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Exposure assessment

Gender and context, and target groups for prevention of neck/shoulder and low back pain

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ABSTRACT

Neck/shoulder and low back pain are the most frequent sources of pain complaints, health care utilization, and lost work time. The etiology is multifactorial, and includes physical and psychosocial working conditions, outside work conditions, and psychological factors. The sizable number of females and males suffering from neck/shoulder and low back pain underscores the societal importance of the problem, emphasizing that there is urgent need for effective strategies to address it. The *main aim* of this thesis is to broaden the understanding of gender and context in both the assessment of physical load exposure and the identification of target groups of prevention of neck/shoulder and low back pain.

This thesis is based on the MOA Study and the MUSIC-Norrtälje Study. In *Paper I*, the reproducibility and the validity of eight physical load questions in a public health questionnaire were evaluated by the test-retest method and by a structured personal interview (n=203). *Paper II* investigated if and how exposure to awkward work postures is associated with occupational gender segregation. Direct measurements of sitting, arm and trunk postures were taken with two different technical instruments on 78 matched pairs of one female and one male worker over one full workday in diverse labor markets (n=156). *Paper 3* took an exploratory approach to identification of potential target groups for prevention of neck/shoulder and low back pain, using cluster analysis of 15 variables on different aspects of working and living conditions (n=1,341). In *Paper 4* these clusters or groups were followed up after 5 years with respect to neck/shoulder and low back pain, and care seeking during the follow-up period (n=1,095).

Six of the eight questions had high or moderate accuracy and thus can be recommended for questionnaires to study health effects in epidemiological studies. Two questions on bent/twisted work posture and repetitive movements had low accuracy and should be avoided, at least in general population studies. Gender, type of work, and musculoskeletal complaints did not influence the ability to respond to the physical load questions. Level of exposure to awkward work postures was associated with vertical occupational segregation, and this appeared to be most prominent in female-dominated jobs. Female and male workers in such jobs with low status and authority had the overall highest exposure levels.

Eleven groups with different working and living conditions were identified. Four of the groups had an increased risk for persistent neck/shoulder or low back pain 5 years after the baseline measurements (OR 2.4–2.6). The working and living conditions of these four groups had quite different features, but were all characterized by an overstrained situation. In three of them, the working and living conditions were rather gender-specific.

In conclusion, this thesis emphasizes the need for both reevaluation and redesign of "old" questionnaire instrument, as well as the requirement for new questions relevant for contemporary work situations. Structural factors in the labor market, such as occupational gender segregation, need to be addressed in order to decrease physical load exposure, especially in female-dominated jobs. Gender sensitive methods are essential in both research and prevention. Different broad-based prevention strategies are needed for different groups, i.e., a selective public health approach in prevention. Cluster analysis seems to be a practicable method for identifying target groups for primary/secondary prevention.

Keywords: exposure assessment, physical load, validity, gender, occupational segregation, holistic perspective, context, cluster analysis, neck/shoulder pain, low back pain, prevention

SAMMANFATTNING

Besvär i nacke/skuldra och ländrygg är den vanligaste orsaken till smärta i rörelseorganen, sjukvårdsutnyttjande och sjukfrånvaro. Orsaken till dessa besvär är multifaktoriell och innefattar fysiska och psykosociala villkor i och utanför arbetet, samt psykologiska faktorer. Att en mycket hög andel av kvinnor och män drabbas av besvär i nacke/skuldra och ländrygg är ett stort samhällsproblem och understryker vikten av att skapa effektiva strategier för att förebygga konsekvenserna av dessa besvär. Huvudsyftet med denna avhandling är att öka förståelsen av genus och kontext både vid mätning av fysisk exponering och vid identifiering av målgrupper för prevention av besvär i nacke/skuldra och ländrygg.

Denna avhandling baserar sig på material från både MOA studien och MUSIC-Norrtälje studien. I *studie I* validerades åtta enkätfrågor om fysisk belastning med test-retest metod och med en strukturerad personlig intervju (n=203). I *studie II* undersökte om och hur exponeringar för belastande arbetsställningar är associerade med yrkesmässig könssegregering i arbetslivet. Med två olika mätapparater gjordes direkta mätningar av arbetsställningar – sittande, arm och rygg – på ett könsmatchat urval av arbetstagare i ett flertal olika yrken (n=156). *Studie III* hade en explorativ ansats för att identifiera potentiella målgrupper för prevention av besvär i nacke/skuldra och ländrygg. Grupper identifierades med en klusteranalys av 15 variabler om olika aspekter av arbets- och livsvillkor (n=1341). I *studie IV* följde vi upp dessa grupper (kluster) 5 år senare, med avseende på besvär i nacke/skuldra och ländrygg samt sjukvårdsutnyttjande.

