SWEDISH WORK ENVIRONMENT AUTHORITY

Physical work, gender, and health in working life

State of Knowledge Report

State of Knowledge Report

Physical work, gender, and health in working life

Charlotte Lewis, Ph.D., and Professor Svend Erik Mathiassen University of Gävle,
Faculty of Health and Occupational Studies, Centre for Musculoskeletal Research

ISSN 1650-3171

Report 2013:9

Foreword

The Swedish Work Environment Authority has been commissioned by the Swedish Government to inform and disseminate knowledge in areas of significance for the working environment. In the coming years, several State of Knowledge Reports will therefore be published, in which well-renowned researchers have summarised the current state of knowledge on a number of themes. A scientific review of this report was carried out by docent Hélène Sandmark. The authors, however, are themselves responsible for the final wording.

The report is available at no cost on the Work Environment Authority Web site. There is also material from the seminar series the Authority arranges in connection with the publication of the reports.

The project manager for this State of Knowledge Report at the Work Environment Authority was Ulrika Thomsson Myrvang. We also wish to thank our other colleagues at the Authority, who have been instrumental in the work on the reports.

The opinions expressed in this report are those of the authors and do not necessarily reflect the opinions of the Work Environment Authority.

Magnus Falk, Ph.D. *Jan Ottosson, professor*

Innehåll

Foreword 2
1. The Swedish Work Environment Authority and this report 5
2. Disorders among men and women in Swedish working life 6
2.1. Risk factors for musculoskeletal disorders 8
2.2. Causes of differences in disorders between men and women 10
2.3. Where is the knowledge, and what does it look like? 12
2.4. Search strategies 14
3. A labour market segregated by gender 15
3.1. Physical load in various occupations 16
3.2. Workplaces dominated by women and men 17
3.3. Mental loads 19
3.4. Key points 19
4. Same occupation – different work tasks? 21
4.1. Segregated work tasks 21
4.2. Mental loads in the same occupation 24
4.3. Key points 25
5. Same tasks – different loads? 26
5.1. Anthropometry and work postures 26
5.2. Muscle strength 27
5.3. Lifting, pushing, and pulling 28
5.4. Repetitive work 29
5.5. Computer work 30
5.6. Motor variability 31
5.7. Key points 31
6. Same physical load – different reactions? 33
6.1. Fatigue 33
6.1.1. Level of physical load 33
6.1.2. Dynamic vs. static work 35
6.1.3. Endurance in working life 35
6.2. Pain 35
6.3. Pregnancy 36
6.4. Mental loads 37
6.5. Key points 38
7. Summary 39
7.1. Scientific literature 39
7.2. State of research 40
7.3. Conclusion 40
References 43

1. The Swedish Work Environment Authority and this report

This State of Knowledge Report was compiled as part of the Swedish Work Environment Authority's commission from the Government on "special preventive efforts for women's working environments" where preventive work on reducing musculoskeletal disorders is indicated as a particular focus. The report begins with an introduction on gender differences in work-related disorders, with an emphasis on the musculoskeletal system. In addition, an explanatory model of various factors, each of which could contribute to these gender differences – from a societal level down to the physiology of the individual – is presented. After that, the focus of this State of Knowledge Report lies on a review of scientific literature on gender differences in work tasks, physical loads and physiological reactions, and a discussion of the extent to which such differences could explain gender differences in the occurrence of disorders. Even mental loads have been included to the extent they can be linked to physical disorders, but the report does not include the effects of the working environment on mental disorders. The conclusion of the report summarises what support the different steps in the explanatory model have in today's research. The report is directed at work environment practitioners, such as the Swedish Work Environment Authority and occupational health services, even though it is our hope that it can also be of use and inspiration in scientific contexts. An earlier State of Knowledge report within the same Government commission, which is mainly devoted to organisational factors in the work environment, is *Under luppen – genusperspektiv på arbetsmiljö och arbetsorganisation* (Arbetsmiljöverket, 2013).

2. Disorders among men and women in Swedish working life

Disorders believed to be caused by working conditions are usually termed "work-related", or "occupational disorders". The most common occurring disorders are those of the locomotor system. The most frequent symptom is pain, but a disorder can also express itself as impaired physical function, with or without concurrent pain. The disorder can be acute or chronic (lasting for more than 12 weeks). Most work-related disorders in the locomotor system or "musculoskeletal disorders" are "non-specific" – that is, the physiological cause of the disorder is not known and the disorder is not always localised to an exact point in the body (Leijon, 2011).

Musculoskeletal disorders often result in sick leave; and musculoskeletal disorders is one of the two completely predominant reasons for sick leave and early retirement in Sweden (see Figure 1) (Försäkringskassan, 2011). These disorders result in major costs to society and also impact the sufferer's quality of life, just as they impact production in the organisation where the afflicted person works. Research shows that women account for a larger share of ill health than men: in Sweden, women had a total sickness allowance in 2011 that was 69 % higher than men's (Försäkringskassan, 2012). A significant part of the musculoskeletal disorders are probably caused by exposures at work. Among the working population in Sweden in 2011, 6.4 % of women and 5.7 % of men reported to have experienced disorders due to stressful postures during the previous 12 months (Arbetsmiljöverket, 2012b). Short, repeated movements were reported as the cause for 2.6 % of the women and 1.8 % of the men, and 4.2 % of the women and 4.1 percent of the men reported heavy manual handling to have caused disorders. Women are thus overrepresented as regards musculoskeletal disorders, both measured in terms of self-reported disorders and as sick leave figures.

Women have a higher occurrence of sick leave owing to musculoskeletal disorders than men at all levels of education, but the gender differences are greatest in military work, work that requires theoretical specialist competence and work that requires a shorter university education. Lowest are gender differences within craft work in construction and manufacturing, office and service work, and work in agriculture, gardening, forestry and fishing (Försäkringskassan, 2011).

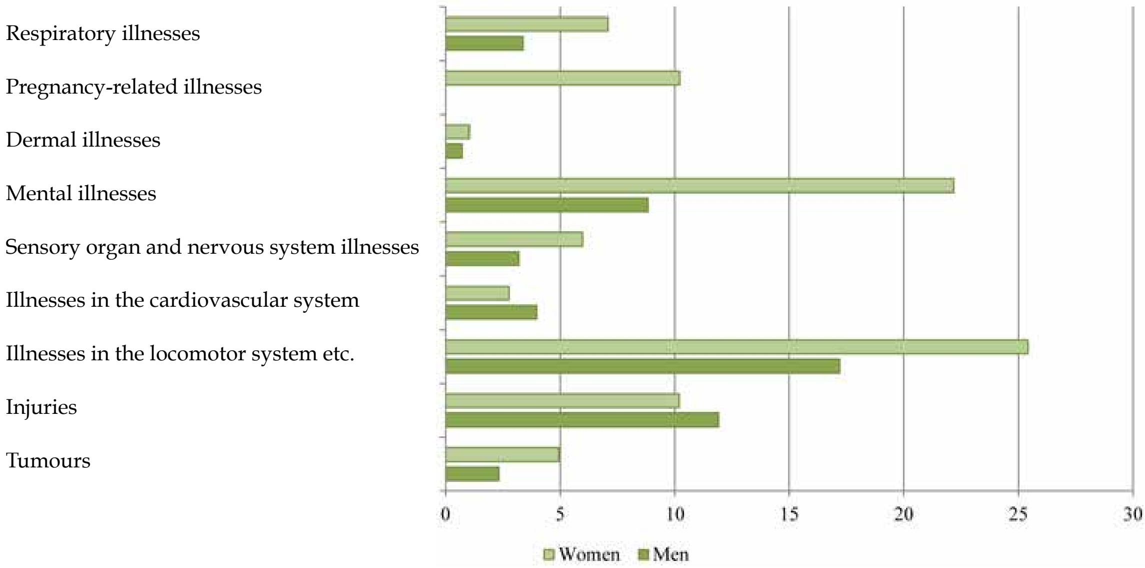

Figure 1: New cases of sick leave (>14 days) for some common diagnosis groups per 1,000 employed women and men in Sweden, 2009 (Försäkringskassan, 2011).

The over-representation of women in musculoskeletal disorders is not as clear in all bodily regions (see Table 1) (Noor and Hagberg, 2012). The differences are most pronounced for disorders in the neck and arms (Bingefors and Isacson, 2004; Treaster and Burr, 2004; Wahlstedt et al., 2010; Nordander et al., 2013; Noor and Hagberg, 2012). As regards disorders in the lower back, men and women are almost equally afflicted. Some reports show that there is a higher prevalence of lower back disorders among men (Leino-Arjas et al. 1998; Picavet and Hoeymans, 2002); other reports suggest that women have a somewhat higher prevalence (Bingefors and Isacson, 2004; Leboeuf-Yde et al., 2009; Fillingim et al; 2009) and still others find no difference whatsoever between the genders (Leboeuf-Yde et al., 1996, Noor and Hagberg, 2012). Even for legs and feet, women experience disorders to a greater extent than men (Messing et al., 2008; Wijnhoven et al., 206), while knee disorders within certain occupational groups have proven to be more prevalent among men (Nag et al., 2010).

Table 1: Proportion of employed (percent) in Sweden with disorders in the musculoskeletal system assumed to be caused by occupational work (AOB-RA). From a report from Arbets- och Miljömedicin in Gothenburg (AMM, Occupational and environmental medicine), which read the statistics from the SCB study, "Arbetsorsakade besvär" (Workrelated disorders) in 2010. The study concerns the situation during 2009 (Noor and Hagberg, 2012).

		Percent employed with AOB-RA (number)		
Disorder	Age	All[1]	Women[2]	Men[2]
Low back	16-29	51 % (53,254)	53 % (30,956) 58 %	49 % (22 ,298) 42 %
	30-49	43 % (139,099)	40 % (68,086) 49 %	45 % (71,013) 51 %
	50-64	37 % (81,519)	35 % (40,663) 50 %	40 % (40,856) 50 %
	16-64	42 % (273,871)	41 % (139,705) 51 %	44 % (134,166) 49 %
Shoulder/ Arm	16-29	24 % (25,347)	30 % (17,461) 69 %	17 % (7,886) 31 %
	30-49	34 % (110,474)	37 % (62,956) 57 %	30 % (47,518) 43 %
	50-64	38 % (83,376)	42 % (47,648) 57 %	35 % (35,729) 43 %
	16-64	34 % (219,197)	37 % (128,065) 58 %	30% (91,132) 42 %
Neck	16-29	13 % (13,665)	16 % (9,500) 70 %	9 % (4,164) 30 %
	30-49	21 % (67,309)	27 % (45,126) 67 %	14 % (22,183) 33 %
	50-64	21, % (45,272)	26 % (29,680) 66 %	15 % (15,592) 34 %
	16-64	19 % (126,245)	25 % (84,306) 67 %	1 4% (41,939) 33 %
Fingers, Hand/ Wrist	16-29	16 % (16,562)	15 % (8,921) 54 %	17 % (7,641) 44 %
	30-49	13 % (42,188)	13 % (21,677) 51 %	13 % (20,510) 49 %
	50-64	14 % (30,417)	17 % (19,445) 64 %	11 % (10,972) 36 %
	16-64	14 % (89,167)	15 % (50,044) 56 %	13 % (39,123) 44 %

[1] % employed (number employed), [2] % employed (number employed) % within age category

2.1. Risk factors for musculoskeletal disorders

Lifting is found in several occupations, for example in construction, health care, and in restaurants and institutional housekeeping. Lifting has proven to be associated with an increased risk of lower back disorders (da Costa and Vieira, 2010; Marras, 2000) and pain in the neck (da Costa and Vieira, 2010) while the Swedish SBU report on risk factors in the work environment for disorders in the shoulders, neck and upper extremities (2012) drew the conclusion that there was limited scientific evidence for force demanding work (lifting, carrying, pushing, pulling) being associated with a higher risk of disorders in the neck and the shoulders. The SBU report, however, included no cross-sectional studies, which may be an explanation of why insufficient evidence for an association was found.

Work that requires pushing and pulling has proven to be significantly related to low back disorders. A case-control study on patients who sought help in primary care at a clinic in northeast Vermont in the United States showed that 20 % of the men who reported low back disorders had been exposed to work with pushing and pulling, compared with 2 % of the men who did not report lower back disorders (Frymoyer et al., 1980). For women, it was 31 % of those with disorders, and 2 % of those who did not have disorders, who had been exposed to tasks that required pushing and pulling. The neck and the shoulders have also proven to be sensitive to exposure to occupational pushing and pulling (SBU, 2012). As an example, van der Beek et al. (1993) found a significantly increased risk for pain and stiffness in the neck, shoulders and legs among truck drivers who regularly pushed or pulled wheeled postal containers compared to those who only drove trucks.

In some review papers, repetitive work, such as found in manufacturing and cashier work, is concluded to be associated with a somewhat increased risk of neck and shoulder pain (Côte et al., 2008; da Costa and Vieira, 2010) while others state that the scientific evidence is too limited to draw conclusions on such a connection (SBU, 2012; Hansson and Westerholm, 2001). Associations between repetitive work and pain in the shoulders (Mayer et al., 2012) as well as the forearms and wrists have also been presented (da Costa and Vieira, 2010). Work using a computer mouse, which involves long periods of low-intensity but uninterrupted muscular activity in work postures that vary very little, have proven to be related to disorders in the shoulders (SBU, 2012).

Work with the hands above shoulder level is found among painters, carpenters, and hairdressers, for example, and has shown associations with neck and shoulder pain (Côte et al., 2008; Mayer et al., 2012), but there are also studies that have not succeeded in demonstrating an association (SBU, 2012).

Whether bent or twisted work postures are associated with lower back disorders is a controversial issue. Some review articles have concluded that such an association does not exist (Kwon et al., 2011; Wai et al., 2010) – an assertion supported by Ribeiro et al. (2012), which could only find limited evidence that time in a forward-bent work posture increased the risk of lower back disorders. Other review articles, for example Costa et al. (2010) conclude, however, that there is an association between awkward work postures and lower back disorders. This has been supported by later studies (van Oostrom et al., 2012; Sterud and Tynes, 2013). Crouching has proven to be related to knee pain (Klussmann et al., 2010). Bent and twisted work postures occur in assembly and in patient handling in health care, for example.

A review article by Côte et al. (2008) concluded that there is evidence for a relationship between working with the neck bent forward and neck pain, while others have claimed that the scientific basis is not sufficient for such an assertion (Mayer et al., 2012; SBU, 2012). Mayer et al. (2012) also found that trunk flexion and rotation had a strong association to pain in the neck and the shoulders. The Swedish SBU report on risk factors in the work environment for disorders in the shoulders, neck and upper extremities (2012) concluded that there was only scientific support for work with a bent or twisted trunk being associated with disorders in the neck and shoulders, but that the scientific basis for the position of the neck (extension, flexion, rotation) being related to these disorders is insufficient.

Exposure to whole-body vibrations has proven to be associated with lower back disorders (Marras, 2000, Bovenzi and Hulshof, 1999, Krause et al., 1997) and neck disorders (Krause et al., 1997). Exposure to hand and arm vibrations are associated with disorders in the neck, shoulder, and hands (Wahlström et al., 2008). Exposure to whole-body vibrations occur primarily when driving vehicles, such as among truck, bus, and forest machinery drivers. High levels of hand and arm vibrations are found in the construction sector while high-frequency, barely perceptible vibrations are found among dentists and dental hygienists, for example.

A review article devoted to cold as a possible risk factor for musculoskeletal disorders found some scientific evidence for cold influencing certain forms of tendinitis, carpal tunnel syndrome and low back disorders (Pienimäki, 2002). Standing for long periods has also proven to be a risk factor for low back pain (Sterud and Tynes, 2013).

There are also organisational, social, and psychological risk factors such as mental stress, high demands and a lack of control that have proven to be associated with musculoskeletal disorders (Bernard, 1997; Ariens et al., 2001; Bongers et al., 2002; Sterud and Tynes, 2013). Conflicting results have, however, also been presented (Bongers et al., 2006).

One mechanism that might explain mental stress leading to musculoskeletal disorders could be that stress gives rise to muscular tension, primarily in the neck and shoulders, which in turn leads to disorders in the same way as uninterrupted physical loads. Mental stress would then activate in particular those parts (motor units) of the muscles that are already active at low force demands, and these "Cinderella fibres" would then be overloaded and injured (Lundberg, 2002; Eijckelhof et al., 2013).

2.2. Causes of differences in disorders between men and women

The fact that work-related disorders are more prevalent among women than men may be due to several factors that contribute to the difference in different ways and to different degrees. These factors add to each other in a "cascade" or "staircase" effect, as illustrated in Figure 2. Some of the steps in the staircase are on the societal level; others are found in the organisation where the individual works, and still others are tied to the physiology and psychology of the specific individual.

