, 73]	[7, 36, 73]	[33, 40, 72, 73]	[73]
Extra-occupational factors				
Hobbies	[1, 10, 16, 19, 31, 33, 36, 39, 40, 59, 65]	[59]	[1, 10, 16, 19, 31, 32, 33, 48, 56, 59, 60, 61, 64]	[10]
Physical exertion	[16, 17, 18, 36, 39, 40, 65, 66, 69, 71]	[17, 36]	[16, 24, 47, 56]	[24, 47]
Sport	[10, 19, 62]		[10, 19, 48, 64]	[48]
Sport (upper limb)	[16]	[16]	[16, 48]	[16, 48]
Medical history				
General health status	[6, 10, 33, 42, 66]	[10, 33, 42]	[10, 33, 42, 48]	[48]
Number of medical visits	[10, 54, 71]	[54]	[10, 48, 50]	
Previous medical history	[10, 39, 40]		[10, 32, 43, 50, 55, 60, 61]	[43]
Medication			[49, 50]	[50]
Chronic diseases	[1, 10, 31, 33, 59]		[1, 2, 10, 14, 27, 31, 33, 43, 48, 55, 59, 60, 61]	[2, 27, 31, 48]
Hormonal factors	[55]		[2, 14, 15, 43, 49, 50, 55, 56, 60, 61]	[14, 15, 55]
Previous upper limb accidents	[26, 55]		[19, 27, 43, 48, 49, 50, 55, 60, 61]	[27, 48]
Heart rate	[36, 39, 40]			
Personality				
Type A	[9, 23, 30, 57, 69]	[9, 23, 57]	[24]	[24]
Neurotic	[3, 9, 69]	[3, 9]	[38]	
Extravert	[9, 69]			

Among the extra-occupational factors, the practising of some hobbies and physical activities was often considered, but none of these factors appear systematically associated with NSs.

Finally, three personality factors were investigated: type A behaviour, associated with NSs in 3/5 studies, neuroticism in 2/3 and extraversion in 0/2. These personal characteristics were investigated in four prospective studies. Age was associated in 2/3.

Musculoskeletal disorders of the hand-wrist

The most frequently studied factors were the same but none appeared associated with the HWs in more than 50% of the studies. It must be noted that very few studies took into consideration the personality of the workers. The main information concerns age (8/30) and gender (9/23).

Psycho-organisational factors

These factors are displayed in Table 3.

Musculoskeletal disorders of the neck-shoulder region

The work-related psycho-organisational factors most frequently considered are: the mental requirements (considered by the different authors as mental load, psychological demand, vigilance, information treatment), the lack of control of the job, the lack of responsibility, a low work content (without challenge, repetitive, without new learning) and, finally, job dissatisfaction. Only the first factor was found associated with NSs in approximately 50% (9/16) of the studies. Factors less frequently considered, such as monotony, high work rate, high time pressure and absenteeism were also found associated in more than 50% of the studies.

Other psycho-organisational factors, such as role ambiguity, individual productivity or high concentration, were considered in very few researches, but they suggest that a relationship might exist.

Factors linked to human support were often considered, but were not found systematically correlated with NSs.

Stress was considered in three different ways:

- Perceived stress, that is, the degree of stress felt by the subject
- Mental stress, that is, sensation of anxiety, nervousness or depressive feelings
- Psychosomatic symptoms, such as headaches, gastrointestinal problems and sleeping problems

Among these factors, the perceived stress (4/9), the mental stress (5/6), the sensation of fatigue (3/4) and dizziness (2/3) showed a significant association with NSs.

Among the five prospective studies, two found an association with individual productivity and absenteeism (Jonsson et al. 1988; Kilbom and Persson 1987), one with dissatisfaction (Jonsson et al. 1988) and one with time pressure (Takala et al. 1991). Stress was investigated in the five studies and appeared generally (3/5) associated with NSs. Depression was also a relevant factor in the 10-year research by Leino and Magni (1993).

Musculoskeletal disorders of the hand-wrist

Fewer studies considered the influence of psycho-organisational factors on HWs. These factors were essentially mental requirements, lack of responsibilities, dissatisfaction, and relations with colleagues and supervisors. The most systematic association was found with the first factor (5/13).

Very few researchers have investigated the association between HWs and stress factors, and no conclusion can be drawn.

Discussion

The discussion includes two sections: the first one about the type of papers that were considered and how this may affect the conclusions, the second one specifically about the risk factors and co-factors.

Influence of the type of studies taken into consideration

The researches reviewed in this paper were conducted in industry on people still at work and concomitantly exposed to all factors and co-factors (stress, psycho-organisational factors). For most of them, it can be suspected that the most sensitive workers, who had developed pains or disorders, had left these workplaces. The “healthy worker effect”, therefore, definitely plays a role.

This review includes researches conducted in industry and in services, on blue- and white-collar workers. Of these studies, 19/64 considered mixed populations without differentiating between the two types of environments. The comparison between the two would require reducing the number of studies. This will not be done here.