Sex av enkätfrågorna hade hög eller måttligt hög precision och kan således rekommenderas för enkäter och för att studera hälsoeffekter i epidemiologiska studier. De två enkätfrågorna om böjd/vriden arbetsställning och repetitiva arbetsrörelser hade låg precision och bör undvikas i befolkningsstudier. Genus, typ av arbete eller besvär i rörelseorganen (dvs. beroende felklassificering) påverkade inte individens förmåga att besvara dessa enkätfrågor om fysisk belastning. Exponeringsnivåer för belastande arbetsställningar var associerade med vertikal segregering i arbetslivet. Detta var tydligast i kvinnodominerade yrken; kvinnor och män i dessa yrken hade de högsta exponeringsnivåerna av alla grupper.

Elva grupper med olika arbets- och livsvillkor kunde identifieras. Fem år efter baslinjeundersökningen hade fyra av dessa grupper en ökad risk för ihållande, långvariga besvär i nacke/skuldra och ländrygg (OR 2,4–2,6). Arbets- och livsvillkoren för dessa fyra grupper hade olika särdrag, men alla karaktäriserades av en spänd och belastande situation av något slag. Arbets- och livsvillkoren var genusspecifika i tre av de fyra grupperna.

Sammanfattningsvis visar denna avhandling på vikten av att både utvärdera och anpassa ”gamla” enkätfrågor och att konstruera nya enkätfrågor anpassade till nutida, moderna arbetsförhållanden. Strukturella faktorer på arbetsmarknaden som t.ex. yrkesmässig könssegregering behöver beaktas vid förebyggande arbete med avsikt att minska exponering för belastande arbetsställningar. Detta gäller framför allt i kvinnodominerade yrken. Genussensitiva mät- och arbetsmetoder är av största vikt både i forskning och i preventivt arbete. Olika preventionsstrategier behövs för olika grupper, dvs. en selektiv preventionsansats. I stort sett alltid bör prevention omfatta insatser på flera olika nivåer samtidigt (individ, arbetsplats, organisation, samhälle etc.). Klusteranalys visade sig vara en användbar metod för att – med ett helhetsperspektiv – identifiera målgrupper för primär/sekundär prevention.

Nyckelord: mätning av exponering, fysisk belastning, validitet, genus, helhetsperspektiv, yrkesmässig könssegregering, kontext, klusteranalys, nacke/skuldra, ländrygg, prevention

LIST OF PUBLICATIONS

This thesis is based on the following papers, which will be referred to in the text by their Roman numerals (I– IV).

I. Leijon O, Wiktorin C, Härenstam A, Karlqvist L, MOA Research Group. Validity of a self-administered questionnaire for assessing physical work loads in a general population. *J Occup Environ Med* 2002;44(8):724–735

II. Leijon O, Bernmark E, Karlqvist L, Härenstam A. Awkward work postures: association with occupational gender segregation. *Am J Ind Med* 2005;47(5):381–393

III. Leijon O, Härenstam A, Waldenström K, Alderling M, Vingård E. Target groups for prevention of neck/shoulder and low back disorders: an exploratory cluster analysis of working and living conditions. *WORK: a journal of prevention, assessment and rehabilitation, in press*

IV. Leijon O, Lindberg P, Josephson M, Wiktorin C. Different life conditions and their associations with neck/shoulder and low back disorders. *Submitted*

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
ARIA	Work content analysis [Arbetsinnehållsanalys]
BMI	Body mass index
CI	Confidence interval
e.g.	For example (*exempli grati*)
GNP	Gross National Product
GP	General practitioner [allmänläkare, distriktsläkare]
IASP	International Association for the Study of Pain
i.e.	That is (*id est*)
MET	Metabolic rate
MOA	Modern work and living conditions for women and men (research project)
MSD	Musculoskeletal disorder
MUSIC	Musculoskeletal Intervention Center (research program)
n.a.	Not applicable
NYK	Nordic Occupational Classification [Nordisk yrkesklassificering]
OR	Odds ratio
p.h.	Per hour
POR	Prevalence odds ratio
PPT	Pressure pain threshold
SCB	Statistics Sweden [Statistiska centralbyrån]
SEK	Swedish krona (currency)
TWA-MET	Time weighted average metabolic rate
VDU	Video display unit
WBW	Whole body vibration