An initial explanation of the gender difference in the prevalence of musculoskeletal disorders may be that men and women have different occupations. The Swedish labour market is segregated to a great degree, with a majority of men found in technical occupations dominated by men, while a majority of employees in health care are women (SOU, 2004:43; SCB, 2012b). The occupational categories where women predominate most are office and medical secretary, where 97% of employees are women. The occupational categories where men predominate most are construction woodworkers and fitting carpenters, with 99 % men (SOU, 2004:43). The typically male occupations include tasks requiring considerable force development, and heavy lifting, and these occupations also have a high occurrence of work-related disorders. Heavy lifting is also found in the health care sector, however, where women are clearly overrepresented. Other typically female occupations with a high occurrence of work-related disorders – sales, administration, and craft work – are characterized by tasks of a more repetitive nature (Arbetsmiljöverket, 2012b, SOU, 2004:43).

In a next step (Figure 2) it could also be that women and men having the same occupation still perform different work tasks, which lead to different physical loads. Only using an occupational title as a measure of exposure in risk assessment and research can therefore lead to a misleading picture of the associations between exposures at work and musculoskeletal disorders (Hooftman et al., 2005; Messing et al., 1998b; Nordander et al., 1999). In an attempt to reduce the occurrence of musculoskeletal disorders in a Brazilian factory, women workers were replaced with men. After a while, the male workers developed disorders to an equally great extent as the previously employed women; the conclusion was that the work being performed, but not gender was an explanatory variable in why workers developed disorders (Coury et al., 2002). Orthodontists have turned out to have a high occurrence of disorders in both the lower back and the neck and arms, but the occurrence is roughly the same for men and women (Punnett and Herbert, 2013). Orthodontics is an occupation where neither the work tasks nor the physical strain differ between men and women to any great extent.

As a further step (Figure 2), it may be that even though men and women have the exact same work tasks, they perform the tasks differently. Women are, on average, smaller and weaker than men, but in many cases the work stations are designed to suit the average man, and sometimes even the physically stronger man. This would mean that women on average will be required to work at higher loads, both in absolute terms and relative to their maximal capacity, than men with the same work task.

A further step in the explanatory staircase (Figure 2) is that women and men working at equal loads could react differently in a physiological sense. Women and men differ, for example, as regards muscle morphology, which could have an effect on the capacity for performing different types of work tasks. Sex hormones have an effect on sensitivity to pain; there is, for example, research showing that male sex hormones have a pain-reducing effect (Wiesenfeld-Hallin, 2005; Craft et al., 2004).

How men and women react to and deal with fatigue and pain in their current jobs can also differ, for instance due to gender-stereotypical roles (Bartley and Fillingim, 2013). In addition to these explanations, gender difference in whether – and how – disorders are reported can also occur as the final step in the staircase (see Figure 2). Men and women with disorders are possibly cared for in different ways in public systems for health care, rehabilitation and social insurance. Factors outside of work, such as women's generally greater responsibility for family and housekeeping, can also contribute to explaining that the "cumulated" load may differ between genders (Vroman and MacRae, 2001).

The present State of Knowledge Report will provide an introduction to the different exposures that men and women may have owing to their different occupations. After that, there is a discussion of the scientific literature on whether men and women in the same occupation actually do the same things, whether the eventual load differs when men and women perform the exact same task, and finally if biological differences in reaction to physical loads can explain the gender difference in occurrence of musculoskeletal disorders. The report thus moves from the exposures to which individuals are subjected at work to the reactions – immediate and more chronic – that may result from these loads (Toomingas et al., 2008). It does not discuss in any depth factors concerning the disproportionate distribution of men and women in different occupations, or the factors that lie "after" a disorder has emerged (see Figure 2). Any significance of factors outside work also lies beyond the focus of this report.

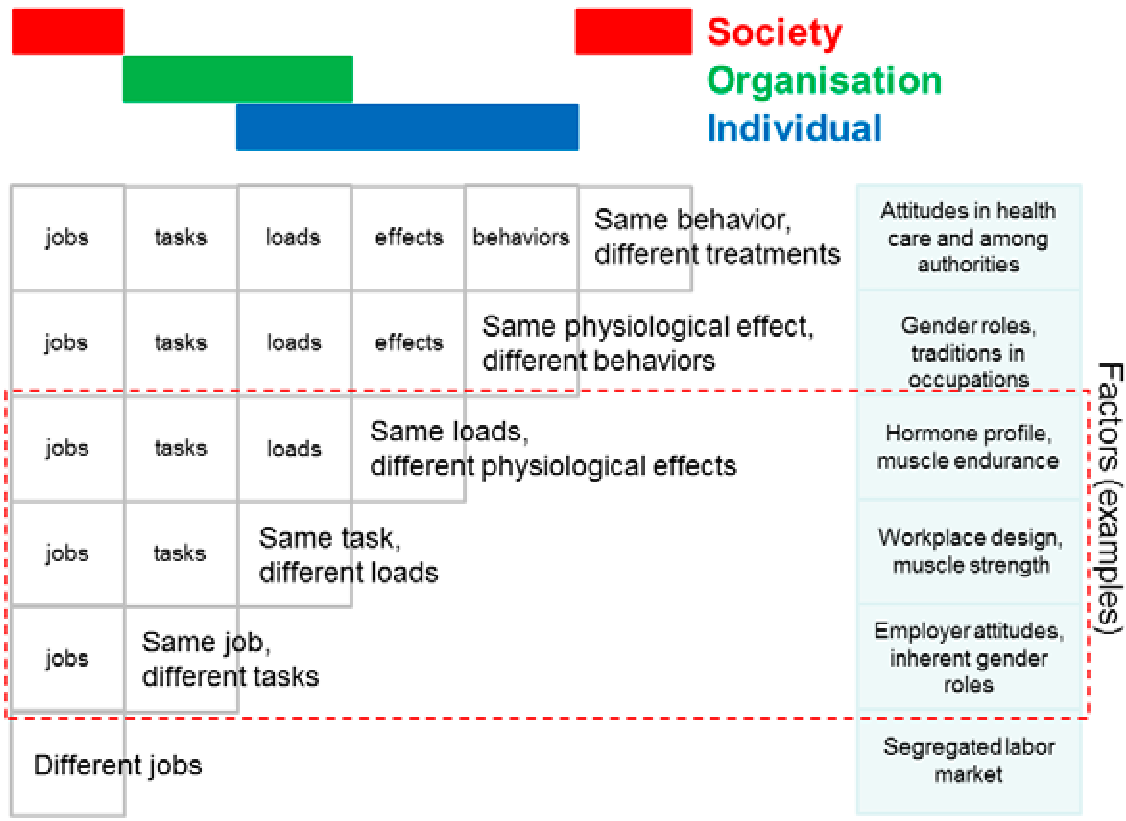

Figure 2: Schematic over possible "independent" steps in the explanation of why women have a higher occurrence of work-related musculoskeletal disorders than men. The fact that women and men have different occupations may contribute to explaining the difference in the occurrence of disorders (step 1). Even when men and women have the same occupation, there may be a difference in work tasks (2), which can further contribute to women having more disorders. Although men and women perform the same work tasks they may experience different loads, owing to such things as differences in strength and body size (3). Finally, although men and women work at equal loads, there may be a difference in physiological reactions (4).

"After" that, women and men may have different behaviours once a disorder has emerged (5), and may be treated in different ways, for example in health care or by the Swedish Social Insurance Agency (step 6). The cross-hatched box marks the steps that are in focus in this State of Knowledge Report.

2.3. Where is the knowledge, and what does it look like?

First, information on labour market statistics was sought in order to determine the extent to which men and women are found in different occupations. The next question was: *Do men and women do different tasks within the same occupation?* (see Figure 2). An answer to this question can be provided by epidemiological studies where the researcher have asked the workers themselves to report on the work tasks they perform, and to what extent. A few studies have used observations to get that same information. Epidemiological studies also often gather information on illnesses and disorders, for example pain in the back or the neck, and individual factors such as sex and age. Based on this, associations between factors at work and health outcomes are presented. Cross-sectional studies investigate both work and health at a single point in time, while longitudinal studies follow a population over a longer period, typically by registering exposures at a certain point in time and health outcomes during a period after that, up to several years in some studies. This provides more credible answers to whether factors in the work environment really lead to disorders. One disadvantage to epidemiological studies is that the information about the work is often quite rough, as it must be collected from a very large number of individuals. In the greater share of epidemiological studies on musculoskeletal disorders, physical work loads are assessed only through occupational title or through simple questions to the participants.

A number of occupation-specific studies draw the conclusion that women have a higher risk of injuries and disorders than men when they perform the same work tasks despite the fact that the researchers have not controlled for whether men and women do, in fact, perform the same tasks when they are in the same occupation (Taiwo et al., 2009). Similarly, Zetterberg and Öfverholm (1999) studied hand and wrist disorders in a large population of men and women who worked in assembling cars. They found that the women had more symptoms, both according to their subjective claims, and as determined by a clinical test. In contract to this, a study of over 800 men and women showed that repetitive work increased the risk of carpal tunnel syndrome more for men than for women (Giersiepen et al. 2000) Two different conclusions are thus drawn here, which could be due to the fact that the actual work tasks were divided in different ways between the men and the women in the two organisations studied. McDiarmid et al. (2000) made use of American registry data for six occupations considered to have a high risk of developing carpal tunnel syndrome: assemblers, blue collar workers (apart from construction workers), machine operators, guards and cleaners, butchers and meat-cutters, and data entry administrators. For data entry administrators, the researchers found no difference between the sexes in the risk for carpal tunnel syndrome. In the other five occupational groups, the researchers found that men had approximately half as great a risk as women, and suggested that the difference between the sexes in these five occupations was due to differences between the sexes in the actual work tasks, while for data entry administrators, it was not particularly likely that the work tasks varied between the sexes. Two North American studies on employees at larger hospitals suggested that the difference between the sexes in work tasks within certain occupational categories was the cause of differences in the occurrence of musculoskeletal disorders. This may very well be true, but both studies used occupational categories as the only measure of physical load. Safe conclusions on whether it is tasks, physical load within tasks, or differences in physiological responses that result in a difference in the occurrence of disorders between the sexes cannot really be drawn. There are, however, studies where more detailed surveys of actual physical loads allow more substantiated suggestions that differences in work tasks could be an important explanation to the gender difference in risk (Wiktorin et al., 1999; Vingård et al., 1999).

Apart from turning to epidemiological studies based on self-assessed information from men and women about their work tasks, information can be sought in observational studies. Researchers have gone out to workplaces and observed the various tasks in one or more occupations through video recordings or through observations on site. This yields more certain and more detailed information on work tasks.

Observation studies can also be used to answer the question: *Do men and women experience different physical loads when performing the same task*. Researchers then have the opportunity to observe work techniques and work postures out in the workplace in a standardised manner. The question can also be studied in a controlled environment where the researcher copies one or more work tasks, typically in the laboratory, and measures the exposure of interest, for example muscle activity or joint angles.

Controlled experiments are also suitable for studying the next question: *If men and women are exposed to equal physical loads, do they display different physiological reactions?*

The researcher then has the opportunity to arrange the load him- or herself and follow the physiological response – for example blood flow, endurance, and pain – in detail. The disadvantage of controlled studies in a laboratory is that the subjects are only followed for a shorter time – in the best cases, only a few hours. This is too short to follow the emergence of musculoskeletal disorders. The researcher then studies a physiological response that is presumed to have an association with the risk of developing injuries over a much longer time. Additionally, it is important to remember that reconstructing and controlling a particular work task in the laboratory often puts that task far from the loads of real life. Tasks vary substantially in working life, even in occupations that are considered highly standardized and constrained. In summary, different kinds of studies will be needed to get information on the three steps in the explanatory model discussed in this report (see Figure 2). Each kind makes its specific contribution to an understanding of gender differences in the emergence of work-related disorders in the musculoskeletal system, but each kind also has its own limitations.

This State of Knowledge Report is primarily grounded in a biological approach to the sexes. There are also other ways of regarding sex, including a social approach where sex or gender is seen as a social construct. The various approaches can overlap each other, for example when looking at muscle strength, which can be considered to be influenced by biology but also influenced by the effects of exercise during growth, which in turn is influenced by gender norms (Hammarström, 2005). The studies this report is built on do not rest on any gender theoretical foundations. In the selection of studies for the report, biological sex has instead been regarded as an interesting variable – sometimes the main focus, sometimes one of several variables of interest. Through a non-biological approach – gender theory, for example – increased insight can successfully be attained into the answer to why differences between women and men occur in working life. This report, for example, finds evidence in the literature that women and men in the same occupation perform different work tasks. The reason for work tasks being distributed differently between the sexes is obviously an important question to discuss, even from a non-biological starting point, but this lies outside the framework of this report.

2.4. Search strategies

This report used broad search strategies to find as much material as possible in order to answer its main question: Are there differences between the sexes in work tasks, physical loads, and physiological effects that could explain a higher occurrence of musculoskeletal disorders in women? Literature searches were run on PubMed, Cinahl, Web of Science, and Google Scholar. Where high-quality systematic review articles that were relevant to one or more of the questions in the report were found, they were used. Where this was not the case, the information was sought in original articles. Searches were run with a large number of search terms, for example "sex", "gender", "task", "occupational injury", "pain" and "muscle fatigue". Combinations of these terms were used; for example "gender AND muscle fatigue" and "gender AND pain". It turned out that many relevant studies containing data on both men and women were not found by these search terms because the authors had not indicated "sex" as a keyword for their articles, or had not taken up the aspect of the sexes in the abstract. The reference lists in articles of interest were therefore also an important source of additional relevant literature.

3. A labour market segregated by gender

Sweden's labour market is segregated, which results in men's and women's working environments looking different. Men predominate in craft, construction, and manufacturing, as well as in processing, machine operation, and transport (see Figure 3). Women are found primarily in service, care, and sales, as well as in offices and customer service. In occupations that require higher education, on the other hand, there is a more even distribution by sex (Arbetsmiljöverket, 2012a). Men are more spread out over the entire labour market than women are. Twenty-seven percent of all women are found in the five most common women's occupations, while only 15% of all men work in the five most common men's occupations. Nine percent of all gainfully employed women work as nurses, followed by personal assistants at 6 % (Danielsson et al., 2012).

The occupations dominated by men include physical loads such as heavy lifting, vibrations, and work with hand-held tools. Occupations dominated by women, apart from also including heavy lifting (primarily the health care occupations with handling of patients) are characterised by repetitive movements (processing work, cashier work). Using computers for a larger part of the work day is more common among women (Arbetsmiljöverket, 2012a). Many women (66-80%) in service, sales, machine operation, assembly and care report that they are physically exhausted after work at least one day a week. 62% of women teachers and recreation instructors also report this. The occupations in care involve contact with other people; in addition, they are often physically challenging, with heavy lifting and repetitive work tasks, but often also a strong mental component, which can express itself in an experience of physical fatigue. For men, on the other hand, traditionally heavy men's work is associated comparatively high levels of perceived physical fatigue, both in work that does not require special vocational training and among vehicle drivers (Arbetsmiljöverket, 2012

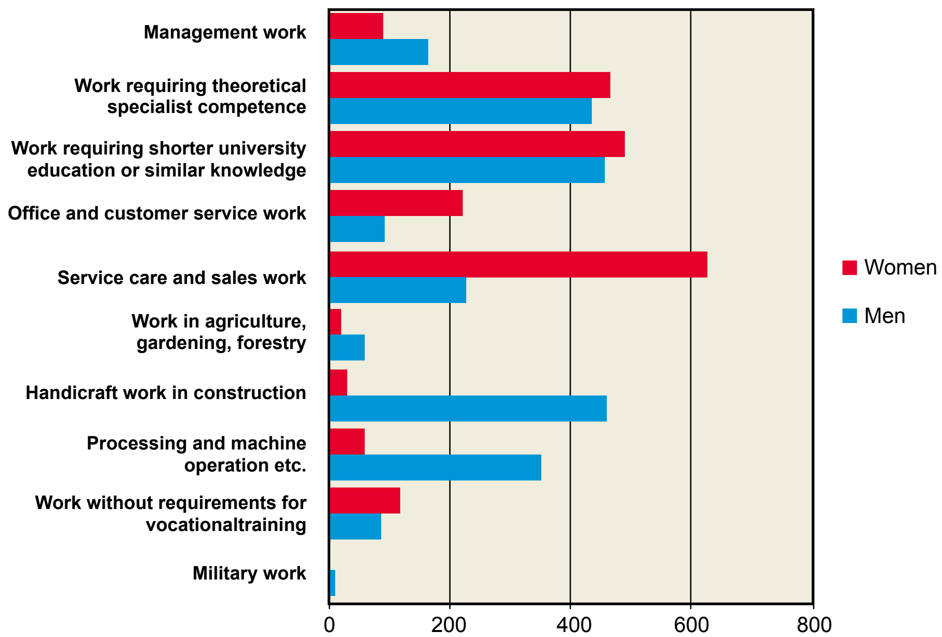

Figure 3: Number of women and men employed in Sweden, by occupation (Arbetsmiljöverket, 2012a).

3.1. Physical load in various occupations

Nearly one-third of all new cases of sick leave is due to musculoskeletal disorders. For both women and men, the number of new sick leave cases per 1,000 employees during 2009 due to these causes was highest in processing and machine operation (45 for women and 25 for men) and in occupations that have no requirements for vocational training (44 for women and 29 for men) (see Figure 4). Among women, there is also a high incidence of sick leave in service, care, and sales (34 per 1,000 employees). Nearly four times as many new cases of sick leave owing to musculoskeletal disorders occur every year among women employees in processing and machine operation than among women who work in management and executive positions. Among men, nearly six times more cases of sick leave arise among employees in occupations without a vocational training requirement than among men in the military, and nearly five times more than among employees working in occupations that require theoretical specialist competence (Försäkringskassan, 2011).