The review includes only seven longitudinal studies among which five concerned the cervicobrachial region. The fact that the majority of the studies are cross-sectional implies that the associations found can be incidental. However, the strength of the association and the possibility of the cause-response relationship will be improved if several studies arrive at the same conclusions.

A statistical meta-analysis is traditionally recommended to synthesise several studies. It is difficult to conduct in this case, as the type and number of parameters and the methods used are strongly divergent.

Table 3 Psycho-organisational factors

Factors	Neck and shoulders		Wrists and hands	
	Studied	Associated	Studied	Associated
Job-related factors				
Mental requirements	[10, 16, 18, 20, 25, 29, 31, 33, 34, 35, 37, 42, 46, 59, 62, 67]	[10, 16, 20, 29, 31, 35, 42, 62, 67]	[5, 10, 16, 20, 25, 31, 33, 34, 35, 38, 42, 59, 67]	[10, 16, 31, 35, 38]
Lack of responsibilities	[3, 6, 20, 29, 31, 33, 35, 53, 54, 59, 67]	[6, 31, 33]	[6, 20, 31, 33, 35, 38, 59, 67]	[59]
Job control	[6, 18, 30, 31, 34, 37, 42, 46, 53, 62, 69]	[37, 42, 46, 62, 69]	[5, 6, 31, 34, 42, 44]	[44]
Role ambiguity	[17, 18, 62]	[17, 18]	[38]	
Low work content	[17, 18, 31, 34, 37, 42, 46, 53]	[17, 18, 46]	[31, 34, 42]	[42]
Monotony	[3, 10, 25, 30, 31, 37, 54, 62]	[10, 30, 54, 62]	[5, 10, 25, 31]	[5, 10]
High work rate	[6, 17, 18, 51]	[6, 17, 18, 51]	[6, 51]	[6]
Job security	[6, 17, 18, 31, 62]	[31, 62]	[5, 6, 31]	
Time pressure	[3, 6, 31, 65]	[6, 31, 65]	[6, 31]	[6]
Concentration	[10, 17]	[17]	[10]	[10]
Work dissatisfaction	[10, 30, 33, 36, 39, 59, 66, 69, 73]	[30, 36, 66, 73]	[5, 10, 24, 33, 38, 44, 59, 72, 73]	[38]
Productivity	[36, 39, 40]	[36, 40]		
Absenteeism	[7, 36, 40, 71]	[7, 36, 40]	[14, 24]	
Human-related factors				
Lack of social support	[13, 20, 25, 31, 33, 37, 46, 53, 67, 69]	[67]	[5, 13, 20, 25, 31, 33, 43, 67]	[5, 67]
Lack of colleagues' support	[3, 6, 30, 31, 33, 34, 35, 36, 37, 46, 53, 62, 70, 73]	[37, 46, 70, 73]	[5, 6, 24, 31, 33, 34, 35, 38, 73]	[5]
Lack of supervisory support	[6, 30, 31, 33, 34, 35, 37, 42, 59, 62, 70, 73]	[42, 73]	[5, 6, 31, 33, 34, 35, 38, 42, 59, 73]	[5, 6]
Conflicts	[6, 62]		[6]	
Social climate	[17, 18]			
Stress symptoms				
Mental stress	[30, 36, 39, 40, 54, 65, 69, 70, 73]	[40, 54, 65, 73]	[73]	[73]
Stress symptoms	[45, 52, 53, 65, 68, 69]	[45, 52, 53, 65, 68]	[44, 53]	[53]
Depression	[45, 65, 69]	[45, 65]		
Irritability	[23, 65]	[65]	[48]	
Memory problems	[65]	[65]	[48]	
Fatigue	[3, 23, 39, 65]	[3, 39, 65]	[48]	
Sleeping problems	[23, 39, 69]	[39]	[48]	
Headaches	[23, 39, 65, 69]	[39]	[48]	
Gastrointestinal problems	[3, 23]	[3]		
Dizziness	[39, 65, 69]	[39, 65]		

One advantage of a meta-analysis is that it takes into account the statistical strengths of each study in terms of number of subjects and characteristics of the population. In the present review, all studies are taken equally in that respect. It is clear also that all studies do not have the same scientific validity, even though they were all published in peer-reviewed journals. They will not be discussed further.

Most studies took into consideration only a few factors (biomechanical, psycho-organisational, personal). This influences considerably the review as, obviously, a study cannot show a relationship with a factor that it did not consider, while, nevertheless, this factor might have played a role which could be reflected indirectly through another factor or which could mask the influence of another factor.

For the majority of the studies, the dependent variable was the presence or not of musculoskeletal complaints during the past year. For the others, it was the presence or not of an MSD authenticated through a clinical examination, on the day of the interview. Ideally, these two sets of studies should not be grouped. However, the separate discussion of the results would lead to different and opposite relationships. Since co-factors such as personality and stress are likely to have a systematic influence, if any, on complaints and disorders, we decided to keep the two types of studies together. Therefore the paper deals with MSDs in general, making a distinction only between the two anatomical zones. It is worth adding that the "healthy worker effect" is likely to play a less significant role in studies considering complaints than in those relying on clinical disorders.