INTRODUCTION AND BACKGROUND

NECK/SHOULDER AND LOW BACK PAIN

Prevalence in the general population

Musculoskeletal pain is a major worldwide health problem, with the most common pain sites being the neck/shoulder and low back. However, there is considerable variation in the estimates produced by epidemiological studies as to the point prevalence, period prevalence, and lifetime prevalence of neck/shoulder and low back pain (Table 1). Such estimates are highly sensitive to factors such as phrasing and setting of inquiry and cultural differences.[116,183] Heterogeneous case definitions — for example, persistent symptoms versus any self-reported symptoms or work-related symptoms versus symptoms from all causes — also complicate the matter. Moreover, neck pain is often not distinguished from shoulder pain, and the two are sometimes measured separately and sometimes together. Each of these factors makes it difficult to compare prevalence rates among different populations and countries.

Table 1. Prevalence of neck, shoulder, neck/shoulder and low back pain in some reviews and in some large, representative population surveys.

Body region	Prevalence			Country	Study
	Point	1-year	Lifetime		
Neck	6–22%	17–75%	14–71%	*Multi-national*	Fejer et al., in press (review)[55]
		34%		Norway	Bovim et al., 1994[22]
		37%		Canada	Côté et al., 2004[35]
		34%		UK	Palmer et al., 2001[167]
	21%	31%		Netherlands	Picavet and Schouten., 2003[175]
Shoulder	7–26%	5–47%	7–67%	*Multi-national*	Luime et al., 2004 (review)[134]
	21%	30%		Netherlands	Picavet and Schouten., 2003[175]
Neck/shoulder	40%			Sweden	Statistics Sweden, 2002[196]
Low back	13–30%	25–42%	49–70%	*Multi-national*	Andersson, 1999 (review)[3]
	28%		85%	Canada	Cassidy et al., 1998[27]
	27%	44%		Netherlands	Picavet and Schouten., 2003[175]
		40%	70%	UK	Office for National Statistics, 2000[166]
	36%[a]			Sweden	Statistics Sweden, 2002[196]

[a] Including hip pain.

It has been hypothesized that the prevalence of musculoskeletal pain is increasing, but until now the evidence has been both sparse and inconsistent. A recent study by Harkness et al. (2005) compared the prevalence of low back, shoulder, and widespread pain in two surveys conducted 40 years apart in the northwest of England.[75] For all three symptoms examined the prevalence increased from 2- to 4-fold between the two surveys. In another UK study, Palmer et al. (2000) found a 12.7% rise in the 1-year prevalence of low back pain over a 10-year period.[168] In contrast to the results of the

UK studies, two Finnish studies have reported that the prevalence of back pain changed little over a 14-year,[120] and 20-year period.[79] The divergent results of these studies might be explained by the methodological difficulties inherent in epidemiological research, for example, different modes of data collection or different definitions for identifying pain syndromes, and by population factors associated with pain occurrence including age, gender, ethnicity, socioeconomic status, occupation, and so on. It has also been suggested that the increase in prevalence reported by some studies may actually reflect an increased willingness to report musculoskeletal pain symptoms — for cultural, social, and legal reasons.[75]

Definitions

The terms of neck/shoulder pain or low back pain requires only that a person is suffering from either pain localized in the appropriate bodily region, or pain-related functional impairment or disability relating to that body region. Neither the grade of pain nor the severity of the functional impairment is taken into account, and, moreover, it is recognized that pain and pain-related disability are subjective and personal experiences. The International Association for the Study of Pain (IASP) has defined pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage".[152] However, many people report pain in the absence of tissue damage or any likely pathophysiological cause. It has been hypothesized that this happens for psychological reasons. There is usually no way to distinguish their experience from that due to tissue damage, and it should be accepted as pain.[152]

Neck/shoulder pain can be defined as any pain located in the neck/shoulder region, i.e., pain in the neck and/or one or both shoulders, originating from any cause. Pain in the neck may arise from various structures in the neck, vertebrae, intervertebral discs, synovial joints, spinal nerve roots, blood vessels, ligaments, tendons, or muscles within or associated with the cervical spinal column.[14] Shoulder pain may arise in or around the shoulder from the glenohumeral, acromioclavicular, sternoclavicular, subacromial, and scapulothoracic articulations, and surrounding soft tissues.[194] Neck symptoms are often combined with symptoms of the upper extremities, and it is often difficult to differentiate shoulder pain from neck pain. [14,167,194] Moreover, most cases of neck/shoulder pain are labeled as non-specific, that is, no direct cause for the pain can be detected.[7,193]