When SCB, on commission from the Swedish Work Environment Authority, investigated self-reported physical loads in typical women's and men's occupations using surveys, it was found that heavy lifting occurs more often in classic men's occupations than in women's (Arbetsmiljöverket, 2012a). Occupations where, in 2009 and 2011, daily lifting of more than 15 kg was commonly reported were construction and public works (56 %), work without a special vocational training requirement (39 %) and warehouse assistants (39 %). Occupations where women reported daily lifting of more than 15 kg were nurses and health care assistants (28 %), paramedics and personal assistants (28 %) and institutional housekeeping and restaurant staff (23 %) (Arbetsmiljöverket, 2012a). Despite the higher occurrence of musculoskeletal disorders among women, typical women's work is often regarded as being less physically demanding than typical men's work. But for example in the health care occupations, where women dominate, heavy lifting and moving of patients often occurs (as has been reported); both are considered risk factors for disorders, in particular in the low back (Punnett and Herbert, 2013).

Reports of heavy physical work are somewhat more common among men working in a profession (40 %) than women (35 %). Ninety-six percent of male construction woodworkers, and 87% of workers in agriculture, gardening, forestry and fishing reported working purely physically at least 25 % of the time. A similar workload, however, is also common among women hotel and office cleaners (81 %), industrial housekeeping and restaurant staff (78 %) and among nurses and health care assistants (76 %). Work in a twisted position, which is common both among service occupations (49-53 %) and construction and public works (60 %), displays no clear difference between the sexes. Work with arms lifted above shoulder level is common for men in construction and handicrafts (56-77 %), and also among women in service and sales (36-52 %). Repetitive movements, on the other hand, are most common in occupations dominated by women, such as service and the retail trade (57-78 %). For women in sales work, these brief repeated work movements occur combined with awkward work postures, while among men they are often combined with both heavy lifting and awkward work postures (Arbetsmiljöverket, 2012a).

Being able to sit down for at most 1/10 of working time is equally as common among men as among women, while sitting for long periods (sitting down and working for more than two hours at a stretch) is somewhat more common among men, and most common among vehicle drivers. Men are clearly overrepresented as regards exposure to vibrating hand-held tools (men: 15%, women: 3%) and cold (men: 22%, women: 10%) (Arbetsmiljöverket, 2012a).

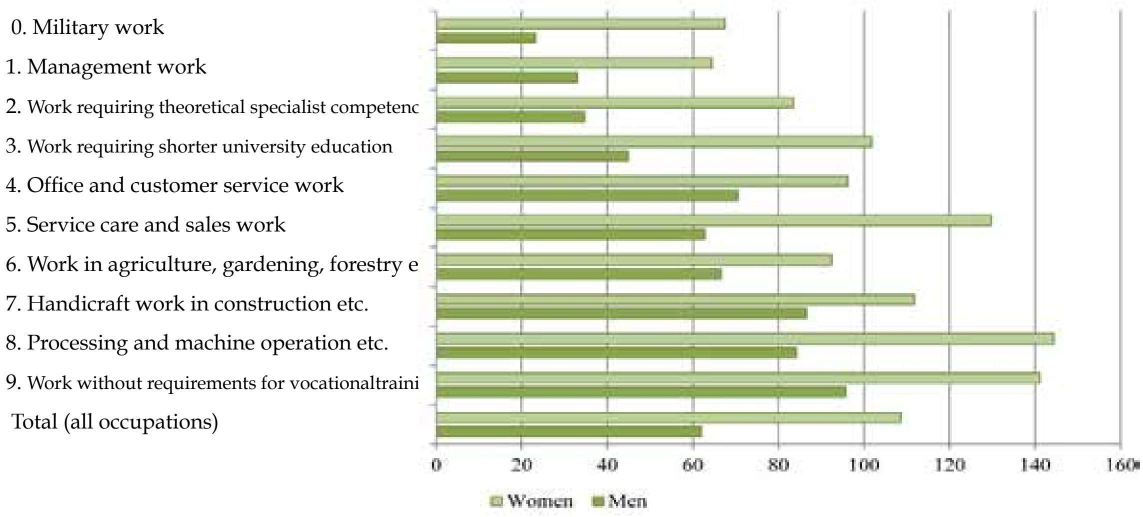

Figure 4: Sick leave (>14 days) initiated per 1,000 employed women and men in the respective work types during 2009 in Sweden (Försäkringskassan, 2011).

3.2. Workplaces dominated by women and men

In both male- and female-dominated occupations and workplaces the opposite sex is, of course, also represented. The working environment for both the majority and minority sexes has been investigated in a couple of studies. Karlqvist and Gard (2012) investigated ergonomics and musculoskeletal disorders in workplaces with more than 60% women and men, respectively, and found significant differences in the working conditions between men and women in both female- and male-dominated workplaces (Table 2). In occupations dominated by women, the women had relatively heavy work tasks compared with the men. Women in occupations dominated by men had lighter work, more sitting, and repetitive movements, especially for the hands and fingers, than men. Researchers only found two exposures that occurred significantly more among men in female-dominated occupations than among men in male-dominated occupations: standing for long periods (men in female-dominated occupations: 20 %, men in male-dominated occupations: 12 %), and sitting for long periods (men in female-dominated occupations: 35 %, men in male-dominated occupations: 28 %). More men in male-dominated occupations had a high occurrence of other exposures than men in female-dominated occupations. Among women there was a more uniform occurrence of physical exposures in male- and female-dominated occupations. The differences indicate that men and women in occupations segregated by gender have different work tasks.

The researchers (Karlqvist and Gard, 2012) also put employees into three categories: "working with people", "working with things", "working with data", and found in both male- and female-dominated occupations that significantly more men than women worked with things, such as machines. Women worked more with people than men irrespective of occupation. Working with people means that the job is governed by another person's needs, which can make it difficult to control one's own work pace, including taking breaks when needed. The physical loads are also more unpredictable in work with people than in work with machines. For example, lifting and moving in health care may entail a higher risk, as a person's movement patterns cannot be predicted in the same way as when lifting a box. This can be of significance for musculoskeletal disorders in female-dominated occupations.

Women in female-dominated occupations worked more with their hands above shoulder level than women in male-dominated occupations, while men to a greater extent worked with their hands above shoulder level in male-dominated occupations than in female-dominated occupations. This indicates that men and women do different things in these segregated workplaces. Finally, a low level of control combined with high demands (as a measurement of mental stress) occurs more among women in male-dominated occupations than among women in female-dominated occupations. This may show that women had more repetitive tasks in the male-dominated occupations. Men in male-dominated occupations, however, also had a high occurrence of mental stress, which suggests that male-dominated occupations in general are associated with higher demands and/or less control. It is also interesting to note that men in male-dominated occupations reported better mental well-being than both women in male-dominated occupations and men and women in female-dominated occupations (Karlqvist and Gard, 2012).

Table 2: Prevalence (percent) of various physical workloads in female- (>60% women) and male-dominated (>60% men) workplaces in three municipalities in Sweden (Norrköping, Finspång, Söderköping) (Karlqvist and Gard, 2012).

	Most women (>60%)		Most men (>60%)	
	Men (N=227)	Women (N=1487)	Men (N=1236)	Women (N=266)
Sedentary work	35 %	23 %	29 %	51 %
Computer work	39 %	30 %	35 %	60 %
Using a VDU	32 %	26 %	28 %	55 %
Standing for a long time	20 %	27 %	12 %	13 %
Moving	26 %	36 %	33 %	19 %
Sitting for long periods	35 %	24 %	28 %	34 %
Work on vibrating surface	7 %	3 %	37 %	16 %
Work with vibrating tools	14 %	6 %	46 %	13 %
Precision work	14 %	8 %	20 %	9 %
Work with hands above shoulder level	17 %	22 %	35 %	16 %
Work with hands below knee height	16 %	19 %	36 %	15 %
Repetitive hand and finger movements	29 %	31 %	30 %	56 %
Manually handling weights of 1-5 kg	39 %	49 %	51 %	41 %
Manually handling weights of 5-15 kg	26 %	34 %	48 %	22 %
Manually handling weights of >15 kg	27 %	33 %	45 %	17 %
Experience of high exertion	16 %	34 %	31 %	19 %

Leijon et al. (2005) investigated whether there was a difference in time sitting or standing, as well as the occurrence of uncomfortable work postures and movements of the arms and trunk in female-dominated, male-dominated, and mixed-gender occupational groups, and whether there were differences within these groups related to status and authority. The researchers collected direct measurements of physical activities during work and found that workers in female-dominated occupations had shorter periods of sitting than those in male-dominated occupations or mixed-gender occupations. There were also tendencies, though not statistically significant, towards the occurrence of work with the arms above shoulder level being higher in female-dominated occupations than in the other two occupational categories. The researchers also found that low status had a strong association with standing for long periods, work with the arms above the head, and work with the trunk bent forward. This association was clearest in the female-dominated occupational groups but was not seen at all in the mixed-gender occupational groups. Low status was suggested by Bryngelson et al. (2011) as being one part of the cause of the increased long-term sick leave for women within extremely male-dominated occupations (0-20 % women) and within extremely female-dominated occupations (80-100 % women) in comparison with the mixed-gender occupations. On the other hand, men's risk of long-term sick leave was not impacted by status in the same way. High physical load seems to occur in parallel with high mental stress in female-dominated occupations, and this interaction also seems to be clearer among women than among men (Josephson et al., 1999).

3.3. Mental loads

Convincing research confirms that mental loads experienced as stressful can give rise to or reinforce musculoskeletal disorders (Lundberg, 2002). It is therefore important to be attentive to whether stress occurs in the job, either together with physical loads or without any especially heavy physical requirements.

Swedish statistics show that nearly two out of three gainfully employed people feel their work is hectic. In the 45–65 age range more women than men think this way. In relation to the level of education, women with a post-secondary education report to have a stressful job to a greater extent than men with a similar education. White-collar workers have a higher occurrence of perceived stress than blue-collar workers, and those who have some sort of executive position are clearly overrepresented with eight out of ten feeling their job is hectic (SCB, 2012a).

The feeling that the work pace is controlled is more common in female-dominated occupations. Sixty percent of women and forty-four percent of men reported that they can influence their work pace during at the most half of their working time (Arbetsmiljöverket, 2012a). This is primarily common in occupations where the work tasks are largely controlled by other people's needs, for example in health care. It is also common within the teaching profession.

Furthermore, four out of ten asked experience that they have mentally strenuous work, something that more women than men report (women: 48 %, men: 37 %). The differences between men and women are greatest for trained specialist workers and upper civil servants. It is primarily within the municipal and county sector that a large proportion (six out of ten) feel that their work is mentally exhausting, in comparison with 35 % in the private sector. Health care (66 %) and education (57 %) are the two occupations where most people feel they have mentally strenuous work (SCB, 2012a). It is more common among women than men to have the feeling almost every day that the work can't be done well enough, and to have a job where one encounters strong feelings from others on a daily basis (SCB, 2012a).

3.4. Key points

- Sweden's labour market is segregated to a great extent. Typical men's occupations involve heavy lifting and work with machines and vehicles, while women's occupations involve heavy lifting, repetitive movements, and human contact.

- In gender-segregated occupations, men's and women's tasks differ owing to whether it is a male- or female-dominated workplace. Women have heavier work tasks such as lifting in the female-dominated occupations, and more of sedentary, repetitive tasks in the male-dominated occupations.

- More women than men report that they have a mentally strenuous job due to stress and lack of control, especially in health care.

- Gender segregation on the labour market likely contributes to differences in physical and mental load. This can, in turn, be an important explanation of the differences between the sexes in the prevalence of work-related musculoskeletal disorders.

4. Same occupation – different work tasks?

Even though men and women have the same occupation, it may be that they perform different work tasks, which in turn leads to different loads and thereby different risks of developing musculoskeletal disorders (see Figure 2).

4.1. Segregated work tasks

Messing et al. (1994) showed that women and men with the same occupational title within blue-collar occupations in Canada did not always perform the same types of tasks. Over half (52 %) of the women reported they had other tasks than their male colleagues. Ten women (mostly cleaners) reported that women performed tasks that required more attention and high quality, and 17 women (mostly gardeners) reported that men performed tasks that required more physical strength. The work tasks were analysed more carefully in a subgroup consisting of 21 men and 22 women gardeners. Forty-four percent of this group reported differences between the sexes in work tasks. Women performed repetitive tasks such as pruning, planting, and trimming, while men performed heavier tasks such as pushing wheelbarrows, and they used machines to a greater extent.

Nordander et al. (1999) showed clear differences in women's and men's work tasks and physical load within the Swedish fish processing industry. The most common tasks for women were cleaning of fish manually and using machines, and packaging. This comprised 82 % of the women's total working time. The men worked primarily at the fish-cleaning machines and in the warehouse, handled boxes of fish and maintained the mechanical equipment. This comprised 85 % of the men's total working time (see Table 3). The researchers' assessment of physical loads showed that the typical "woman's" work tasks were characterised by repetitive movements and poor work postures. The men's work tasks showed substantially greater variation in physical load, since the "man's" work tasks differed much more. For example, there were great differences in load between maintenance work and work at the codfish-cleaning machines. Twenty-five percent of the men's working time comprised work with low physical exertion; 35 % of the time was spent in heavy lifting (>25 kg). Women spent 63 % of their working time in awkward or very awkward work postures for the neck during handling of light objects (<1 kg) with a work cycle time of less than 10 seconds. For 25 % of their working time, they handled material weighing more than 5 kg with a cycle time of 10-60 seconds. Women also had a worse psychosocial working environment and reported lower levels of control, lower stimulation at work, more often combinations of high demands and low control, worse social networks at work and a higher occurrence of stress and anxiety related to work. The prevalence of disorders in the neck, shoulders, elbows and hands was almost three times higher among women than among men.

Table 3: Proportion (in percent) of total working time in the six most common tasks in a fish processing factory, for men and women separately (Nordander et al., 1999).

Work task

Sex	No.	Cod machine	Trimming of cod	Herring machine	Packing	Supply, removal	Mainten ance	Total
Men	116	15 %	1 %	1 %	11 %	34 %	36 %	98 %
Women	206	3 %	32 %	11%	39 %	6 %	6 %	97 %

Messing et al. (1998a) studied cleaners at a hospital in Canada where work was categorized into "heavy" and "light". In general, "heavy work" was characterised by neutral work postures, walking, and repetitive movements that included handling a 1-6 kg mop. "Light work" was characterised by bent work postures, walking, and quick repetitive movements where the workers had to lift light objects (dusting) or a somewhat heavier object of about 1-3 kg (emptying dustbins). It was almost exclusively men who performed "heavy work", while women performed "light work".

In another study, the same researchers investigated work tasks at 17 poultry slaughterhouses and 6 food factories in France, and found that men and women had different exposures to several ergonomics risk factors. More women than men reported performing highly repetitive (≥ 30 repetitions per minute) tasks (women: 24 %, men: 16 %) and sitting down a lot (women: 7 %, men: 4%). Women also reported work in colder environments to a greater extent than men (women: 58 %, men: 39 %) while men reported more work in varying temperatures, something that was due to their often moving among different locations in the workplace. Men and women performed different work tasks. The men worked with manual handling, slaughtering and supervision, while cleaning, weighing, preparation and cooking were often performed by women. Men worked more and more irregular hours per week (Messing et al. 1998b).

In another Canadian study of 661 employees at 9 poultry slaughterhouses (Mergler et al., 1987) more women than men reported musculoskeletal disorders in the hands (women: 68 %, men: 45 %), shoulders (women: 48 %, men: 36 %), upper back (women: 68%, men: 45 %), legs (women: 71 %, men: 57 %) and feet (women: 48 %, men: 36 %). More women than men also reported that their work involved standing still (women: 76 %, men: 58 %), repetitive tasks (women: 94 %, men: 85 %), and more than 60 movements per minute (women: 24 %, men: 15 %) while more men than women reported that they moved a lot (men: 42 %, women: 24 %,) drove trucks (men: 19 %, women: 2 %) and lifted (men: 62 %, women: 33 %). Men and women with the same work tasks did not distinctly differ in the occurrence of disorders.

Hooftman et al. (2005), in one study of a large group of office workers and assembly workers in the Netherlands, found differences between the sexes in self-reported physical loads (Table 4). More men than women in assembly work reported that they lifted frequently or very frequently in their work, both weights heavier than 5 kg and weights heavier than 25 kg. More women than men among office workers reported that they worked with their arms above shoulder level, while the reverse pattern was displayed among assembly workers.

A significantly larger proportion of women than men among office workers reported that they frequently, or very frequently, worked in twisted and bent work posture, while the reverse pattern was reported among assembly workers. A higher share of women than men reported that they often worked with the neck bent forward, both among office workers and among assembly workers. Also repetitive work with the hands figured more frequently among the women than among the men in both occupational groups. More women than men working in offices reported that they often had to work with a rotated neck and a bent wrist. In one group of 24 Swedish office workers, on the other hand, Balogh et al. (2004) reported no differences between the sexes in self-reported work postures, movements and manual handling, and did not find differences either when physical loads were measured with technical equipment.