One additional reason for grouping all studies is that the criteria to diagnose a given disorder vary between authors. The comparison of these criteria and the discussion of their influence on the results are beyond the scope of the present article.

For the majority of the studies based on complaints, the same questionnaire (Kuorinka et al. 1987) was used. The reliability of the data might however vary according to whether the questionnaire was self-administered or administered during an interview.

The first difference is the low response rate in the first case, with the suspicion that those who responded are a biased sample of the whole group. Another is the fact that complaints might be due to extra-occupational activities, and the confusion might be greater in case of a self-administration (Ingelgard et al. 1996).

A significant difference between complaints and clinical disorders is also that the complaints relate to the past 12 months, while the disorders are those observed on the day of the clinical examination.

Few authors actually draw the attention to a possible time shift between the reported complaints and the working conditions observed by the expert or described by the workers on the day of the administration of the questionnaire.

One main problem of this review was to prepare the list of factors, and to allocate the different researches. In many studies, the definition of the risk factors was often lacking or vague or specific. Examples are hobbies and physical activities, sports (soccer or tennis,...), social climate, psycho-organisational workload or job demands, ...

Grouping of the factors was essential and unavoidable in order to reduce their numbers and to increase the number of papers per factor. This was done as best as possible based on the information available, and, although details can be questionable, this should not bias the conclusions.

The tables presented above indicate which studies took into consideration a given factor, and which ones found an association with MSDs. As was seen and as will be discussed, these numbers vary considerably between factors. Not all factors could obviously be considered in all studies. While some factors (age, seniority, sports, ...) should have been considered by all, others (such as vibration) obviously could not. For some factors, this is less obvious: forces, for instance, are limited in cases of keyboard work.

Some occupational groups were more systematically investigated than others, in particular those in food sectors and administrative work. Therefore, the associations will be dependent on the characteristics of these groups and of their working and psycho-organisational environment. In particular, as the investigated conditions concerned more women than men, possible associations between MSDs and psycho-organisational conditions will be more dependent on the psycho-organisational conditions of women, which, in many situations, are significantly different from those of men.

Multivariate vs. univariate analyses

Most researchers performed both univariate and multivariate statistical analyses between the presence of MSDs and potential risk factors. Few, however, reported information about the correlation between these risk factors.

We chose to report the results of the multivariate analyses. This is disputable. Indeed, in this type of analysis, age and seniority, for example, appear rarely at the same time, as these factors are usually highly correlated. It would however be premature to conclude that age in itself or seniority in itself cannot play a role.

The situation is not so clear for other factors. In a typical case, a strong association with the percentage of the time with the wrist in deviation was reported in the univariate analysis, but completely disappeared in the multivariate analysis due to a strong covariation with another characteristic.

The opposite situation also occurs: in one study (Brusco and Malchaire 1993), the height of the person was not a significant factor in the univariate analysis ($P = 0.281$) but was rather strongly significant in the multivariate analysis ($P = 0.001$).

The conclusions regarding the associated factors are therefore influenced by the type of statistical analysis performed and taken into consideration. As the statistical power of a multivariate analysis is greater, we gave preference to these results.

Association between musculoskeletal disorders and risk factors

The data presented in the tables and the discussion hereunder do not take into account the strength of the associations found in the different studies. It would actually be impossible to report these strengths (through odds ratios and confidence intervals) for all 276 associations mentioned in the tables, without increasing dramatically their complexity.

It is indeed worth noting that the associations with grip forces are in general very strong, while the associations with postures are often weak. The reader interested in a particular factor or group of factors will easily find, from the tables, the references for where the statistical data are available for more detailed analyses. The discussion will therefore be limited to the report or not of an association at the 5% significance level.

Occupational risk factors

The factors systematically found associated with MSDs are:

- For NSs: repetitiveness, physical workload and static efforts
- For HWs: repetitiveness, physical workload only

The factor “awkward posture” is missing, while most ergonomic recommendations concern this factor.

The workload at previous workplaces is significantly associated in 4/4 studies on NSs and 0/3 for HWs. This discrepancy is rather surprising and could be due to a bias: these parameters being taken or not taken into consideration because the authors had reasons to believe that the exposure at previous workplaces was significant. These results certainly suggest that the previous exposure should be more systematically investigated, especially since the progression over time of MSDs remains largely unknown (Silverstein and Hughes 1996).

It is remarkable that factors such as job rotation and number of breaks are not associated. Actually, a few studies (11) did consider either of these factors that are usually recommended to reduce the risk, and two only found an association in each case.

The last factor to be mentioned in this category is the number of working hours found associated with HWs in 4/8 and with NSs in 1/9 studies. A close relationship can be expected between work duration and fatigue or strain accumulation, and this could justify the association, for HWs. However, this reasoning should also apply for the neck and shoulder region. For HWs, it is likely that this association actually reflects the association with the workload.