Low back pain can be defined as any pain concentrated in the lower back, i.e., between the costal margins and the gluteal folds, originating from any cause.[59] Sometimes the pain may extend to the buttocks and thighs, above or below the knee. Low back pain may be caused by a disease or a functional problem of one or more of the anatomical structures, vertebrae, intervertebral discs, facet joints, spinal nerve roots, blood vessels, ligaments, tendons, or muscles within or associated with the lumbar spinal column. It has been estimated that 95% of cases in the working-age population result from soft-tissues, i.e., muscle, tendon and ligament.[59] However, the large majority of cases of low back pain are labeled as non-specific, because the cause of pain is unknown or is unrelated to organic disease.[12,59]

Etiology

Musculoskeletal pain has a number of causes. The most important factors, both individually and in interaction, seem to be work-related (physical and psychosocial), leisure time, demographic, and psychological. It is worth noticing that the majority of musculoskeletal pain conditions develop slowly; only a minority are due to a sudden event or an acute trauma.[4]

Occurrence/onset of neck pain

There is moderate to strong evidence for a connection between neck/shoulder pain and work-related physical factors such as duration of sitting, neck posture, trunk posture, arm posture, static posture and contraction, forceful arm movements, and repetitive movements,[5,12,214] as well as work-related psychosocial factors such as quantitative job demands, social (co-worker) support, job control, skill discretion, job satisfaction, and perceived job stress.[6,18,19,128] In addition, conclusive evidence has been reported for relationships between work place design and neck pain, and between duration of employment and shoulder pain.[6,214] For males, it has also been shown that the risk of neck/shoulder pain increases with the number of risk indicators.[65] Several researchers have suggested that health-related factors such as general health and concomitant pain elsewhere as well as individual factors such as gender, family situation, body weight, and sporting activities are related to the onset of neck/shoulder pain.[57,83] However, consistent evidence for the contribution of these factors to the onset of pain is still lacking.

Occurrence/onset of low back pain

There is also moderate to strong evidence for a relationship between low back pain and both psychological factors and work-related physical factors. However, as can be seen from the summary of 20 systematic reviews presented in Table 2, the evidence for a link with individual/leisure factors and work-related psychosocial factors is rather contradictory. Some reviews report strong or moderate evidence for a relationship while others claim that there is insufficient evidence, or even no evidence at all. It has also been suggested that there is a relatively strong genetic component to low back pain in both young people and adults.[113] However, further studies are needed to reveal the true impact of heredity.

The natural course

The vast majority of individuals with a new onset of neck/shoulder or low back pain recover within about one month.[159] In other words, musculoskeletal problems are usually self-limiting conditions, and so time may be the single most important prognostic factor.[96] A true natural history of musculoskeletal pain is difficult to establish, since the course and outcome of a pain episode may be influenced by the different strategies that people use to deal it with. The strategies are shaped by a large number of factors, including recommendations from family, friends, colleagues, the media, the Internet, as well as from healthcare providers. Figure 1 presents a conceptual model outlined by the National Research Council (2001) for the course of musculoskeletal pain.[161] The model is broad and dynamic, and aims to encompass and describe such things as variation from person to person variation within one individual over time,

Table 2. Summary of factors associated with the occurrence and chronicity of low back pain, based on systematic reviews.

Risk category	Relationship between different factors and occurrence of low back pain		Relationship between different factors and chronicity of low back pain	
	Strong/moderate evidence	**Insufficient/no evidence**	**Moderate/strong evidence**	**Insufficient/no evidence**
Demographic/individual				Gender[192]
			Age[203]	Age[192]
				Ethnicity[192]
				Marital status[192]
				Urban residence[192]
				Educational level[192]
				Financial situation[192]
		Body weight[114]		Body weight[192]
		Smoking[115]		Smoking[192]
		Alcohol consumption[112]		
				Caffeine consumption[192]
Work-related factors				
Physical	Heavy physical work[12,87,210]		Heavy physical work[192,203]	
	Awkward trunk posture[12,87,137,138]			
		Static work posture[12]		
		Prolonged standing/walking[87]		
		Prolonged sitting[87]		
	Manual handling[12,33,87,89,137,138,210]			
	WBV[12,87,127,137, 138,210]			
Psychosocial	Work demands[18,137]	Work demands[40,88]		
	Monotonous work[18]			
	Time pressure[18]	Time pressure[77,88,137]		
	Job dissatisfaction[40,88,137,138]			Job dissatisfaction[192]
	Influence over work[18,88,137]	Influence over work[40]		
	Social support[88,137]	Social support[40,77]	Social support[192]	
		Job content[88]		
			Job tenure[203]	Job tenure[192]
			Company size[203]	Company size[192]