Table 4: Self-reported physical loads (percent of those asked) for men and women in a Dutch study of assemblers and office workers (Hooftman et al., 2005).

	Assembly work		Office work	
	Women (n=200)	Men (n=218)	Women (n=142)	Men (n=273)
Lifting (>5 kg)	34 %	80 %	2 %	4 %
Lifting (>25 kg)	9 %	32 %	1 %	1 %
Arms above shoulder level	21 %	31 %	4 %	0.4 %
Rotated or bent upper body	54 %	81 %	44 %	28 %
Neck bent forward	87 %	59 %	85 %	71 %
Rotated neck	53 %	57 %	63 %	41 %
Repetitive work with the hands	93 %	73 %	63 %	54 %
Bent wrists	69 %	61 %	40 %	31 %

Karlqvist et al. (2002) studied men and women office staff using a comprehensive questionnaire and found differences between the sexes in the occurrence of disorders in the back, shoulders, arms, and hands. The highest occurrence of disorders in all bodily regions was found among women call centre operators. Even in the occupational category with the most men, i.e. engineers (134 men, 53 women), a larger proportion of women reported that they had disorders in the neck and shoulders. In the largest occupational category for women, insurance clerical workers with 149 women and 20 men, a larger proportion of women had symptoms in the neck, shoulders and upper arm than men. The survey showed that more women than men sat at least twice a week at a computer for more than 3 hours at a stretch without a break (women: 19%, men: 12 %). Among men, the variation in work tasks at the computer was also greater. The most common task for both men and women was writing and text editing, but more women than men performed simple text or data entry (women: 51 %, men: 38 %), that is, a repetitive task. Apart from computer work, work tasks performed more than 30 minutes per day were desk work (70 % of the men), meetings, seminars, and discussions with colleagues (48 % of the men) and telephone calls (43 % of the men). For women, the corresponding predominant tasks apart from computer work were desk work (60% of the women) and telephone calls (43 % of the women). 26 % of the men and 18 % of the women had more than two different types of tasks at the computer, each of which lasted more than 30 minutes per day. Men used more time for e-mail and searched for more information on the Internet than women. A Danish field study of 24 women and 11 men with administrative work reported that women used the keyboard more and tended to click the mouse less often, while the researchers did not find any significant difference between the sexes in muscle activity in the neck or lower arms for people in the same department (Blangsted et al., 2003).

In a study of over 500 women and men who worked in a Swedish automobile factory, 1.2 - 1.5 times more women than men reported that they performed precision movements, repetitive finger movements, repetitive hand movements, flexion and extension of the wrists and handling of objects weighing between 1 and 5 kg for more than four hours per day (Fransson-Hall et al., 1995). The women reported using hand tools to a lesser extent than the men. Dahlberg et al. (2004) showed that men in a metal factory took more short breaks from work than women, and devoted a larger part of their time to diverse activities such as moving without external load, writing, handling materials that weighed less than 1 kg, and pushing buttons.

In a large epidemiological study from New Zealand, researchers interviewed 3,000 gainfully employed workers by telephone. They found that twice as many men as women reported that they were exposed to dust, chemicals, noise, irregular shifts, night shifts, and work with vibrating tools. Thirty percent more women than men reported that they had repetitive tasks and worked at a high pace, and were exposed to disinfectants, hair dye and textile dust. When men and women within the same occupation were later compared, the differences decreased somewhat but it was still found that the men were exposed more to certain chemical products, worked more on night and irregular shifts, and worked more with vibrating tools. More women had work that was repetitive and required a rapid pace. In addition, women reported more awkward and strenuous work postures than men in the same occupation (Eng et al., 2011).

In a study of cleaners at a Canadian hospital, the researchers proposed a number of improvements to the working environment, which would, among other things, make it possible for women to manage the tasks that have been categorised as heavy (Calvet et al., 2002). The researchers then compared working conditions before and twelve years after the proposed changes. Some segregation by sex of the work tasks remained after the 12 years. Previously, cleaning tasks had been divided into light and heavy tasks, where the men were assigned the heavy tasks and the women the light ones. Despite this division being removed, many differences between the sexes remained regarding which tasks the cleaners performed. The men worked night shifts to a great extent, which they themselves often explained by saying that they avoided working with people, while the women worked in the daytime and had to adapt themselves to a great extent to both colleagues with other work tasks and to patients. The men operated more machinery for cleaning and waste handling, while the women dusted and cleaned the toilets more. Both employees and management explained in interviews that gender-stereotypical roles were the most substantial reason for the persistent division of work tasks. After the removal of the distinction between heavy and light work the proportion of women cleaners decreased, something that may have been due to them feeling they couldn’t manage the heavy work tasks that the job now involved. After twelve years, the hospital had only accomplished one-third of the work environment improvements recommended by the researchers.

4.2. Mental loads in the same occupation

Chapter 3.3 argued that stress and a controlled work pace was more prevalent in female-dominated occupations. But more women experience this even when women and men in the same occupation are compared. 83 % of women and 73 % of men high-school teachers in 2011 reported to experience a controlled work pace. Among health care staff, corresponding numbers were 79 % of the women and 65% of the men. As presented in Chapter 3.2, women work more with people, both in female-dominated occupations and male-dominated occupations. It is possible that working with people, among health care staff for example, gives rise to an increased feeling of controlled work pace compared to working with, for example, machines.

In a group of assembly workers and a group of office workers, the men reported greater control over their work than the women (Hooftman et al., 2005). Women assembly workers reported higher work demands than their male colleagues. In both occupational groups, repetitive work with the hands was more prevalent among women than among men, which may be associated with the feeling of low control for the women.

4.3. Key points

- Research clearly shows that men and women in the same occupation often perform different work tasks.

- Women perform more repetitive and hand-intensive work, while men perform more heavy lifting and work more with machinery.

- As repetitive, monotonous work in many studies has been associated with disorders in the neck and shoulders, different work tasks for men and women in the same occupation presumably contributes to a great degree to explaining the higher occurrence of disorders in the neck, shoulders and arms among women.

- In health care, women work with people to a greater extent than men do, which can involve both heavy physical work and high mental stress. This could explain why women have more disorders than men in these occupations.

5. Same tasks – different loads?

In the previous chapter, we showed that the occurrence of musculoskeletal disorders differs between men and women in the same occupation and that an important cause in many cases may very well be that men and women perform different work tasks, despite having the same occupational title. Studies, for example of orchestral musicians and air traffic controllers, have, however, shown that disorders in the neck and arms occur more among women even though women and men in these occupations perform the exact same work tasks (Arvidsson et al., 2006; Paarup et al., 2011). Asking whether women and men with the same work task are exposed differently owing, for example, to differences in size and strength, is thus justified (Figure 2).

5.1. Anthropometry and work postures

The stature of women on average is approximately 90 % of men's (SCB, 2005). There is no evidence that stature in itself is a risk factor for developing musculoskeletal disorders, but as many work stations and work tools are constructed to suit the average man, it could contribute to the average woman (and the shorter man) working in less favourable work postures (Leijon, 2011). Dahlberg et al. (2004) studied working techniques among men and women who performed the same tasks in a metal factory. Women handled materials with their hands at and above shoulder level more often than men did – on average 72 times per hour compared with 56 times per hour for the men, something that could be due to the difference in stature between men and women. The women worked approximately 8% of the observed work time with their arms at or above shoulder level, while men worked in this position approximately 6% of the time. Expressed over a working day, this means that women worked in this unfavourable posture for 34 minutes, and men for 27 minutes. Kennedy and Koehoorn (2003) studied all the employees at a large emergency hospital, and in their observations of men and women dietary aids – where both men and women worked with food preparation and meal planning for patients, for example – found that women worked with their arms stretched out in front of their bodies or with their arms out to the side more than men did, despite the work tasks being identical.

In a controlled laboratory study O'Sullivan and Gallwey (2002) investigated differences between the sexes in work postures for the elbows and shoulders in a number of assembly tasks at three different distances from the subjects. The men lifted their arms more, while the women had greater elbow flexion. The women's work posture depended on the distance to the task, while the men were not impacted by this to as great a degree. This could be explained by the fact that women's reach is more limited; the study indicates that this limited reach could lead to an increased occurrence of work in non-neutral work postures.

Messing et al. (1998b) found, in one study of workers at food factories, that women reported work stations not being adapted to the size of their bodies to a greater extent than men did (women: 18.5 %, men: 8.1 %). The researchers found this (lack of) accommodation to be associated with sick leave; if the work station was not adequately adapted, sick leave was doubled.

In a literature review, Dutch researchers concluded that there is clear evidence that the association between self-reported uncomfortable work postures for the arms and disorders in the neck and shoulders is stronger for women than for men (Hooftman et al., 2004). But when the same researchers then followed a group of women and men for three years in order to study the association between physical risk factors and disorders, it turned out that work above shoulder level entailed the same risk for men and women of developing neck and shoulder disorders (Hooftman et al., 2009). A study by Anders et al. (2004) measured the activity in the shoulder musculature during brief (five-second) static shoulder contractions in 24 different work postures in the shoulder joint. The study showed that women activated the primary muscle to a lesser degree than men did. On the other hand, women activated muscles that were not directly necessary for holding the arms in position to a greater degree than men did; men were therefore described to have a more "economical" activation pattern. This higher level of activity in stabilising, non-primary muscles could increase the risk of disorders in the shoulder region among women who work with their arms lifted.

5.2. Muscle strength

It is generally known that women, on average, are weaker than men. If an average of several muscles is taken, women's strength is approximately 60 % of men's, but different studies show a large dispersion – between 20 % and 83 % – depending on muscle group and study population (Chiu et al., 2002; Frontera et al., 1991; Murray et al., 1985; Sepic et al., 1986). The difference in strength between men and women is greatest in the upper extremities, where women on average have 45-55 % of men's strength, while strength in the legs does not differ as much (women 60-70% of men) (Bohannon, 1997; Frontera et al., 1991). In a study from Hong Kong, women's neck strength showed to be 59-83 % of men's depending on the direction of movement (Chiu et al., 2002). As regards grip strength in the hands, women are at around 60% of men. This difference in grip strength remains with increased age (Mathiowetz et al., 1985a). All these results are averages; many women are stronger than many men. In addition, the differences in strength are smaller when men and women undergo physical training to the same extent or have similar occupational backgrounds (Leijon, 2011).

Grip strength has been proven to vary with the body's posture, which means that if men and women work in different work postures, the differences in grip strength can increase or decrease (Mogk and Keir, 2003; Balogun et al., 1991; Hendriksen, 2011; Mathiowetz et al., 1985b). A study of grip strength showed that up to 9 % of the maximum strength in the musculature of the forearm was needed just to hold the measuring instrument used to measure strength, which can be compared to the muscle activity when simply holding a tool (Mogk and Keir, 2003). Women therefore had to engage 2-3 % more of their maximum strength to hold the apparatus than men did, which indicates that women in general must perform to a higher degree of their capacity than men when handling tools.

It has been suggested that differences in muscle strength between men and women depend mainly on differences in the cross-sectional area of the muscles (Maughan et al., 1983), but the morphology of muscle fibres can also play a role. Studies where muscle tissue samples were analysed have shown that women have somewhat greater relative areas of Type I muscle fibres – which have good endurance but are relatively weak - in the thighs (women: 44 %, men: 36 %) and the back (women: 68 %, men: 62 %). Men have more of the fast and stronger Type IIA fibres in their thighs (men: 41 %, women: 34 %) (Staron et al., 2000; Mannion et al., 1997). A corresponding difference between men and women has also been observed for the upper part of the trapezius muscle, even though it was small (Lindman et al., 1991; Lindman et al., 1990).

The difference in muscle strength can lead to women being forced to get closer to their maximum capacity when working with a given external load. Being closer to maximum capacity means that the possibilities of varying the working technique become more limited and that the risk of overloading the muscles and joints could increase. As Leijon (2011) points out, great muscle strength does not necessarily mean great strength in other anatomical structures, for example the discs between the vertebrae, and that great muscle strength does not therefore necessarily protect against disorders.

5.3. Lifting, pushing, and pulling

Hooftman and Poppel (2004) concluded in a review paper that there is strong evidence for men having a stronger association between heavy lifting and the risk for back disorders than women do. This is further supported in a study by the same authors on a group of gainfully employed men and women for three years (Hooftman et al., 2009). In that study, however, the researchers divided lifting coarsely into light (>5 kg) and heavy (>25 kg) and did not specify other factors such as lifting technique or lifting speed. It is likely that men and women have different techniques when lifting the same weight. In a controlled laboratory study, Lindbeck and Kjellberg (2001) found that women's hip and knee angles were more in phase – that is, more "coordinated" – during the entire lift than men's. In the initial phase of the lift, men extended their knees more quickly than they did their hips. Whether this would have an impact on the risk of suffering disorders, for example in the low back, is not clear.

Ciriello (2007) studied the influence of lifting frequency and lifting technique on the weight considered by women to be acceptable for an entire day of industrial work. There were certain differences between the sexes when comparing with the results for men in an earlier study (Ciriello, 2003). An increased number of lifts per minute reduced the acceptable weight of the load for both men and women. Both the frequency and other factors such as the size of the box to be lifted and the work posture (lifting close to or far away from the body) influenced the acceptable load to a greater extent for men than for women. This may have to do with the fact that men generally chose to lift loads 1.8 times heavier than the women did, and were thus influenced more by the changed conditions for performing the work. Thus, lifting behaviour seemed to differ between men and women, and this can be assumed to influence the risk of suffering both musculoskeletal disorders and acute injuries.

In a review article, Hoozemans et al. (1998) concluded that men can generate greater pushing and pulling forces than women. When men and women were asked to push a cart in front of them as hard as they believed they could, the women's pushing force at the start of the push was only 60 % of the men's (Resnick and Chaffin, 1995). Women and men in the studies included in Hoozeman's review article, however, had different weights and heights. Since there is an association between body size and pushing and pulling force, this can explain a part of the difference in working techniques (Hoozeman et al., 1998). This explanation was investigated in a study by van der Beek et al. (2000) where men and women pushed and pulled a wheeled postal container. Even when the researchers corrected for personal factors such as weight, height, maximum strength and maximum oxygen uptake, the men exerted a significantly higher average force throughout the entire task and greater force in the deceleration phase, than the women. The researchers found that the women took longer time to move the cart, presumably in order to compensate for their lower strength. This adjustment of pushing force and speed had previously been observed by Resnick and Chaffin (1995) in a study of two women (weak / moderately strong) and two men (moderately strong / strong). Additionally, for both men the estimated compression in the discs of the lower back exceeded the limit value of 3,400 N proposed by NIOSH, the American institute for working life, which was not the case for women.

Marras et al. (2009) confirmed that higher speed was associated with greater development of force in pushing. Shear forces - that is forces that run perpendicular to the longitudinal axis of the back - increased substantially at increased speed. At 43% increased speed, shear force in the lower back increased by 26-30%. As other, previously mentioned studies (van der Beek et al., 2000; Resnick and Chaffin, 1995) show that men often use a higher speed in their work than women, this could mean an increased risk of back problems for men during manual handling (Marras et al., 2009).

Thus there seems to be differences in behaviour between men and women as regards manual handling. This can in turn be an expression of masculine norms, as was discussed in the Swedish Work Environment Authority's State of Knowledge Report on gender perspectives in work environments and work organisation (Arbetsmiljöverket, 2013). It is considered manly to be strong and dominant, and men may therefore find it difficult to set limits on the loads they take on. This difficulty in setting limits may also occur for women when transferring patients in health care, as studies have shown that women are often acutely injured during these transfers (Saleh et al., 2001).

Marras et al. (2009) also showed that lower handle heights (50 % of body length compared with 60 % and 80 %) produced higher shear force in the back. This could be a greater risk factor for men, who are on average taller than women. Lin et al. (2010) measured the developed force and the muscle activity in men and women who had to push and pull various carts in front of them in the laboratory. The direction of force, the height of the handles and the weight of the cargo impacted both force and muscle activity. The study found no statistically significant differences between the sexes, even though the women had somewhat larger muscular activity than the men in the upper trapezius (in the shoulder), the anterior deltoid (on the front of the shoulder) and the flexor carpi muscles (wrist flexors) in the lower arm. There was no muscle activity difference for the lower back.

5.4. Repetitive work

In a review article, Hooftman et al. (2004) concluded that it is unclear whether women have a higher risk than men for neck and shoulder disorders or hand and wrist disorders when both sexes perform the same repetitive work. Nordander et al. (2008) measured work postures, movement patterns and muscle activity in men and women engaged in identical repetitive work in rubber production and assembly. Work postures and movement patterns did not differ between men and women, while the women had higher relative muscle activity in the scapula (women: 18 % of maximum; men: 12 % of maximum) and the lower arm (women: 39 % of maximum; men 27 % of maximum). Furthermore, women had an approximately 2.5 times greater occurrence of disorders in the neck and arms than men did, even after the researchers adjusted for differences, for example in household work and physical activity in leisure time.