Medical history

From Table 2, it is clear that medical history was suspected of playing a role – and was investigated – much more in HWs than in NSs.

Bad health is found significant for NSs (3/5) and less systematically for HWs. The opposite is suggested for chronic diseases (0/5 and 4/13). Again, these items group together so many different aspects that interpretation is difficult. In addition, as most studies are cross-sectional, the association with bad health can be interpreted as a cause as well as an effect.

Personal factors

Many studies considered only men or women, and gender differences were investigated in 19 NSs and 23 HWs studies (ten common). These were found associated with MSDs in respectively ten and seven (one common).

Several of them postulated differences in the type of muscle fibres (for neck disorders) and hormonal differences (especially for carpal tunnel syndrome) but, most of all, differences in occupational exposures and home activities.

It is worth noting that when the comparison was restricted to men and women performing exactly the same tasks, these differences were no longer significant or the odds ratio (OR) was much smaller (OR = 1.2; Hagberg et al. 1995).

It can therefore be concluded that repetitive work appears to be the (sad) “privilege” of women, with more hand-intensive tasks. This, coupled with more intensive home activities, fewer adapted tools (Buckle and Devereux 1999) and unfavourable functional characteristics (smaller hands, lower grip force) explains the greater prevalence of MSDs of the upper limbs in women.

Height, weight and smoking habits are variables traditionally considered (32 studies). Very few, however, (six, five and four) found an association with MSDs in one or both regions. This shows clearly that these parameters do not play a direct role.

The anthropometrical characteristics may intervene indirectly in some conditions (raised arms, distance in the sagittal plane, ...) and are worth being included systematically in the co-factors. On the other hand, smoking or drinking habits, number of children, ... might be dropped from the list of factor to be considered systematically, in favour of other items.

The same is true for the hobbies (2/16), physical exertion (4/14) and sports in general (2/6).

A closer comparison of the studies shows that the associations found are in opposite directions: extra-occupational physical exertion is associated with an increase of MSDs in one study (Ekberg et al. 1994) and a decrease in two studies (Jonsson et al. 1988; Fransson-Hall et al. 1995). Similarly Brusco and Malchaire (1993) found an increase, and Silverstein and Hughes (1996) a decrease, in prevalence of MSDs with the practising of hobbies. It is likely that such an association does not exist, except in extreme cases (very intensive or unusual practices). These associations could result also from the fact that the subjects with musculoskeletal complaints or disorders did stop, in some cases, any extra-occupational activities.

One reason for the lack of significance of these parameters might also be that the information that the researchers include is vague and varied: gardening, knitting, construction, ... do not give rise to the same constraints (in intensity, duration, localisation, ...). Similarly, tennis, soccer and jogging do not train or fatigue the same muscles or tendons. The questions should therefore be more specific or are short of interest.

The association with maximum force was found significant more often for NSs (3/7: force of the shoulders in six studies and handgrip force in one), than for HWs (1/4: hand grip force). It appears unfortunate that this factor was not taken into consideration more systematically, particularly for HWs. While it seems to be established that the risk is proportional to the force constraints, the results do not seem to confirm that it is inversely proportional to the physical capacity.

The interest for personality characteristics is recent and promising, as 3/5 studies find a greater prevalence of NSs in subjects with type A personality, and in 2/3 studies of neuroticism. The explanations are: greater muscular tension of the trapezius, increased vulnerability to stress, in the type A, and greater attention for

oneself, increased tendency to complain from small sensations, in neurotic personalities.

The same interest has not yet been developed concerning the HWs, partly because the models do not suggest such an association.

Additional studies are clearly needed on these factors, as well as about how, indirectly, they play a role through stress, muscular tension, ...

Psycho-organisational factors

Thirty-eight (82%) of the 46 studies concerning NSs investigated a possible association with one or several psycho-organisational factors. For HWs, the figures are 24 (61%) out of 39, and the number of factors considered simultaneously per study is lower. Almost all studies on NSs (31/38) found an association, and 12/24 in the case of HWs. These elementary statistics suggests that psycho-organisational and stress factors are more associated with musculoskeletal complaints or disorders in the cervicobrachial region.

In their literature review, Bongers et al. (1993) identified monotony, time pressure, lack of control and poor work content as risk factors. The present review suggests that the association is very subtle. Some of the findings (poor work content and mental requirement) might appear contradictory unless they are interpreted as divergences from a personal optimum.

High work rate (4/4), time pressure (3/4) and productivity (2/3) taken into consideration in different studies might indicate a similar relationship with time constraints. This would then be one of the most significant associations for NSs, but would not indicate much more than work repetitiveness.

Low work content and lack of responsibilities and decision latitude were mentioned by Bongers et al. (1993) as significant factors. Like job rotation, discussed hereunder, these are part of the standard package of measures recommended for improvement in working situations. However, few studies found an association with NSs (6/18), and even fewer with HWs (2/9). Actually, the work content and decision latitude for some of these repetitive tasks were so obviously non-existent that the persons performing the tasks would not even complain anymore (or they would have already left), and would prefer to accept it rather than seek any work content in an inevitably boring task. Again, this stresses the fact that conclusions cannot be extrapolated outside the context of the studies.