Table 2. Continued

Risk category	Relationship between different factors and occurrence of low back pain		Relationship between different factors and chronicity of low back pain	
	Moderate/strong evidence	**Insufficient/no evidence**	**Moderate/strong evidence**	**Insufficient/no evidence**
Private/leisure	Physical activity/sports[83]	Physical activity/sports[87] Social support[88]		
			Difficult life circumstances[192]	
Psychological	Personality traits[18]	Personality traits[128]		Personality traits[176]
			Psychological distress[176,203]	
	Depression/anxiety[128]		Depression/anxiety[128,176]	
	Stress symptoms[18,40,77,128,137]			
	Cognitive factors[128]			
			Poor coping[192]	
			Somatization[176]	
			(Catastrophizing)[176]	
				Physical/sexual abuse[128]
Onset circumstances			Delayed reporting/treatment[192]	
Clinical picture		General health[18]	General health[128]	
				Injury type[192,203]
			Severity in pain[192,203]	
			Functional impact[192,203]	
			Radicular symptoms[192]	
			Extreme symptom reports[192]	
				Previous pain episode[192]

Reviews: Bernard, 1997[12]; Bongers et al., 1993[18]; Cole and Grimshaw, 2003[33]; Davis and Heaney, 2000[40]; Hartvigsen et al., 2004[77]; Hildebrandt et al., 2000[83]; Hoogendoorn et al., 1999[87]; Hoogendoorn et al., 2000[88]; Hoozemans et al., 1998[89]; Leboeuf-Yde, 2000[112]; Leboeuf-Yde, 2000[114]; Leboeuf-Yde, 1999[115]; Lings and Leboeuf-Yde, 2000[127]; Linton, 2000[128]; Lyons, 2002[137]; Lötters et al., 2003[138]; Pincus et al., 2002[176]; Shaw et al., 2001[192]; Turner et al., 2000[203]; Walker-Bone and Palmer, 2002[210]

the capacity of any of its sub-elements to diminish or expand, the ability of the individual to adapt, changes in mechanical factors, and changes in the social or cultural context.

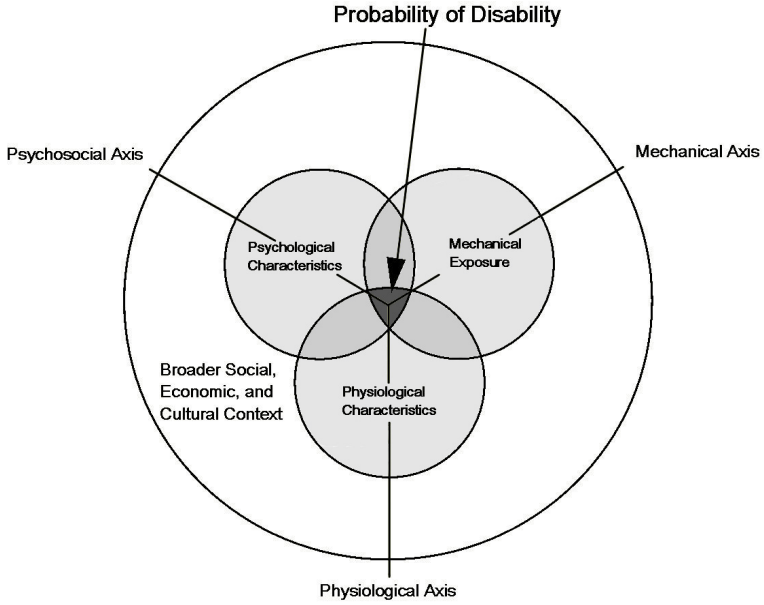

Figure 1. Risk factors for the injury, impairment, and disability attributed to musculoskeletal disorders in the individual. Reprinted with kind permission of National Academy Press, © 2001 by the National Academy of Sciences (National Research Council and Institute of Medicine, 2001).