In a further study of differences between the sexes in repetitive work, Nordander et al. (2009) compiled epidemiological data on musculoskeletal disorders in 40 female and 15 male occupational groups. The study both confirmed that the women had a higher occurrence of musculoskeletal disorders than the men in the far majority of occupations, and showed that for both sexes the risk for disorders increased to an equal extent in occupations with repetitive work tasks compared with occupations offering a more varied work.

Johansen et al. (2013) studied men and women during a repetitive task folding boxes. The women had greater muscle activity in the upper trapezius (5.3 % of maximum) than men (3.2 % of maximum) and more pronounced coordination between different parts of the trapezius muscle. This indicates that women made use of another motor strategy than men did to perform the repetitive task.

A laboratory study on the effects of exposure to cold during repetitive work on eight women and eight men showed that women generally had greater muscle activity than men. Exposure to cold increased muscle activity only in men, in the forearm and in the elbow extensor muscles (Sormunen et al., 2009).

5.5. Computer work

Women computer users have been reported to have a greater risk of disorders in the neck, shoulders and arms than men computer users (Tornqvist et al., 2009; Juul-Kristensen et al., 2004; Karlqvist et al., 2002). A Danish study of 24 women and 11 men with administrative work showed that women used the keyboard more and tended to click the mouse less often than men, while the researchers did not find any difference between the sexes in muscle activity for people in the same department (Blangsted et al., 2003). On the other hand, the researchers found that secretaries (six women) had significantly higher static muscle activity than the rest of the participants. This indicates that difference between the sexes in physical load for office workers is due rather to the content of the work than to gender per se. A study of operators at Swedish call centres showed that both men and women average employees were sitting for more than 80 percent of the working time (Toomingas et al., 2012). The women spent an average of 11% of their working day in uninterrupted periods of more than an hour sitting down, while for men it was only 4.6 % of the working day. The women had fewer changes between sitting and standing or walking than the men did, and spend longer periods sitting before they stood up or walked for at least ten minutes (women: 72.5 minutes, men: 60.1 minutes). The women, in other words, had less variation in their work postures than the men did. The researchers suggested that this reflected differences in work behaviour and that it could be an explanation of why women in occupations with a great deal of computer use report more musculoskeletal disorders than men in the same occupation.

In an experimental study, Karlqvist et al. (1998) had men and women perform a standardised task with a computer mouse at a standardised work station. The researchers saw that people with narrower shoulders worked with their wrists and arms rotated outwards to a greater extent. As women are, on average, smaller than men, this could contribute to women working more often in awkward postures when working at a computer. Won et al. (2009) showed in a similar laboratory study that women used 2.3 % of their maximum strength when working at a keyboard, whereas men only used 1.5 %. The women also had greater muscle activity in the muscles of the forearm. The women's median muscle activity in the extensor muscles was 6.6 % of the maximum while that of men was 3.8 %. For the flexor carpi muscles, the activity was 15.0% for women and 8.1 % for men. In addition, the women had a greater range of motion in wrist extension (women: 16.3 degrees, men: 13.3 degrees), and shoulder rotation (women: 35.0 degrees, men: 14.2 degrees). Body size had a strong association with these variables, and the authors address the fact that one single computer work station does not suit all individuals. In a similar study, Wahlström et al. (2000) investigated work with a computer mouse. The women used a higher relative force in clicking the mouse (women: 4.6 % of maximum; men: 2.9 % of maximum) and also worked with greater relative muscle activity in the finger muscles (women: 11.3 % of maximum; men: 7.6 % of maximum). On the other hand, men had greater muscle activity in the trapezius muscle. The women also worked with greater movements in the wrist (wrist extension/flexion: 21.8 degrees compared with 15.9 degrees; lateral flexion: 21.7 degrees compared with 16.8 degrees).

Greater muscle activity in the wrist extensors for women was also seen in a study by Yang and Cho (2012) where the subjects worked with a keyboard and computer mouse under standardised, experimental conditions. When working with the keyboard, the women had muscle activity in the finger extensors of 0.25 % of maximum, and the men 0.16 % of maximum. When working with the computer mouse, women had 0.22% of maximum while the men's activity was 0.14 % of maximum. These levels, however, are so low that it is doubtful they can be distinguished from the noise level in the EMG signal and thus be regarded as biological signals. No difference between the sexes could be seen in muscle activity in the shoulders. The men had greater neck flexion when working with the keyboard than women did (men: 83.0 degrees; women: 77.3 degrees). When working with the computer mouse, men had their upper arms drawn further back (men: 30.4 degrees; women: 20.7 degrees), their elbows more bent (men: 113.1 degrees; women: 102.2 degrees) and greater lateral flexion in the wrists (men: 23.5 degrees; women: 19.7 degrees). The authors suggested that differences in body size were the cause, despite the work station being adjusted to suit the subject – but perhaps not to the extent necessary.

Lindegård et al. (2003) found, like the studies above, that women used greater force in clicking the mouse, but found no differences in muscle activity either in the hands, arms, or shoulders, or in the work postures of the arms and hands. A study of air traffic controllers who primarily worked in front of a computer screen – work that was identical for men and for women – presented an occurrence of neck and shoulder diagnoses that was twice as high for the women as it was for the men. No difference between the sexes could be demonstrated as regards muscle activity, whereas the women worked with the wrist bent more upwards. The women experienced less decision latitude than the men; the authors suggested that this could be an explanation for the higher occurrence of disorders among women, as the physical load was so similar between men and women (Arvidsson et al., 2006).

5.6. Motor variability

Even though a person tries to repeat the same movement again and again, such as in a gait stride or in an assembly cycle, there will be differences in both movement and muscle activation patterns between repetitions (Srinivasan and Mathiassen, 2012). This is called "motor variability" and is a result of how the brain controls a person's movements. It has been suggested that the ability – or lack thereof – of an individual to utilise his or her intrinsic motor variability is a contributory explanation to some people developing musculoskeletal disorders when doing work that others manage to do without problems (Mathiassen, 2006; Mathiassen et al., 2003). Differences between the sexes in motor variability have not been studied to any great extent. Svendsen and Madeleine (2010) studied force variations during an endurance test for the elbow flexor muscles. Different types of static contractions were performed, and the researchers found that the force during a maintained contraction varied less for women than for men. Even if this is only the result of one study, it could mean – if the result is confirmed in future studies and for other work tasks – that women run a greater risk of overloading certain structures in repetitive work. Since women are overrepresented in occupations of a repetitive nature, differences in motor control could be an additional contributing cause of why women in these occupations develop disorders to a greater extent than men.

5.7. Key points

- Differences between the sexes in bodily dimensions contribute to women often working in unfavourable work postures, since work stations have often not been sufficiently adapted for women.

- Differences between the sexes in behaviour during lifting, pushing and pulling have been presented in several studies. Men, who in general are stronger, tend to lift, push, and pull heavier weights (even relative to their maximum capacity). Women choose alternative strategies to manage heavy handling tasks, such as adjusting their work pace. This may be a contributory explanation for men catching up on women in the occurrence of low back disorders.

- Some studies show that women work with greater relative muscle activity in the shoulder and arm during repetitive work than men do, which could contribute to an increased risk of musculoskeletal disorders for women.

- Greater muscle activity in women has also been shown during computer work, but only in the forearms, not for the shoulders. The differences between the sexes are small, and the extent to which it could contribute to musculoskeletal disorders is uncertain.

- All together, this chapter shows that women in some, but not all, work tasks are exposed to somewhat larger loads than men. This could contribute to the occurrence of musculoskeletal disorders, but is probably not a very strong cause.

6. Same physical load – different reactions?

As men and women are subjected to similar physical loads in their work, differences between the sexes – in hormone production, for example – could mean that men and women differ in physiological reactions such as endurance time or sensitivity to pain (Figure 2). This chapter deals with physiological differences between women and men that could possibly contribute to explaining why women suffer more often from musculoskeletal disorders. A recent review article by Côte (2012) presents the majority of these physiological differences in the context of work-related disorders.

6.1. Fatigue

Fatigue is often used as an indication that work is physically demanding and could potentially lead to musculoskeletal disorders. It can be described as a temporary decrease in the ability to develop force, for example as a consequence of physical exercise (Enoka, 2012). Fatigue can have both central causes – for example, the brain is incapable of fully activating muscles – or peripheral causes, for example the chemical environment in the muscle has changed in a way that limits the ability of the muscle fibres to deliver force (Toomingas et al., 2008). The ability to endure physical load for a longer time is often termed "muscular endurance" and can be used as a measurement of how quickly fatigue arises.

6.1.1. Level of physical load

Some studies have shown that women have better muscular endurance than men in static, sub-maximal contractions of muscles in the lower back, thighs, arms, hands and thumbs (Fulco et al., 1999; Kankaanpaa et al., 1998; Maughan et al., 1986; West et al., 1995; Yoon et al., 2007). During static back extensions, the researchers found that the electromyographic signal (EMG) changed more quickly for the men than for the women, which was interpreted as the women not fatiguing to the same extent as the men (Umezu et al., 1998; Kankaanpaa et al., 1998). The endurance studies saw significant differences for contractions at 20-70 % of maximum force.

Other research shows that the differences between the sexes in endurance decrease at higher contraction levels. A study comparing the endurance of men and women in static contractions of the muscles that bend the elbow found that the women had longer endurance than men in contractions at 20 % of maximum, but found no difference at 50 % and 80 % of maximum. In dynamic contractions of both the upper arm and the thigh, women had longer endurance at 50 %, 60 % and 70 % of maximum but no difference between the sexes was found at 80 % or 90 % (Maughan et al., 1986). Similar results were presented by Yoon et al. (2007), who studied static endurance in the biceps. At 20 % of maximum ability women had greater endurance, but not at contractions at 80 % of maximum ability. Nor were any differences between the sexes in the development of fatigue found during repeated maximum contractions of the grip muscle in the thumb (Ditor and Hicks, 2000). Hunter and Enoka (2001) demonstrated greater endurance in women than in men during static elbow flexion at 20 % of maximum force. When the link between endurance and absolute force – that is, force expressed in Newton and not as a percent of maximum – was analysed instead, there was no longer any difference between men and women. To further investigate this, Hunter et al. (2004b) matched men and women according to strength; no differences in endurance, increase in heart rate during the contraction, or perceived fatigue were found. A study of static, submaximal contractions in the muscles of the lower leg in women and men of equal strength confirmed that endurance times in this case were the same (Hatzikotoulas et al., 2004). This discovery has further support in a comprehensive study by Mathiassen and Åhsberg, which investigated endurance in static shoulder flexion in 20 men and 20 women. The subjects held their dominant arm straight out in front of the body until exhaustion, a load corresponding to between 10% and 21% of maximum strength in shoulder flexion. When the load was expressed relative to maximum strength, there was no longer any difference between the sexes in endurance (Mathiassen and Åhsberg, 1999), and the study therefore conclude that the entire difference in endurance between the sexes could be explained by women and men having different maximum strengths. In contrast to this, a study of endurance in men and women matched for strength who performed a repeated series of five-second static contractions with the grip muscle of the thumb at approximately 50 % of maximum ability, followed by five seconds of rest, showed that women not only had longer endurance, but also recovered more quickly than men (Fulco et al., 1999). Demura et al. (2008) showed that men reported greater subjective fatigue in static grip contractions at 40 %-60 % of maximum while no statistically significant difference between the sexes was demonstrated at lower and higher relative forces.

The quite extensive research available on gender and endurance is thus quite ambiguous. One explanation may be that different muscle groups differ as regards whether or not there is a difference between the sexes in endurance. Avin et al. (2010) showed that women were more tolerant of fatigue than men during static contraction of the elbow flexors, but not during contraction of the flexor and extensor muscles in the foot. Clark et al. (2003) showed that men had greater endurance in the thigh muscles than in the extensor muscles of the back, while women displayed no such differences between muscle groups. Age seems to have different influences on endurance of men and women. In a study of static endurance of the biceps, younger women (18-35) had better endurance than men of the same age, but the difference was not found among the older age groups (65-80) (Hunter et al., 2004a).

If cognitive requirements in the form of difficult counting tasks are added during physical work, endurance time decreases (Mehta and Agnew, 2012; Yoon et al., 2009). This effect has proven to be greater for women than for men (Yoon et al., 2009).

One possible explanation for men and women differing in endurance is that men have a greater muscle volume and can produce greater absolute force than women can, even when the muscle contraction is performed at the same relative force. These higher absolute forces in men lead to greater mechanical compression in the muscle, thereby hampering blood flow, which in turn could contribute to more rapid development of fatigue. The fact that men's strength advantage is more obvious in the arms than in the legs, as described in Section 5.2, can therefore be an explanation for the difference between the sexes in endurance appearing to be greatest for the muscles of the arms. The influence of blood flow was evaluated in a study of eight men and eight women who performed repeated maximal static contractions of the muscles that bend the ankle upwards (dorsal flexors), while, at the same time, the muscle was stimulated with an electric current. This took place under two different conditions: free blood flow in the muscle and blocked blood flow (ischemia). The women fatigued to a lesser extent than the men did during the contraction with free blood flow, but no difference between the sexes was seen during the ischemic contraction where endurance times were shorter. The researchers concluded that differences between the sexes in endurance were related to the blood flow in the muscle (Russ and Kent-Braun, 2003).

The greater presence of Type I muscle fibres in women has been suggested as another explanation for the difference between the sexes in endurance (Hunter, 2009). Wust et al. (2008) investigated the development of fatigue during electrically induced contractions in the thigh muscle (quadriceps femoris) over two minutes. The researchers found that women became less fatigued than men. This difference was also seen when blood flow to the muscle was blocked. No association between strength and fatigability was found. The researchers suggested that the differences between the sexes could depend on differences in muscle fibre composition. Fulco et al. (2001) found that women's endurance in the muscles of the thumb during contractions at 50 % of maximum was not just longer than men's, but also that low oxygen supply did not influence women's endurance, while men's endurance was reduced. The researchers suggested that the endurance differences between the sexes could be explained by the women's Type II fibres having a greater ability to use oxygen during contractions than men's.

6.1.2. Dynamic vs. static work

The type of muscle work also seems to be of significance. One study of men and women who performed static and dynamic back extensions at 50% of maximum strength showed that the women had better endurance than the men in the static exercise (women: 146 seconds, men: 105 seconds) but that both sexes showed the same capacity for dynamic work (both men and women managed 24 repetitions on average) (Clark et al., 2003). Senefeld et al. (2013) investigated the differences between the sexes in repeated dynamic flexions of the elbow and extensions of the knee, both at 20 % of maximum. Every now and then during the task, the subjects had to perform a maximum static contraction and the reduction of the maximum force was used as a measure of fatigue. The researchers found no differences between the sexes in how fatigue developed during the knee extensions; on the other hand, it was found that maximum force during elbow flexion fell more quickly for the women than for the men.

6.1.3. Endurance in working life

It is not clear whether or not great muscular endurance in static work is favourable, or even relevant in the context of occupational work performance. In repetitive work, where endurance can be assumed to be especially relevant, women have a higher occurrence of disorders in the neck, shoulders, and arms than men do. This goes against the idea that there should be a clear link between good endurance during static contractions and a reduced risk of developing disorders. In general, it is risky to apply results from strictly controlled tasks in the laboratory straight away to working life, where load patterns in most occupations are much more varied (Mathiassen and Winkel, 1992). But provided that women's greater endurance in static work is, indeed, relevant for occupational work, it can be speculated that great endurance may actually be a risk factor as it opens up the possibility of individuals being exposed to loads for such a long time that it puts their health at risk. In that case, women would more than men risk overloading the muscle fibres that are thought to be continuously active in long-lasting, low-intensity work (the "Cinderella fibres") (Hägg, 1991).

6.2. Pain

Over the last decade, pain research has included studies of differences between the sexes in pain development and clinical pain conditions to an increasing extent; the results have been summarised in review articles (Racine et al., 2012b; Racine et al., 2012a; Fillingim et al, 2009). According to one of these (Fillingim et al., 2009) there are clear indications that women have a higher occurrence of several clinical pain conditions. Apart from musculoskeletal disorders, the authors also point out a higher occurrence of neuropathic pain, fibromyalgia, headaches, and migraine. Thus, this emphasises the starting point of this report: women have more disorders than men. Furthermore, the article presents evidence that women consistently have a higher sensitivity to pain than men, as revealed when the researchers introduce pain through pressure, electric stimulation, restricted blood flow, heat, cold, or injections of saline solutions directly into the muscles. Racine et al. (2012a), however, arrived at somewhat contradictory results in a later review article, where clear differences between the sexes were found to only appear with regard to pressure, as well as heat or cold. The studies included in the two review articles were not exactly the same, which could be an explanation for the differences in the conclusions.