The same remark might apply also to the items related to social support. Contacts with colleagues and supervisors, and lack of support are not systematically found in association with NSs (6/21), nor HWs (3/16), maybe because the type of work involved in these musculoskeletal problems does not require or classically does not make possible these contacts and support systems.

Job dissatisfaction is not a significant factor in most studies (4/9 for NSs and 1/9 for HWs), maybe simply because many such jobs can never be satisfying.

Classically, the conclusions are that:

- Occupational biomechanical factors play the most important role in HWs, even if some other aspects may play a role (Buckle 1997).
- For complaints of the cervicobrachial region, it is necessary to act simultaneously on biomechanical and psycho-organisational factors to reduce the risk of MSDs (Sauter and Swanson 1996).

This discussion suggests that an association is not found with the psycho-organisational factors, not because the biomechanical factors are predominant or the psycho-organisational factors are less important, but because the subjects themselves believe that the possibilities for improvement of the psycho-organisational environment are too limited.

Table 3 shows that the stress and the somatic symptoms of stress were rarely investigated, especially in relation to HWs. Since, in addition, the stress evaluations were different, few conclusions are possible. Therefore, the different explanations proposed in the literature still remain to be validated:

- Reduction of the “coping” capabilities and increase of the somatic symptoms (Bongers et al. 1993)
- Psychiatric problems leading to physical disorders (Skov et al. 1996)
- Behavioural changes: more work, more effort, fewer breaks (Eysenck and Eysenck 1981)
- Increase in muscle tonus and biochemical reactions (Bongers et al. 1993; Hales et al. 1994)
- Lowering of immunity and repair capabilities of tissues (Skov et al. 1996).

Comparison between cross-sectional and longitudinal studies

Table 4 compares the numbers of cross-sectional and longitudinal studies finding a significant association between NSs, and the factors most frequently studied. This is limited to NSs, as only two longitudinal studies are available for HWs.

Among the six longitudinal studies on NSs, two (Fredriksson et al. 1999; Leino and Magni 1993) did actually consider a few factors but from one or two categories only. On the other hand, the studies by Kilbom and Persson (1987) and by Jonsson et al. (1988) took into consideration many personal, occupational and psycho-organisational factors. Four of them concerned only women, so the gender effect cannot be investigated.

As Table 4 shows, two factors only (age and mental stress) were investigated in comparable ways in four longitudinal studies. This lack of uniformity in the protocol makes comparisons and conclusions difficult. Nevertheless, it can be concluded at this point that cross-

Table 4 Comparison of the main associations between cross-sectional and longitudinal studies on the neck-shoulder regions (*NSs*)

		Cross-sectional	Longitudinal
1. Occupational factors	Physical workload	6/14	0/1
	Awkward postures	5/14	2/2
	Repetitiveness	8/1	10/0
	Static efforts	2/6	2/2
	Previous workload	2/2	2/2
2. Personal factors	Age	12/3	22/4
	Gender	10/19	0/0
3. Medical history	General health status	3/5	0/0
4. Psycho-organisational factors	Mental requirements	9/15	0/1
	Monotony	4/7	0/1
	High work rate	4/4	0/0
	Time pressure	2/3	1/1
	Lack of social support	1/9	0/1
	Work dissatisfaction	3/8	1/1
	Mental stress	2/5	2/4

sectional and longitudinal studies apparently obtain similar results. Indeed, results are consistent concerning age, mental stress, and previous workload, as well as repetitiveness (or number of cycles per hour). However, associations with awkward postures and static efforts were found in 2/2 longitudinal studies, but only in about 1/3 of the cross-sectional studies.

Conclusion

Extensive reviews of the literature about risk factors of MSDs of the upper limbs have been published. The present paper takes a simpler but interesting approach in making the systematic list of factors considered and found associated with MSDs. The validity of this approach and whether it is complementary with other scientific reviews is discussed. The tables show clearly the types of factors that were investigated and those that received less concern.

Few factors have been systematically found in association with MSDs but the information available appears to justify technical actions on the biomechanical and organisational factors. In contrast, the scientific evidence is probably not strong enough to demonstrate a definite cause-effect relationship between a specific work situation and a specific disorder, for compensation purposes in particular.

In that regard however, attention must be drawn to the fact that, among all the 70 factors listed in this review, those in Table 2, related to individual characteristics, extra-occupational factors and medical history are, by far, those the least associated with MSDs. Some factors traditionally taken into consideration could actually be completely abandoned: this is the case for instance for weight and hobbies.

In contrast, all factors related to the biomechanical or psycho-organisational aspects show a much greater rate of significant association. Restricting the causality of MSDs to biomechanical factors is certainly too simple. Relating them primarily to personal characteristics would be simplistic.

References

- Andersen JH, Gaardboe O (1993) Musculoskeletal disorders of the neck and upper limb among sewing machine operators: a clinical investigation. *Am J Ind Med* 24: 689–700
- Barnhart S, Demers PA, Miller M, Longstreth W, Rosenstock L (1991) Carpal tunnel syndrome among ski manufacturing workers. *Scand J Work Environ Health* 17: 46–52
- Bergqvist U, Wolgast E, Nilsson B, Voss M (1995) Musculoskeletal disorders among visual display terminal workers: individual, ergonomic, and work organizational factors. *Ergonomics* 38: 763–776
- Bernard BP (ed) (1997) Musculoskeletal disorders (MSDs) and workplace factors. NIOSH
- Bernard B, Sauter SL, Fine LJ, Petersen M, Hales T (1992) Psychosocial and work organisation risk factors for cumulative trauma disorders in the hands and wrists of newspaper employees. *Scand J Work Environ Health* 18[Suppl 2]: 119–120
- Bernard B, Sauter S, Fine L, Petersen M, Hales T (1994) Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. *Scand J Work Environ Health* 20: 417–426
- Bjelle A, Hagberg M, Michaelson G (1987) Work-related shoulder-neck complaints in industry: a pilot study. *Br J Rheumatol* 26: 365–369
- Bongers PM, de Winter CR, Kompier MAJ, Hildebrandt VH (1993) Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 19: 297–312
- Bru E, Mykletun R, Svebak S (1993) Neuroticism, extraversion, anxiety and type A behavior as mediators of neck, shoulder and lower back pain in female hospital staff. *Pers Individ Differ* 15: 485–492
- Brusco F, Malchaire J (1993) Problèmes musculosquelettiques des membres supérieurs. Facteurs professionnels et extraprofessionnels. *Cah Med Travail* XXX 4: 181–185
- Buckle P (1997) Upper limb disorders and work: the importance of physical and psychosocial factors. *J Psychosom Res* 43: 17–25
- Buckle P, Devereux J (1999) Work-related neck and upper limb musculoskeletal disorders. European Agency for Safety and Health at Work
- Burdorf A, van Riel M, Brand T (1997) Physical load as risk factor for musculoskeletal complaints among tank terminal workers. *Am Ind Hyg Assoc J* 58: 489–497
- Cannon LJ, Bernacki EJ, Walter SD (1981) Personal and occupational factors associated with carpal tunnel syndrome. *J Occup Med* 23: 255–258
- Chiang HC, Ko YC, Chen SS, Yu H, Wu T, Chang P (1993) Prevalence of shoulder and upper-limb disorders among workers in the fish-processing industry. *Scand J Work Environ Health* 19: 126–131