The mechanisms as to why women seem to be more sensitive to pain than men, at least for some triggers, are not fully known. Some research suggests than pain-related information is processed differently in the brains of men and women. Other research suggests that sex hormones could play a role. For example, the prevalence of migraines is the same among prepubescent boys and girls, while after puberty it climbs to 18 % in girls but lies only at 6 % for boys. Pain conditions such as headache and fibromyalgia have been shown to vary during the menstruation cycle, and migraines have been shown to decrease during pregnancy. It has been seen in clinical studies that the supply of the female sex hormone oestrogen increases the occurrence of several types of pain, for example lower back pain and jaw pain; on the other hand, research has also shown that the occurrence of pain increases among women who terminate oestrogen treatment after menopause. As regards variations in sensitivity to pain over the menstruation cycle, the results are too contradictory for a clear conclusion to be drawn. Which properties of sex hormones could have effects on sensitivity to pain is also discussed; one suggestion is that women's sex hormones influence inflammatory reactions, which in turn lead to women having a more pronounced pain reaction for certain influences than men do (Fillingim et al., 2009).

Racine et al. (2012b) reviewed the physiological factors that could contribute to differences in sensitivity to pain between healthy men and women. Hormonal and physiological explanations were too uncertain for the researchers to draw clear conclusions. Temporal summation of pain signals (that is, several smaller pain impulses are built on one another until the pain threshold is reached), allodynia (a condition where stimulation that is normally not painful is felt to be painful) and secondary hyperalgesia (a condition where pain is felt to be stronger than normal) were argued to be more pronounced in women than in men (Racine et al., 2012b). The experience of pain is influenced by mechanisms in the brain that can inhibit pain signals once they have reached the level of awareness. It has been suggested that women might have less effective pain inhibition, but the evidence is uncertain and does not seem to apply to all types of pain. Nor did differences in the tendency for depression seem to be able to explain differences between the sexes in experiencing pain. On the other hand there is some evidence, however sparse, for differences between the sexes in how discomfort and catastrophising (negative thoughts about pain) influence sensitivity to pain and how pain is reported (Racine et al., 2012b).

6.3. Pregnancy

A total of 10 new cases of sick leave per 1,000 employees on the entire labour market appear in a year owing to pregnancy-related illnesses (Försäkringskassan, 2011). Women undergo a number of physical changes during a pregnancy. Their weight increases and the distribution of weight changes drastically. In addition, the ability to provide the trunk with muscular support decreases as abdominal muscle function is gradually impaired. Hormonal changes soften ligaments up, and the joints become more unstable. Changes in body size and proportions can put women at greater risk for negative effects of physical loads (Punnett and Herbert, 2013). A study that compared work postures for pregnant and non-pregnant women found that the pregnant women sat further away from the work area with their hips further back, which resulted in increased forward bending of the upper body, and less neutral work posture for the shoulders.

It was found, however, that the physical loads could be reduced by adjusting the work station (Paul and Frings-Dresen, 1994).

Even lifting becomes more difficult as the women often find it harder to lift close to the body. Impaired abdominal muscle function as well as loosened ligaments can also make lifting more risky for pregnant women. An increased risk of developing lower back disorders owing to heavy lifting and climbing stairs often has been described for pregnant women (Punnett and Herbert, 2013). Carpal tunnel syndrome and its link with pregnancy is a well-described phenomenon. A review article by Padua et al. (2010) reports that 7-43 % of all pregnant women suffer from carpal tunnel syndrome, while in the general population the prevalence is approximately 9.2 % among women and 6 % among men (Ibrahim et al., 2012). On the other hand, it is not known whether pregnant women who work in repetitive, hand-intensive occupations have a higher risk of developing carpal tunnel syndrome than pregnant women not subjected to such work (Punnett and Herbert, 2013).

6.4. Mental loads

A review article by Hooftman et al. (2004) discussed whether there were differences between the sexes in the risk of developing musculoskeletal disorders as a consequence of psychosocial exposures. As regards demands and control in work, no firm evidence was found that sexes differ in risk, while for social support the researchers concluded that there was evidence for no difference existing between the sexes.

In a study of car engine assembly, the researchers compared two different working organisations: one where the workers stood by an assembly line without the opportunity to affect the speed or content of their work, and one where the workers were organised in teams of six to eight persons with some responsibility for organising the work (Melin et al., 1999). The core assembly work of the two groups was thus the same, but the one organisation offered more freedom regarding work pace and content. Stress levels measured with biological markers in the body, as well as perceived fatigue, increased more at the end of the work shift in the group working on the assembly line. As the researchers studied men and women separately, they found that women had higher stress levels during assembly line work than they did in the less controlled work, and that this difference was even clearer at the end of the work day. In other words, women seemed to be more sensitive to the stress contained in not being able to control their work themselves. The researchers did not, however, know for certain that the men and the women were subjected to the exact same physical load, since, for example, muscle activity was not measured; they simply state that the men and the women performed the exact same assembly work.

Herrero et al. (2012) showed that women's stress increased more than men's during work with tight deadlines; women had a 4.7 % higher probability of experiencing stress than the men did. Other factors that increased the likelihood of women experiencing stress more than men were rapid work (4.0 % higher), complex tasks (3.2 %), intellectually challenging work (2.2 %) and work that demanded attention (1.8 %). No differences between the sexes, however, could be shown in work that the employees judged to be "too much" or in repetitive tasks. Nordander et al. (2008) found no differences either in psychosocial stress between men and women who performed identical repetitive work.

As studies have shown, for example, that computer work under time pressure can give rise to increased muscle activity (Wahlström et al., 2002; Wang et al., 2011), increased sensitivity to stress among women could likely lead to increased, more continuous muscle activation, thereby contributing to a greater risk of developing musculoskeletal disorders. This hypothesis also has support from a study of cashiers in fast-food restaurants. The researchers investigated the association between stress and muscle activity. As expected, high levels of chemical markers for stress were found, but also a significant correlation between self-reported negative stress and muscle activity in the shoulder musculature (trapezius) during work (Rissen et al., 2000). The researchers suggested that this could be a biological mechanism that explains why perceived long-lasting negative stress could be a risk factor for developing musculoskeletal disorders.

6.5. Key points

- Women have better endurance than men in most muscle groups during static contractions at a certain percentage of maximum strength. The mechanisms behind this difference and whether it has any relevance for occupational injuries have at present not been delineated.

- Women are more sensitive to some types of experimental pain. It is unclear whether this is applicable to pain that arises due to exposures in working life.

- There is some evidence for differences between the sexes in sensitivity to different types of mental stress. For example, women can develop stronger stress reactions during time pressure than men.

- In summary, physiological differences between the sexes seem to only explain the larger occurrence of musculoskeletal disorders in women to a small degree.

7. Summary

7.1. Scientific literature

This report's review of the scientific literature points out a clear segregation of the sexes on the labour market. The segregation is horizontal – that is, men and women are found in different occupations (see Figure 2); internal – that is, men and women in the same occupation have different tasks; and vertical, which means that men and women have different positions within the same occupation (management, worker, etc.). The horizontal segregation shows up in men working in construction, processing, machine operation, and transport, while women are typically found in occupations such as health care, nursing, and service. Since the work and therefore physical loads differ among occupations, this results in different work demands for women and men. Women's work is typically more repetitive and/or involves contact with people. Heavy lifting is also common. Male-dominated occupations often involve heavy lifting and work with machinery and vehicles.

Internal segregation is evident in a number of different occupations; men and women perform work tasks that differ to a great degree. Like horizontal segregation, internal segregation contributes to women performing more repetitive and more hand-intensive tasks. Men lift heavier loads and deal with machinery and vehicles. Repetitive and hand-intensive work increases the risk for developing musculoskeletal disorders, primarily in the neck, shoulders and arms, whereas heavy manual handling increases the risk of low back disorders. Taken together, both internal and horizontal segregation could be strong contributing factors to women reporting more musculoskeletal disorders in the neck, shoulders, and arms than men do, while the sexes are more alike as regards the occurrence of disorders in the low back.

Even when men and women perform the exact same tasks, the physical load can differ (see Figure 2). Women seem to use a larger proportion of their maximum muscle force than men doing the same work task, as for instance in computer work. Even the work posture can differ, with women often working in a less neutral position than men, for example as a consequence of the dimensions of the work station being typically adapted to men. This could mean that women not only perform repetitive tasks more often than men do (as noted above), but that they also have greater physical load once they perform them. The literature suggests that women may have different motor strategies than men do to handle long-lasting and/or repetitive work, but it remains to be seen whether this applies to real occupational work, and whether it is of significance for the risk of developing disorders, which is a reasonable hypothesis.

Women experience greater psychosocial stress than men. This is especially apparent in the health care occupations, where you work with people. On the other hand, it is not completely clear whether women are more sensitive to stress and psychosocial factors, even if certain research points to women reacting more strongly to demands of working quickly (which is common in health care and nursing). Women also feel, to a greater extent than men, that their work is controlled – often by another person's needs, which most likely depends on differences between the sexes in occupations and work tasks rather than on a difference between the sexes in sensitivity to lack of control.

Women seem to have better muscular endurance than men in most muscle groups, but this has especially been shown in strictly controlled static contractions in experimental studies. It is unclear whether, and if so how, this is relevant to conditions in working life, and therefore if it can explain differences between the sexes in the occurrence of disorders. One theory may be that women, due to their greater endurance, work longer, thus overloading certain structures. This, however, needs to be verified in field studies.

Studies have shown that women are more sensitive to certain pain stimuli, but it is unclear how transferable these results are to working life. Hormonal differences between men and women should theoretically be of significance for sensitivity to pain, but this has not been established; currently it cannot be considered to contribute appreciably to women's increased risk for musculoskeletal disorders. Our conclusions above for the most part agree with those proposed by Härenstam et al. (2000) in the large MOA study. Differences between men and women's reactions to their work in non-gender matched materials can largely be explained by the two sexes not having similar working and living conditions. Côte (2012) concluded, unlike this report, that differences between the sexes in physiological reactions are an important explanation for women suffering more from musculoskeletal disorders than men. She did not, however, discuss the potential physiological explanations in relation to the effects of organisational factors (see Figure 2).

7.2. State of research

In reviewing the literature, we have identified several evident gaps in knowledge. A large portion of both epidemiological and experimental studies of physical loads in working life have neither gathered nor analysed data for women and men separately. Significant differences in results and conclusions may arise depending on whether one adjusts for the sexes in the statistical analyses or whether stratified analyses are conducted – that is, when men and women are analysed as two separate groups (Silverstein et al., 2009). As described in the introduction, many studies only measure physical load by occupational title. As it is common that women and men in the same occupation have different work tasks, this can lead to erroneous interpretations: women seem to be especially vulnerable in certain occupations compared to men, which in reality covers over that the work tasks, and thereby the loads, are different. It is therefore desirable that the researchers really investigate which physical loads people – both men and women – are exposed to, with valid and reliable methods. Furthermore, several of the studies that compared work tasks for men and women within the same occupation are from the 1990s. As it is likely that the occupations, work organisation and work tasks change over time, there is a need for current studies with a focus on gender.

Our review of the literature also showed a need for additional studies of women and men who perform identical work tasks in order to establish if there are, indeed, differences between the sexes in motor strategies, physiological reactions, and perceived effects. It is important that the tasks studied are relevant for working life, even if the studies may be realised in a laboratory. Some recent review articles do, however, discuss relevant physiological differences between men and women in a more fundamental sense, for example regarding basic mechanisms explaining muscle fatigue and sensitivity to pain.

7.3. Conclusion

There is a marked segregation by gender in working life. A number of occupations are dominated by men and others by women. In many workplaces men are assigned (or take) heavier tasks, as women are not considered (or do not consider themselves) physically capable of them, while women perform repetitive tasks and work with people. Constructing work tasks and equipment to also suit women (and other groups that are, on average shorter and physically weaker) should be self-evident in an inclusive working life. Changing the attitude from one of women's capacities setting limits to that of the limits lying in the task or the design of equipment and work stations, is an important effort in bringing about a change. In the summary to her report Under luppen - genusperspektiv på arbetsmiljö och arbetsorganisation, Vänje takes up issues such as the importance of identifying where differences between the sexes can be found in workplaces and what the causes of this are (Arbetsmiljöverket, 2013). We can agree with this viewpoint and add that it also is important to focus on the factors in the design of work and tools for work that stand, directly and indirectly, in the way for equal opportunities to take on and perform those tasks that might be offered on the labour market.

We would again like to emphasize that there are factors alongside the work – such as physical loads from leisure time – that influence the health of individuals (Vroman and MacRae, 2001). Differences between the sexes in requirements alongside work presumably influence the risk of developing musculoskeletal disorders. For example, women's extended work in the home interferes with proper recuperation from fatigue and wear imposed by their occupational work. Family responsibilities are one such factor than in several studies has proven to lie with women. As illustrated in Figure 2, it may well also be that women have a different tendency than men to seek out health care or accept long-lasting sick leave. This may be an important explanation for the difference in the prevalence of disorders, but a discussion of these causes lies outside the scope of our report.

In summary, we are of the opinion that the fact that men and women have different work tasks even if they work in the same occupation is likely a principal explanation of inequalities in occupational health. Men and women being exposed to different loads when they perform the same work tasks can also be an important explanation. However, we are of the opinion that different physiological reactions of men and women to the same physical loads cannot explain to any particular extent the differences in musculoskeletal disorders between men and women.

References

ANDERS, C., BRETSCHNEIDER, S., BERNSDORF, A., ERLER, K. & SCHNEIDER, W. 2004. Activation of shoulder muscles in healthy men and women under isometric conditions. J Electromyogr Kinesiol, 14, 699-707.

ARBETSMILJÖVERKET 2012a. Arbetsmiljön 2011. Arbetsmiljöstatistik rapport 2012:4. Stockholm.

ARBETSMILJÖVERKET 2012b. Arbetsorsakade besvär 2012. Arbetsmiljöstatistik rapport 2012:5. Stockholm.

ARBETSMILJÖVERKET 2013. Under luppen - genusperspektiv på arbetsmiljö och arbets- organisation. Kunskapssammanställning. Stockholm.

ARIENS, G. A., VAN MECHELEN, W., BONGERS, P. M., BOUTER, L. M. & VAN DER WAL, G. 2001. Psychosocial risk factors for neck pain: a systematic review. Am J Ind Med, 39, 180-93.

ARVIDSSON, I., ARVIDSSON, M., AXMON, A., HANSSON, G. A., JOHANSSON, C. R. & SKERFVING, S. 2006. Musculoskeletal disorders among female and male air traffic controllers performing identical and demanding computer work. Ergonomics, 49, 1052-67.

AVIN, K. G., NAUGHTON, M. R., FORD, B. W., MOORE, H. E., MONITTO-WEBBER, M. N., STARK, A. M., GENTILE, A. J. & LAW, L. A. 2010. Sex differences in fatigue resistance are muscle group dependent. Med Sci Sports Exerc, 42, 1943-50.

BALOGH, I., ORBAEK, P., OHLSSON, K., NORDANDER, C., UNGE, J., WINKEL, J., HANSSON, G. A. & MALMO SHOULDER/NECK STUDY, G. 2004. Self-assessed and directly measured occupational physical activities-influence of musculoskeletal complaints, age and gender. Appl Ergon, 35, 49-56.

BALOGUN, J. A., ADENLOLA, S. A. & AKINLOYE, A. A. 1991. Grip strength normative data for the harpenden dynamometer. J Orthop Sports Phys Ther, 14, 155-60.

BARTLEY, E. J. & FILLINGIM, R. B. 2013. Sex differences in pain: a brief review of clinical and experimental findings. Br J Anaesth, 111, 52-8.

BERNARD, B. P. 1997. Musculoskeletal disorders and workplace factors. In: (NIOSH), D. (ed.). Cincinnati: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health.

BINGEFORS, K. & ISACSON, D. 2004. Epidemiology, co-morbidity, and impact on health- related quality of life of self-reported headache and musculoskeletal pain--a gender perspective. Eur J Pain, 8, 435-50.

BLANGSTED, A. K., HANSEN, K. & JENSEN, C. 2003. Muscle activity during computer- based office work in relation to self-reported job demands and gender. Eur J Appl Physiol, 89, 352-8.

BOHANNON, R. W. 1997. Reference values for extremity muscle strength obtained by hand- held dynamometry from adults aged 20 to 79 years. Arch Phys Med Rehabil, 78, 26-32.

BONGERS, P. M., IJMKER, S., VAN DEN HEUVEL, S. & BLATTER, B. M. 2006. Epidemi- ology of work related neck and upper limb problems: psychosocial and personal risk factors (part I) and effective interventions from a bio behavioural perspective (part II). J Occup Rehabil, 16, 279-302.

BONGERS, P. M., KREMER, A. M. & TER LAAK, J. 2002. Are psychosocial factors, risk factors for symptoms and signs of the shoulder, elbow, or hand/wrist?: A review of the epidemiological literature. Am J Ind Med, 41, 315-42.

BOVENZI, M. & HULSHOF, C. T. 1999. An updated review of epidemiologic studies on the relationship between exposure to whole-body vibration and low back pain (1986-1997). Int Arch Occup Environ Health, 72, 351-65.

BRYNGELSON, A., BACCHUS HERTZMAN, J. & FRITZELL, J. 2011. The relationship be- tween gender segregation in the workplace and long-term sickness absence in Sweden. Scand J Public Health, 39, 618-26.

CALVET, B., RIEL, J., COUTURE, V. & MESSING, K. 2002. Work organisation and gender among hospital cleaners in Quebec after the merger of 'light' and 'heavy' work classifications. Ergonomics, 55, 160-72.

CHIU, T. T., LAM, T. H. & HEDLEY, A. J. 2002. Maximal isometric muscle strength of the cervical spine in healthy volunteers. Clin Rehabil, 16, 772-9.

CIRIELLO, V. M. 2003. The effects of box size,frequency and extended horizontal reach on maximum acceptable weights of lifting. International journal of industrial ergonomics, 32, 115-120.

CIRIELLO, V. M. 2007. The effects of container size, frequency and extended horizontal reach on maximum acceptable weights of lifting for female industrial workers. Appl Ergon, 38, 1-5.

CLARK, B. C., MANINI, T. M., THE, D. J., DOLDO, N. A. & PLOUTZ-SNYDER, L. L. 2003. Gender differences in skeletal muscle fatigability are related to contraction type and EMG spectral compression. J Appl Physiol, 94, 2263-72.

CÔTE, J. N. 2012. A critical review on physical factors and functional characteristics that may explain a sex/gender difference in work-related neck/shoulder disorders. Ergonomics, 55, 173-82.

CÔTE, P., VAN DER VELDE, G., CASSIDY, J. D., CARROLL, L. J., HOGG-JOHNSON, S., HOLM, L. W., CARRAGEE, E. J., HALDEMAN, S., NORDIN, M., HURWITZ, E. L., GUZMAN, J. & PELOSO, P. M. 2008. The burden and determinants of neck pain in workers: results of the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine (Phila Pa 1976), 33, S60-74.

COURY, H., PORCATTI, I. A., ALEM, M. & OISHI, J. 2002. Influence of gender on work- related musculoskeletal disorders in repetetive tasks. International Journal of Industrial Ergonomics, 29, 33-39.

CRAFT, R. M., MOGIL, J. S. & ALOISI, A. M. 2004. Sex differences in pain and analgesia: the role of gonadal hormones. Eur J Pain, 8, 397-411.

DA COSTA, B. R. & VIEIRA, E. R. 2010. Risk factors for work-related musculoskeletal disorders: A systematic review of recent longitudinal studies. Am J Ind Med, 53, 285-323.

DAHLBERG, R., KARLQVIST, L., BILDT, C. & NYKVIST, K. 2004. Do work technique and musculoskeletal symptoms differ between men and women performing the same type of work tasks? Appl Ergon, 35, 521-9.

DANIELSSON, M., HEIMERSON, I., LUNDBERG, U., PERSKI, A., STEFANSSON, C. G. & ÅKERSTEDT, T. 2012. Psychosocial stress and health problems: Health in Sweden: The National Public Health Report 2012. Chapter 6. Scand J Public Health, 40, 121-34.

DEMURA, S., NAKADA, M. & NAGASAWA, Y. 2008. Gender difference in subjective musclefatigue sensation during sustained muscle force exertion. Tohoku J Exp Med, 215, 287-94.

DITOR, D. S. & HICKS, A. L. 2000. The effect of age and gender on the relative fatigability of the human adductor pollicis muscle. Can J Physiol Pharmacol, 78, 781-90.

EIJCKELHOF, B. H., HUYSMANS, M. A., BRUNO GARZA, J. L., BLATTER, B. M., VAN DIEEN, J. H., DENNERLEIN, J. T. & VAN DER BEEK, A. J. 2013. The effects of workplace stressors on muscle activity in the neck-shoulder and forearm muscles during computer work: a systematic review and meta-analysis. Eur J Appl Physiol.

ENG, A., T MANNETJE, A., MCLEAN, D., ELLISON-LOSCHMANN, L., CHENG, S. & PEARCE, N. 2011. Gender differences in occupational exposure patterns. Occup Environ Med, 68, 888-94.

ENOKA, R. M. 2012. Muscle fatigue-from motor units to clinical symptoms. J Biomech, 45, 427-33.

FILLINGIM, R. B., KING, C. D., RIBEIRO-DASILVA, M. C., RAHIM-WILLIAMS, B. & RILEY, J. L., 3RD 2009. Sex, gender, and pain: a review of recent clinical and experimental findings. J Pain, 10, 447-85.

FRANSSON-HALL, C., BYSTRÖM, S. & KILBOM, Å. 1995. Self-reported physical exposure and musculoskeletal symptoms of the forearm-hand among automobile assembly-line workers. J Occup Environ Med, 37, 1136-44.

FRONTERA, W. R., HUGHES, V. A., LUTZ, K. J. & EVANS, W. J. 1991. A cross-sectional study of muscle strength and mass in 45- to 78-yr-old men and women. J Appl Physiol, 71, 644-50.

FRYMOYER, J. W., POPE, M. H., COSTANZA, M. C., ROSEN, J. C., GOGGIN, J. E. & WILDER, D. G. 1980. Epidemiologic studies of low-back pain. Spine (Phila Pa 1976), 5, 419-23.

FULCO, C. S., ROCK, P. B., MUZA, S. R., LAMMI, E., BRAUN, B., CYMERMAN, A., MOORE, L. G. & LEWIS, S. F. 2001. Gender alters impact of hypobaric hypoxia on adductor pollicis muscle performance. J Appl Physiol, 91, 100-8.

FULCO, C. S., ROCK, P. B., MUZA, S. R., LAMMI, E., CYMERMAN, A., BUTTERFIELD, G., MOORE, L. G., BRAUN, B. & LEWIS, S. F. 1999. Slower fatigue and faster re- covery of the adductor pollicis muscle in women matched for strength with men. Acta Physiol Scand, 167, 233-9.

FÖRSÄKRINGSKASSAN 2011. Sjukskrivningsdiagnoser i olika yrken - Startade sjukskrivningar (>14 dagar) per diagnos bland anställda i olika yrken år 2009.

FÖRSÄKRINGSKASSAN 2012. Sjukskrivningar i olika yrken under 2000-talet - Antal ersatta sjukskrivningsdagar per anställd år 2002–2010. Socialförsäkringsrapport. Försäkringkassan.

GIERSIEPEN, K., EBERLE, A. & POHLABELN, H. 2000. Gender differences in carpal tunnel syndrome? occupational and non-occupational risk factors in a population-based case- control study. Ann Epidemiol, 10, 481.

HAMMARSTRÖM, A. 2005. Genusperspektiv på medicinen – två decenniers utveckling av medvetenheten om kön och genus inom medicinsk forskning och praktik. In: HÖG- SKOLEVERKET (ed.). Stockholm.

HANSSON, T. & WESTERHOLM, P. 2001. Arbete och besvär i rörelseorganen - En vetenskaplig värdering av frågor om samband. Stockholm, Arbetslivsinstitutet.

HATZIKOTOULAS, K., SIATRAS, T., SPYROPOULOU, E., PARASCHOS, I. & PATIKAS, D. 2004. Muscle fatigue and electromyographic changes are not different in women and men matched for strength. Eur J Appl Physiol, 92, 298-304.

HENDRIKSE, E. J. 2011. Maximal push/pull strengths in the vertical and horizontal directions with hands above shoulder level PhD, Texas Tech University

HERRERO, S. G., SALDANA, M. A., RODRIGUEZ, J. G. & RITZEL, D. O. 2012. Influence of task demands on occupational stress: gender differences. J Safety Res, 43, 365-74.

HOOFTMAN, W. E., VAN DER BEEK, A. J., BONGERS, P. M. & VAN MECHELEN, W. 2005. Gender differences in self-reported physical and psychosocial exposures in jobs with both female and male workers. J Occup Environ Med, 47, 244-52.

HOOFTMAN, W. E., VAN DER BEEK, A. J., BONGERS, P. M. & VAN MECHELEN, W. 2009. Is there a gender difference in the effect of work-related physical and psychoso- cial risk factors on musculoskeletal symptoms and related sickness absence? Scand J Work Environ Health, 35, 85-95.

HOOFTMAN, W. E., VAN POPPEL, M. N., VAN DER BEEK, A. J., BONGERS, P. M. & VAN MECHELEN, W. 2004. Gender differences in the relations between work-related physi- cal and psychosocial risk factors and musculoskeletal complaints. Scand J Work Envi- ron Health, 30, 261-78.

HOOZEMANS, M. J., VAN DER BEEK, A. J., FRINGS-DRESEN, M. H., VAN DIJK, F. J. & VAN DER WOUDE, L. H. 1998. Pushing and pulling in relation to musculoskeletal disorders: a review of risk factors. Ergonomics, 41, 757-81.

HUNTER, S. K. 2009. Sex differences and mechanisms of task-specific muscle fatigue. Exerc Sport Sci Rev, 37, 113-22.

HUNTER, S. K., CRITCHLOW, A. & ENOKA, R. M. 2004a. Influence of aging on sex differences in muscle fatigability. J Appl Physiol, 97, 1723-32.

HUNTER, S. K., CRITCHLOW, A., SHIN, I. S. & ENOKA, R. M. 2004b. Fatigability of the elbow flexor muscles for a sustained submaximal contraction is similar in men and women matched for strength. J Appl Physiol, 96, 195-202.

HUNTER, S. K. & ENOKA, R. M. 2001. Sex differences in the fatigability of arm muscles depends on absolute force during isometric contractions. J Appl Physiol, 91, 2686-94.

HÄGG, G. M. 1991. Static work loads and occupational myalgia - a new explanation model. . In: ANDERSON, P. A., HOBART, D. J. & DAINOFF, J. V. (eds.) Electromyographical Kinesiology. Amsterdam: Elsevier.

HÄRENSTAM, A., WESTBERG, H., KARLQVIST, L., LEIJON, O., RYDBECK, A., WALDENSTRÖM, K., WIKLUND, P., NISE, G. & JANSSON, C. 2000. Hur kan köns- skillnader i arbets- och livsvillkor förstås? Metodologiska och strategiska aspekter samt sammanfattning av MOA-projektets resultat ur ett könsperspektiv. In: ARBETSLIVS- INSTITUTET (ed.) Arbete och hälsa. Stockholm.

IBRAHIM, I., KHAN, W. S., GODDARD, N. & SMITHAM, P. 2012. Carpal tunnel syndrome: a review of the recent literature. Open Orthop J, 6, 69-76.

JOHANSEN, T. I., SAMANI, A., ANTLE, D. M., COTE, J. N. & MADELEINE, P. 2013. Gender effects on the coordination of subdivisions of the trapezius muscle during a repetitive box-folding task. Eur J Appl Physiol, 113, 175-82.

JOSEPHSON, M., PERNOLD, G., AHLBERG-HULTEN, G., HÄRENSTAM, A., THEORELL, T., VINGÅRD, E., WALDENSTRÖM, M. & HJELM, E. W. 1999. Differences in the association between psychosocial work conditions and physical work load in female-and male-dominated occupations. MUSIC-Norrtalje Study Group. Am Ind Hyg Assoc J,60, 673-8.

JUUL-KRISTENSEN, B., SOGAARD, K., STROYER, J. & JENSEN, C. 2004. Computer us- ers' risk factors for developing shoulder, elbow and back symptoms. Scand J Work Environ Health, 30, 390-8.

KANKAANPAA, M., LAAKSONEN, D., TAIMELA, S., KOKKO, S. M., AIRAKSINEN, O. & HANNINEN, O. 1998. Age, sex, and body mass index as determinants of back and hip extensor fatigue in the isometric Sorensen back endurance test. Arch Phys Med Rehabil, 79, 1069-75.

KARLQVIST, L. & GARD, G. 2012. Ergonomic Conditions and Health at Gender Segregated Work Places. The Ergonomics Open Journal, 5, 19-27.

KARLQVIST, L., WIGAEUS-TORNQVIST, E., HAGBERG, M., HAGMAN, M. & TOOM- INGAS, A. 2002. Self-reported working conditions of VDU operators and associations with musculoskeletal symptoms: a cross-sectional study focussing on gender differences. Int J Ind Ergonom, 30, 277-294.

KARLQVIST, L. K., BERNMARK, E., EKENVALL, L., HAGBERG, M., ISAKSSON, A. & ROSTO, T. 1998. Computer mouse position as a determinant of posture, muscular load and perceived exertion. Scand J Work Environ Health, 24, 62-73.

KENNEDY, S. M. & KOEHOORN, M. 2003. Exposure assessment in epidemiology: does gender matter? Am J Ind Med, 44, 576-83.

KLUSSMANN, A., GEBHARDT, H., NUBLING, M., LIEBERS, F., QUIROS PEREA, E., CORDIER, W., VON ENGELHARDT, L. V., SCHUBERT, M., DAVID, A., BOUIL- LON, B. & RIEGER, M. A. 2010. Individual and occupational risk factors for knee os- teoarthritis: results of a case-control study in Germany. Arthritis Res Ther, 12, R88.

KRAUSE, N., RAGLAND, D. R., GREINER, B. A., FISHER, J. M., HOLMAN, B. L. & SEL- VIN, S. 1997. Physical workload and ergonomic factors associated with prevalence of back and neck pain in urban transit operators. Spine (Phila Pa 1976), 22, 2117-26; discussion 2127.

KWON, B. K., ROFFEY, D. M., BISHOP, P. B., DAGENAIS, S. & WAI, E. K. 2011. Systematic review: occupational physical activity and low back pain. Occup Med (Lond), 61, 541-8.

LEBOEUF-YDE, C., KLOUGART, N. & LAURITZEN, T. 1996. How common is low back pain in the Nordic population? Data from a recent study on a middle-aged general Danish population and four surveys previously conducted in the Nordic countries. Spine (Phila Pa 1976), 21, 1518-25; discussion 1525-6.

LEBOEUF-YDE, C., NIELSEN, J., KYVIK, K. O., FEJER, R. & HARTVIGSEN, J. 2009. Pain in the lumbar, thoracic or cervical regions: do age and gender matter? A population-based study of 34,902 Danish twins 20-71 years of age. BMC Musculoskelet Disord, 10, 39.

LEIJON, O. 2011. Kvinnor har oftare värk - sanning eller konsekvens. In: SANDMARK, H. (ed.) Perspektiv på kvinnors hälsa i arbetslivet. Lund: Studentlitteratur.

LEIJON, O., BERNMARK, E., KARLQVIST, L. & HÄRENSTAM, A. 2005. Awkward work postures: association with occupational gender segregation. Am J Ind Med, 47, 381-93.

LEINO-ARJAS, P., HANNINEN, K. & PUSKA, P. 1998. Socioeconomic variation in back and joint pain in Finland. Eur J Epidemiol, 14, 79-87.

LIN, C. L., CHEN, M. S., WEI, Y. L. & WANG, M. J. 2010. The evaluation of force exertions and muscle activities when operating a manual guided vehicle. Appl Ergon, 41, 313-8.

LINDBECK, L. & KJELLBERG, K. 2001. Gender differences in lifting technique. Ergonomics,44, 202-14.

LINDEGÅRD, A., WAHLSTRÖM, J., HAGBERG, M., HANSSON, G. A., JONSSON, P. & WIGAEUS TORNQVIST, E. 2003. The impact of working technique on physical loads- an exposure profile among newspaper editors. Ergonomics, 46, 598-615.

LINDMAN, R., ERIKSSON, A. & THORNELL, L. E. 1990. Fiber type composition of the human male trapezius muscle: enzyme-histochemical characteristics. Am J Anat, 189, 236-44.

LINDMAN, R., ERIKSSON, A. & THORNELL, L. E. 1991. Fiber type composition of the human female trapezius muscle: enzyme-histochemical characteristics. Am J Anat, 190, 385-92.

LUNDBERG, U. 2002. Psychophysiology of work: stress, gender, endocrine response, and work-related upper extremity disorders. Am J Ind Med, 41, 383-92.

MANNION, A. F., DUMAS, G. A., COOPER, R. G., ESPINOSA, F. J., FARIS, M. W. & STE- VENSON, J. M. 1997. Muscle fibre size and type distribution in thoracic and lumbar regions of erector spinae in healthy subjects without low back pain: normal values and sex differences. J Anat, 190 (Pt 4), 505-13.

MARRAS, W. S. 2000. Occupational low back disorder causation and control. Ergonomics, 43,880-902.

MARRAS, W. S., KNAPIK, G. G. & FERGUSON, S. 2009. Loading along the lumbar spine as influence by speed, control, load magnitude, and handle height during pushing. Clin Biomech (Bristol, Avon), 24, 155-63.

MATHIASSEN, S. & ÅHSBERG, E. 1999. Prediction of shoulder flexion endurance from personal factors. Int J Ind Ergon, 24, 315-329.

MATHIASSEN, S. E. 2006. Diversity and variation in biomechanical exposure: what is it, and why would we like to know? Appl Ergon, 37, 419-27.

MATHIASSEN, S. E., MÖLLER, T. & FORSMAN, M. 2003. Variability in mechanical expo- sure within and between individuals performing a highly constrained industrial work task. Ergonomics, 46, 800-24.

MATHIASSEN, S. E. & WINKEL, J. 1992. Can occupational guidelines for work-rest schedules be based on endurance time data? Ergonomics, 35, 253-9.

MATHIOWETZ, V., KASHMAN, N., VOLLAND, G., WEBER, K., DOWE, M. & ROGERS, S. 1985a. Grip and pinch strength: normative data for adults. Arch Phys Med Rehabil, 66, 69-74.