16. Dimberg L, Olafsson A, Stefansson E, Aagaard H, Odéon A, Andersson G, Hansson T, Hagert C (1989) The correlation between work environment and the occurrence of cervicobrachial symptoms. *J Occup Med* 31: 447–453
17. Ekberg K, Björkqvist B, Malm P, Bjerre-Kiely B, Karlsson M, Axelson O (1994) Case-control study of risk factors for disease in the neck and shoulder area. *Occup Environ Med* 51: 262–266
18. Ekberg K, Karlsson M, Axelson O (1995) Cross-sectional study of risk factors for symptoms in the neck and shoulder area. *Ergonomics* 38: 971–980
19. English CJ, Maclaren WM, Court-Brown C, Hughes S, Porter R, Wallace W, Graves R, Pethick A, Soutar C (1995) Relations between upper limb soft tissue disorders and repetitive movements at work. *Am J Ind Med* 27: 75–90
20. Engström T, Hanse J, Kadefors R (1999) Musculoskeletal symptoms due to technical preconditions in long cycle time work in an automobile assembly plant: a study of prevalence and relation to psychosocial factors and physical exposure. *Appl Ergon* 30: 443–453
21. Eysenck HJ, Eysenck SBG (1981) Manual of the Eysenck personality questionnaire. Hodder and Stoughton, London, p 57
22. Finsen L, Christensen H, Bakke M (1998) Musculoskeletal disorders among dentists and variation in dental work. *Appl Ergon* 29: 119–125
23. Flodmark T, Aase G (1992) Musculoskeletal symptoms and type A behaviour in blue collar workers. *Br J Ind Med* 49: 683–687
24. Fransson-Hall C, Byström S, Kilbom A (1995) Self-reported physical exposure and musculoskeletal symptoms of the forearm-hand among automobile assembly-line workers. *Occup Environ Med* 37: 1136–1144
25. Fredriksson K, Alfredsson L, Köster M, Thorbjörnsson C, Toomingas A, Torgen M, Kilbom A (1999) Risk factors for neck and upper limb disorders: results from 24 years of follow up. *Occup Environ Med* 56: 59–66
26. Frost P, Andersen H (1999) Shoulder impingement syndrome in relation to shoulder intensive work. *Occup Environ Med* 56: 494–498
27. Frost P, Andersen JH, Nielsen VK (1998) Occurrence of carpal tunnel syndrome among slaughterhouse workers. *Scand J Work Environ Health* 24, 4: 285–292
28. Hagberg M, Silverstein B, Wells R, Smith M, Hendrick H, Carayon P, Pérusse M (1995) Work related musculoskeletal disorders (WMSDs) A reference book for prevention. Taylor & Francis, London, p 421
29. Hagen K, Magnus P, Vetlesen K (1998) Neck/shoulder and low back disorders in the forestry industry: relationship to work tasks and perceived psychosocial job stress. *Ergonomics* 41: 1510–1518
30. Hägg GM, Åström A (1997) Load pattern and pressure pain threshold in the upper trapezius muscle and psychosocial factors in medical secretaries with and without shoulder/neck disorders. *Int Arch Occup Environ Health* 69: 423–432
31. Hales T, Sauter S, Peterson M, Fine L, Putz-Anderson V, Schleifer L, Ochs T, Bernard B (1994) Musculoskeletal disorders among visual display terminal users in a telecommunications company. *Ergonomics* 37: 1603–1621
32. Harber P, Blowski D, Beck J, Pena L, Baker D, Lee J (1993) Supermarket checker motions and cumulative trauma risk. *J Occup Med* 35: 805–811
33. Hughes RE, Silverstein BA, Evanoff BA (1997) Risk factors for work-related musculoskeletal disorders in an aluminum smelter. *Am J Ind Med* 32: 66–75
34. Ingelgard A, Karlsson H, Nonas K, Ortengren R (1996) Psychosocial and physical work environment factors at three workplaces dealing with materials handling. *Int J Ind Ergon* 17: 209–220
35. Jensen C, Borg V, Finsen L, Hansen K, Juul-Kristensen B, Christensen H (1998) Job demands, muscle activity and musculoskeletal symptoms in relation to work with the computer mouse. *Scand J Work Environ Health* 24: 418–424
36. Jonsson BG, Persson J, Kilbom A (1988) Disorders of the cervicobrachial region among female workers in the electronics industry. *Int J Ind Ergon* 3: 1–12
37. Kamwendo K, Linton SJ, Moritz U (1991) Neck and shoulder disorders in medical secretaries. Part I: Pain prevalence and risk factors. *Scand J Rehab Med* 23: 127–133
38. Kasl SV, Amick BC (1996) Cumulative trauma disorders research: methodological issues and illustrative findings from the perspective of psychosocial epidemiology. In: Moon SD, Sauter SL (eds) *Psychosocial aspects of musculoskeletal disorders in office work*. Taylor & Francis, London, pp 263–285
39. Kilbom A, Persson J, Jonsson BG (1986) Disorders of the cervicobrachial region among female workers in the electronics industry. *Int J Ind Ergon* 1: 37–47
40. Kilbom K, Persson J (1987) Work technique and its consequences for musculoskeletal disorders. *Ergonomics* 30: 273–279
41. Kuorinka I, Jonsson B, Kilbom A, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K (1987) Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 18: 233–237
42. Lagerström M, Wenemark M, Hagberg M, Wigaeus H (1995) Occupational and individual factors related to musculoskeletal symptoms in five body regions among Swedish nursing personnel. *Int Arch Occup Environ Health* 68: 27–35
43. Latko WA, Armstrong TJ, Franzblau A, Ulin S, Werner R, Albers J (1999) Cross-sectional study of the relationship between repetitive work and the prevalence of upper limb musculoskeletal disorders. *Am J Ind Med* 36: 248–259
44. Leclerc A, Franchi P, Cristofari MF, Delemotte B, Mereau P, Teyssier-Cotte C, Touranchet A (1998) Carpal tunnel syndrome and work organisation in repetitive work: a cross-sectional study in France. *Occup Environ Med* 55: 180–187
45. Leino P, Magni G (1993) Depressive and distress symptoms as predictors of low back pain, neck-shoulder pain, and other musculoskeletal morbidity: a 10-year follow-up of metal industry employees. *Pain* 53: 89–94
46. Linton SJ, Kamwendo K (1989) Risk factors in the psychosocial work environment for neck and shoulder pain in secretaries. *J Occup Med* 31: 609–613
47. Magnavita N, Bevilacqua L, Mirk P, Fileni A, Castellino N (1999) Work-related musculoskeletal complaints in sonologists. *J Occup Environ Med* 41: 981–988
48. Malchaire JB, Cock NA, Piette A, Dutra Leao R, Lara M, Amaral F (1997) Relationship between work constraints and the development of musculoskeletal disorders of the wrist: a prospective study. *Int J Ind Ergon* 19: 471–482
49. Margolis W, Kraus JF (1987) The prevalence of carpal tunnel syndrome symptoms in female supermarket checkers. *J Occup Med* 29: 953–956
50. Morgenstern H, Kelsh M, Kraus J, Margolis W (1991) A cross-sectional study of hand/wrist symptoms in female grocery checkers. *Am J Ind Med* 20: 209–218
51. Ohlsson K, Attewell R, Skerfving S (1989) Self-reported symptoms in the neck and upper limbs of female assembly workers. *Scand J Work Environ Health* 15: 75–80
52. Ohlsson K, Hansson GA, Balogh I, Strömberg U, Palsson B, Nordander C, Rylander L, Skerfving S (1994) Disorders of the neck and upper limbs in women in the fish processing industry. *Occup Environ Med* 51: 826–832
53. Ohlsson K, Attewell RG, Palsson B, Karlsson B, Balogh I, Johnsson B, Ahlm A, Skerfving S (1995) Repetitive industrial work and neck and upper limb disorders in females. *Am J Ind Med* 27: 731–747
54. Pope DP, Croft PR, Pritchard CM, Silman A, Macfarlane G (1997) Occupational factors related to shoulder pain and disability. *Occup Environ Med* 54: 316–321
55. Punnett L, Robins JM, Wegman DH, Keyserling M (1985) Soft tissue disorders in the upper limbs of female garment workers. *Scand J Work Environ Health* 11: 417–425
56. Roquelaure Y, Mechali S, Dano C, Fanello S, Benetti D, Bureau D, Mariel D, Martin Y-H, Derriennic F, Penneau-