MATHIOWETZ, V., RENNELLS, C. & DONAHOE, L. 1985b. Effect of elbow position on grip and key pinch strength. J Hand Surg Am, 10, 694-7.

MAUGHAN, R. J., HARMON, M., LEIPER, J. B., SALE, D. & DELMAN, A. 1986. Endur- ance capacity of untrained males and females in isometric and dynamic muscular contractions. Eur J Appl Physiol Occup Physiol, 55, 395-400.

MAUGHAN, R. J., WATSON, J. S. & WEIR, J. 1983. Strength and cross-sectional area of human skeletal muscle. J Physiol, 338, 37-49.

MAYER, J., KRAUS, T. & OCHSMANN, E. 2012. Longitudinal evidence for the association between work-related physical exposures and neck and/or shoulder complaints: a systematic review. Int Arch Occup Environ Health, 85, 587-603.

MCDIARMID, M., OLIVER, M., RUSER, J. & GUCER, P. 2000. Male and female rate differences in carpal tunnel syndrome injuries: personal attributes or job tasks? Environ Res, 83, 23-32.

MEHTA, R. K. & AGNEW, M. J. 2012. Influence of mental workload on muscle endurance, fatigue, and recovery during intermittent static work. Eur J Appl Physiol, 112, 2891-902.

MELIN, B., LUNDBERG, U., SÖDERLUND, J. & GRANQVIST, M. 1999. Psychological and physiological stress reactions of male and female assembly workers: a comparison between two defferent forms of work organization. J. Organiz. Behav., 20, 47-61.

MERGLER, D., BRABANT, C., VEZINA, N. & MESSING, K. 1987. The weaker sex? Men in women's working conditions report similar health symptoms. J Occup Med, 29, 417-21.

MESSING, K., CHATIGNY, C. & COURVILLE, J. 1998a. 'Light' and 'heavy' work in the housekeeping service of a hospital. Appl Ergon, 29, 451-9.

MESSING, K., DUMAIS, L., COURVILLE, J., SEIFERT, A. M. & BOUCHER, M. 1994. Eval- uation of exposure data from men and women with the same job title. J Occup Med, 36, 913-7.

MESSING, K., TISSOT, F., SAUREL-CUBIZOLLES, M. J., KAMINSKI, M. & BOURGINE, M. 1998b. Sex as a variable can be a surrogate for some working conditions: factors as- sociated with sickness absence. J Occup Environ Med, 40, 250-60.

MESSING, K., TISSOT, F. & STOCK, S. 2008. Distal lower-extremity pain and work postures in the Quebec population. Am J Public Health, 98, 705-13.

MOGK, J. P. & KEIR, P. J. 2003. The effects of posture on forearm muscle loading during gripping. Ergonomics, 46, 956-75.

MURRAY, M. P., GORE, D. R., GARDNER, G. M. & MOLLINGER, L. A. 1985. Shoulder motion and muscle strength of normal men and women in two age groups. Clin Orthop Relat Res, 268-73.

NAG, A., VYAS, H. & NAG, P. K. 2010. Gender differences, work stressors and musculoskeletal disorders in weaving industries. Ind Health, 48, 339-48.

NOOR, A. & HAGBERG, M. 2012. Sjukfrånvaro bland sysselsatta i Sverige till följd av arbetsorsakade besvär i rygg och arm. Rapport från Arbets- och miljömedicin n 144. Sahlgrenska Universitetssjukhuset.

NORDANDER, C., OHLSSON, K., BALOGH, I., HANSSON, G. A., AXMON, A., PERS- SON, R. & SKERFVING, S. 2008. Gender differences in workers with identical repetitive industrial tasks: exposure and musculoskeletal disorders. Int Arch Occup Environ Health, 81, 939-47.

NORDANDER, C., OHLSSON, K., BALOGH, I., RYLANDER, L., PÅLSSON, B. & SKER- FVING, S. 1999. Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. Occup Environ Med, 56, 256-64.

NORDANDER, C., OHLSSON, K., ÅKESSON, I., ARVIDSSON, I., BALOGH, I., HANSSON, G. A., STRÖMBERG, U., RITTNER, R. & SKERFVING, S. 2009. Risk of mus- culoskeletal disorders among females and males in repetitive/constrained work. Ergonomics, 52, 1226-39.

NORDANDER, C., OHLSSON, K., ÅKESSON, I., ARVIDSSON, I., BALOGH, I., HANSSON, G. A., STRÖMBERG, U., RITTNER, R. & SKERFVING, S. 2013. Exposure-response relationships in work-related musculoskeletal disorders in elbows and hands - A synthesis of group-level data on exposure and response obtained using uniform methods of data collection. Appl Ergon, 44, 241-53.

O'SULLIVAN, L. W. & GALLWEY, T. J. 2002. Effects of gender and reach distance on risks of musculoskeletal injuries in an assembly task. Int J Ind Ergon, 29, 61-71.

PAARUP, H. M., BAELUM, J., HOLM, J. W., MANNICHE, C. & WEDDERKOPP, N. 2011. Prevalence and consequences of musculoskeletal symptoms in symphony orchestra musicians vary by gender: a cross-sectional study. BMC Musculoskelet Disord, 12, 223.

PADUA, L., DI PASQUALE, A., PAZZAGLIA, C., LIOTTA, G. A., LIBRANTE, A. & MONDELLI, M. 2010. Systematic review of pregnancy-related carpal tunnel syndrome. Muscle Nerve, 42, 697-702.

PAUL, J. A. & FRINGS-DRESEN, M. H. 1994. Standing working posture compared in pregnant and non-pregnant conditions. Ergonomics, 37, 1563-75.

PICAVET, H. S. & HOEYMANS, N. 2002. Physical disability in The Netherlands: prevalence, risk groups and time trends. Public Health, 116, 231-7.

PIENIMÄKI, T. 2002. Cold exposure and musculoskeletal disorders and diseases. A review. Int J Circumpolar Health, 61, 173-82.

PUNNETT, L. & HERBERT, R. 2013. Work-Related musculoskeletal disorders: is there a gender differential, and if so, what does it mean? In: GOLDMAN, M. H., MC. (ed.) Women and Health. San Diego, CA: Academic Press.

RACINE, M., TOUSIGNANT-LAFLAMME, Y., KLODA, L. A., DION, D., DUPUIS, G. & CHOINIERE, M. 2012a. A systematic literature review of 10 years of research on sex/ gender and experimental pain perception - part 1: are there really differences between women and men? Pain, 153, 602-18.

RACINE, M., TOUSIGNANT-LAFLAMME, Y., KLODA, L. A., DION, D., DUPUIS, G. & CHOINIERE, M. 2012b. A systematic literature review of 10 years of research on sex/ gender and pain perception - part 2: do biopsychosocial factors alter pain sensitivity differently in women and men? Pain, 153, 619-35.

RESNICK, M. L. & CHAFFIN, D. B. 1995. An ergonomic evaluation of handle height and load in maximal and submaximal cart pushing. Appl Ergon, 26, 173-8.

RIBEIRO, D. C., ALDABE, D., ABBOTT, J. H., SOLE, G. & MILOSAVLJEVIC, S. 2012. Dose-response relationship between work-related cumulative postural exposure and low back pain: a systematic review. Ann Occup Hyg, 56, 684-96.

RISSEN, D., MELIN, B., SANDSJO, L., DOHNS, I. & LUNDBERG, U. 2000. Surface EMG and psychophysiological stress reactions in women during repetitive work. Eur J Appl Physiol, 83, 215-22.

RUSS, D. W. & KENT-BRAUN, J. A. 2003. Sex differences in human skeletal muscle fatigue are eliminated under ischemic conditions. J Appl Physiol, 94, 2414-22.

SALEH, S. S., FUORTES, L., VAUGHN, T. & BAUER, E. P. 2001. Epidemiology of occupa- tional injuries and illnesses in a university population: a focus on age and gender differences. Am J Ind Med, 39, 581-6.

SBU, S. B. F. M. U. 2012. Arbetets betydelse för uppkomst av besvär och sjukdomar - Nacken och övre rörelseapparaten - En systematisk litteraturöversikt. In: UTVÄRDERING, S. B. F. M. (ed.).

SCB. 2005. Undersökningen av levnadsförhållanden (ULF), SCB [Online]. http://www.scb.se/ Pages/PressRelease 149797.aspx.

SCB 2012a. Arbetstider och arbetsmiljö 2010–2011. Levnadsförhållanden. Stockholm: Statistiska Centralbyrån.

SCB 2012b. På tal om kvinnor och män - lathund om jämställdhet. Statistiska Centralbyrån. SENEFELD, J., YOON, T., BEMENT, M. H. & HUNTER, S. K. 2013. Fatigue and recovery from dynamic contractions in men and women differ for arm and leg muscles. Muscle Nerve.

SEPIC, S. B., MURRAY, M. P., MOLLINGER, L. A., SPURR, G. B. & GARDNER, G. M. 1986. Strength and range of motion in the ankle in two age groups of men and women. Am J Phys Med, 65, 75-84.

SILVERSTEIN, B., FAN, Z. J., SMITH, C. K., BAO, S., HOWARD, N., SPIELHOLZ, P., BONAUTO, D. & VIIKARI-JUNTURA, E. 2009. Gender adjustment or stratification in discerning upper extremity musculoskeletal disorder risk? Scand J Work Environ Health, 35, 113-26.

SORMUNEN, E., RISSANEN, S., OKSA, J., PIENIMÄKI, T., REMES, J. & RINTAMÄKI, H. (2009) Muscular activity and thermal responses in men and women during repetitive work in cold environments. Ergonomics, 52, 964-76.

SOU 2004:43. Den könsuppdelade arbetsmarknaden. In: UTREDNINGAR, S. O. (ed.). Stockholm. SRINIVASAN, D. & MATHIASSEN, S. E. 2012. Motor variability in occupational health andperformance. Clin Biomech (Bristol, Avon), 27, 979-93.

STARON, R. S., HAGERMAN, F. C., HIKIDA, R. S., MURRAY, T. F., HOSTLER, D. P., CRILL, M. T., RAGG, K. E. & TOMA, K. 2000. Fiber type composition of the vastus lateralis muscle of young men and women. J Histochem Cytochem, 48, 623-9.

STERUD, T. & TYNES, T. 2013. Work-related psychosocial and mechanical risk factors for low back pain: a 3-year follow-up study of the general working population in Norway. Occup Environ Med.

SVENDSEN, J. H. & MADELEINE, P. 2010. Amount and structure of force variability during short, ramp and sustained contractions in males and females. Hum Mov Sci, 29, 35-47.

TAIWO, O. A., CANTLEY, L. F., SLADE, M. D., POLLACK, K. M., VEGSO, S., FIELLIN, M. G. & CULLEN, M. R. 2009. Sex differences in injury patterns among workers in heavy manufacturing. Am J Epidemiol, 169, 161-6.

TOOMINGAS, A., FORSMAN, M., MATHIASSEN, S. E., HEIDEN, M. & NILSSON, T. 2012. Variation between seated and standing/walking postures among male and female call centre operators. BMC Public Health, 12, 154.

TOOMINGAS, A., MATHIASSEN, S. E. & WIGAEUS-TORNQVIST, E. 2008. Arbetslivsfy- siologi Lund, Studentlitteratur.

TREASTER, D. E. & BURR, D. 2004. Gender differences in prevalence of upper extremity musculoskeletal disorders. Ergonomics, 47, 495-526.

TORNQVIST, E. W., HAGBERG, M., HAGMAN, M., RISBERG, E. H. & TOOMINGAS, A. 2009. The influence of working conditions and individual factors on the incidence of neck and upper limb symptoms among professional computer users. Int Arch Occup Environ Health, 82, 689-702.

UMEZU, Y., KAWAZU, T., TAJIMA, F. & OGATA, H. 1998. Spectral electromyographic fatigue analysis of back muscles in healthy adult women compared with men. Arch Phys Med Rehabil, 79, 536-8.

WAHLSTEDT, K., NORBACK, D., WIESLANDER, G., SKOGLUND, L. & RUNESON, R. 2010. Psychosocial and ergonomic factors, and their relation to musculoskeletal complaints in the Swedish workforce. Int J Occup Saf Ergon, 16, 311-21.

WAHLSTRÖM, J., BURSTRÖM, L., HAGBERG, M., LUNDSTRÖM, R. & NILSSON, T. 2008. Musculoskeletal symptoms among young male workers and associations with exposure to hand-arm vibration and ergonomic stressors. Int Arch Occup Environ Health, 81, 595-602.

WAHLSTRÖM, J., HAGBERG, M., JOHNSON, P. W., SVENSSON, J. & REMPEL, D. 2002. Influence of time pressure and verbal provocation on physiological and psychological reactions during work with a computer mouse. Eur J Appl Physiol, 87, 257-63.

WAHLSTRÖM, J., SVENSSON, J., HAGBERG, M. & JOHNSON, P. W. 2000. Differences between work methods and gender in computer mouse use. Scand J Work Environ Health, 26, 390-7.

WAI, E. K., ROFFEY, D. M., BISHOP, P., KWON, B. K. & DAGENAIS, S. 2010. Causal assessment of occupational lifting and low back pain: results of a systematic review. Spine J, 10, 554-66.

VAN DER BEEK, A. J. 1993. Loading and unloading by lorry drivers and musculoskeletal complaints. International journal of industrial ergonomics, 12, 13 - 23.

VAN DER BEEK, A. J., KLUVER, B. D., FRINGS-DRESEN, M. H. & HOOZEMANS, M. J. 2000. Gender differences in exerted forces and physiological load during pushing and pulling of wheeled cages by postal workers. Ergonomics, 43, 269-81.

VAN OOSTROM, S. H., VERSCHUREN, M., DE VET, H. C., BOSHUIZEN, H. C. & PICAVET, H. S. 2012. Longitudinal associations between physical load and chronic low back pain in the general population: the Doetinchem Cohort Study. Spine (Phila Pa 1976), 37, 788-96.

WANG, Y., SZETO, G. P. & CHAN, C. C. 2011. Effects of physical and mental task demands on cervical and upper limb muscle activity and physiological responses during com- puter tasks and recovery periods. Eur J Appl Physiol, 111, 2791-803.

WEST, W., HICKS, A., CLEMENTS, L. & DOWLING, J. 1995. The relationship between voluntary electromyogram, endurance time and intensity of effort in isometric handgrip exercise. Eur J Appl Physiol Occup Physiol, 71, 301-5.

WIESENFELD-HALLIN, Z. 2005. Sex differences in pain perception. Gend Med, 2, 137-45. WIJNHOVEN, H. A., DE VET, H. C. & PICAVET, H. S. 2006. Prevalence of musculoskeletal disorders is systematically higher in women than in men. Clin J Pain, 22, 717-24.

WIKTORIN, C., VINGÅRD, E., MORTIMER, M., PERNOLD, G., WIGAEUS-HJELM, E., KILBOM, Å. & ALFREDSSON, L. 1999. Interview versus questionnaire for assessing physical loads in the population-based MUSIC-Norrtalje Study. Am J Ind Med, 35, 441-55.

VINGÅRD, E., ALFREDSSON, L., HAGBERG, M., JOSEPHSON, M., KILBOM, Å., THEO- RELL, T., WALDENSTRÖM, M., HJELM, E. W., WIKTORIN, C. & HOGSTEDT, C. 1999. Age and gender differences in exposure patterns and low back pain in the MUSIC-Norrtalje study. Am J Ind Med, Suppl 1, 26-8.

VROMAN, K. & MACRAE, N. 2001. Non-work factors associated with musculoskeletal upper extremity disorders in women: Beyond the work environment. Work, 17, 3-9.

WUST, R. C., MORSE, C. I., DE HAAN, A., JONES, D. A. & DEGENS, H. 2008. Sex dif- ferences in contractile properties and fatigue resistance of human skeletal muscle. Exp Physiol, 93, 843-50.

YANG, J. F. & CHO, C. Y. 2012. Comparison of posture and muscle control pattern between male and female computer users with musculoskeletal symptoms. Appl Ergon, 43, 785-91.

YOON, T., KELLER, M. L., DE-LAP, B. S., HARKINS, A., LEPERS, R. & HUNTER, S. K. 2009. Sex differences in response to cognitive stress during a fatiguing contraction. J Appl Physiol, 107, 1486-96.

YOON, T., SCHLINDER DELAP, B., GRIFFITH, E. E. & HUNTER, S. K. 2007. Mechanisms of fatigue differ after low- and high-force fatiguing contractions in men and women. Muscle Nerve, 36, 515-24.

ZETTERBERG, C. & ÖFVERHOLM, T. 1999. Carpal tunnel syndrome and other wrist/hand symptoms and signs in male and female car assembly workers. International Journal of Industrial Ergonomics, 23, 193-204.

The Swedish Work Environment Authority
112 79 Stockholm
Office Address: Lindhagensgatan 133
Phone 010–730 90 00
Fax 08–730 19 67
E-mail: arbetsmiljoverket@av.se
www.av.se

ISSN 1650-3171
Report 2013:9

This publication can be downloaded from
www.av.se/publikationer/rapporter

Our vision: *Everyone wants to, and can, create a good working environment*