- Fontbonne D (1997) Occupational and personal risk factors for carpal tunnel syndrome in industrial workers. *Scand J Work Environ Health* 23: 364–369
57. Salminen JJ, Pentti J, Wickström G (1991) Tenderness and pain in neck and shoulders in relation to type A behaviour. *Scand J Rheumatol* 20: 344–350
 58. Sauter SL, Swanson NG (1996) An ecological model of musculoskeletal disorders in office work. In: Moon SD, Sauter SL (eds) *Psychosocial aspects of musculoskeletal disorders in office work*. Taylor & Francis, London, pp 3–21
 59. Silverstein BA, Hughes RE (1996) Upper extremity musculoskeletal disorders at a pulp and paper mill. *Appl Ergon* 27: 189–194
 60. Silverstein BA, Fine LJ, Armstrong TJ (1986) Hand wrist cumulative trauma disorders in industry. *Brit J Industr Med* 43: 779–784
 61. Silverstein BA, Fine LJ, Armstrong TJ (1987) Occupational factors and carpal tunnel syndrome. *Am J Ind Med* 11: 343–358
 62. Skov T, Borg V, Orhede E (1996) Psychosocial and physical risk factors for musculoskeletal disorders of the neck, shoulders, and lower back in salespeople. *Occup Environ Med* 53: 351–356
 63. Smith MJ, Carayon P (1996) Work organisation, stress, and cumulative trauma. In: Moon SD, Sauter SL (eds) *Psychosocial aspects of musculoskeletal disorders in office work*. Taylor & Francis, London, pp 23–43
 64. Stetson DA, Silverstein BA, Keyserling WM, Wolfe R, Albers J (1993) Median sensory distal amplitude and latency: comparisons between non-exposed managerial/professional employees and industrial workers. *Am J Ind Med* 24: 175–189
 65. Takala EP, Viikari-Juntura E, Moneta G, Saarenmaa K, Kaivanto K (1991) Predictions for the natural cause of neck-shoulder symptoms and headache in light sedentary work. In: Quéinnec Y, Daniellou F (eds) *Designing for everyone. Proceedings of the 11th congress of the International Ergonomics Association*, vol 1, Taylor & Francis, London, pp 129–131
 66. Tola S, Riihimäki H, Videman T, Viikari-Juntura E, Hänninen K (1988) Neck and shoulder symptoms among men in machine operating, dynamic physical work and sedentary work. *Scand J Work Environ Health* 14: 299–305
 67. Toomingas A, Theorell T, Michelsen H, Nordemar R (1997) Associations between self-rated psychosocial work conditions and musculoskeletal symptoms and signs. *Scand J Work Environ Health* 23: 130–139
 68. Ursin H, Endresen M, Ursin G (1988) Psychological factors and self-reports of muscle pain. *Eur J Appl Physiol* 57: 282–290
 69. Vasseljen O Jr, Westgaard RH, Larsen S (1995) A case-control study of psychological and psychosocial risk factors for shoulder and neck pain at the workplace. *Int Arch Occup Environ Health* 66: 375–382
 70. Veiersted KB, Westgaard RH (1992) Work related risk factors for trapezius myalgia. *Arbete och Hälsa* 17: 307–309
 71. Westgaard RH, Jensen C, Hansen K (1993) Individual and work-related risk factors associated with symptoms of musculoskeletal complaints. *Int Arch Occup Environ Health* 64: 405–413
 72. Zetterberg C, Öfverholm T (1999) Carpal tunnel syndrome and other wrist/hand symptoms and signs in male and female car assembly workers. *Int J Ind Ergon* 23: 193–204
 73. Zetterberg C, Forsberg A, Hansson E, Johansson H, Nielsen P, Danielsson B, Inge G, Olsson B-M (1997) Neck and upper extremity problems in car assembly workers. A comparison of subjective complaints, work satisfaction, physical examination and gender. *Int J Ind Ergon* 19: 277–289