In a study of new incidents of neck/shoulder disorders, Pernold and colleagues (2005) reported that the bulk of any reduction in pain and pain-related disability was completed within three months, with only minor improvements taking place thereafter.[173] The same pattern was observed in a systematic review of acute low back pain, in which Pengel et al. (2003) found that that pain decreased rapidly (pooled mean 58%) during the first month, continued to decrease until about three months after onset, and then remained nearly constant through to a 12 months follow-up.[172] A similar trend was seen for pain-related low back disability.

A meta-analysis by Pengel et al. (2003) shows that the vast majority of workers requiring time off due to acute low back pain return to work within one month (pooled estimate 82%), and about nine out of ten resume work by three to six months.[172] Although most people are back at work within six to twelve months, low levels of pain and pain-related disability may still persist. Several researchers have suggested that recovery and return to work after an episode of pain is influenced by clinical, social, economic and legal factors.[48,146] It has also been shown that while in some countries return to work can be predicted from demographic characteristics, in others it cannot, [74] emphasizing the fact that generalization from a study in one country to another should be carried out very carefully.

For the 10–20% of individuals in which severe pain persists, the prognosis is less favorable, and recurrence of symptoms is very common. Pengel et al. (2003) report that the cumulative risk of at least one recurrence of low back pain within 12 months is very high (pooled estimate 73%).[172] Several researchers have also suggested that musculoskeletal pain should be regarded and characterized as an episodic disease.[41,94] Although

the development and long-term prognosis for individuals with different degrees of severity of musculoskeletal pain has not been studied extensively, there are indications that early-in-life musculoskeletal symptoms predispose for a worse prognosis. Several studies have showed that a history of musculoskeletal symptoms is associated with future symptoms.[32,36,61,84,117] The meaning of a previous history of musculoskeletal complaints, however, is not clear as it may itself reflect previous exposure to risk factors, a higher susceptibility, or a higher tendency to report pain.[215]

Very little is known about the predictive factors for the prognosis of neck/shoulder pain. In a review of studies on neck pain, Borghouts et al. (1998) concluded that high pain intensity and a history of previous pain episodes appear to be associated with a worse prognosis.[20] Although age has been proposed as a prognostic factor, a review by Malchaire et al. (2001) revealed that the association between age and musculoskeletal problems was evident in less than half of the studies which included age as a risk factor.[145] It has also been suggested that gender but not age is associated with the onset of neck pain, and that age rather than gender predicts the persistence of pain.[36,84] In a review of studies on the prognosis of shoulder pain, Kuijpers et al. (2004) concluded that there is strong evidence that high pain predicts a poorer outcome in primary care populations and that middle age (45–54) is associated with a poorer outcome in occupational populations.[110] Duration of symptoms and workplace demands are other potential predictive factors for the prognosis of neck and upper extremity disorders,[32] but the evidence is still limited.

The predictive factors of persistent and chronic low back pain have been rather more widely studied. Factors associated with the transition from acute to chronic low back pain concern psychological factors as well as onset circumstances and clinical picture, while work-related or demographic/individual factors seem to be less important (Table 2). Other variables that have been suggested as important for chronicity include unemployment, low educational level, and the occurrence of a significant negative event in the previous year.[49,98]

Co-morbidity

Musculoskeletal co-morbidity, that is, musculoskeletal symptoms in several areas of the body, is common.[84,158,219] Both national and cross-national studies have found that about two-thirds of individuals with musculoskeletal pain reported pain in at least two places.[67,205] An even higher prevalence of musculoskeletal co-morbidity has been reported in specific occupational groups. For example, in a study of male manual workers in Hong Kong, Yeung et al. (2002) found that 77% of workers suffering from pain reported that it was manifested in two or more bodily regions.[236] Urwin et al. (1998) found that the most common overlaps were low back and knee pain, neck and shoulder pain, and low back and hip pain.[205] These overlaps confirm the findings of an earlier Finnish study, which reported that in the presence of osteoarthritis in the knee or hip, low back pain was also prevalent (OR 5.3, 95% CI 4.1–6.9).[80] The link between symptoms in different bodily regions might be explained by shared pathology, common mechanical risk factors, or some aspect of psychological distress. Musculoskeletal co-morbidity, in turn, has been shown to be positively related to outcomes such as health-care utilization,[95] impaired work role functioning,[67] and a delayed return to work.[163]

Psychological factors and mental health problems are known to be intimately associated with musculoskeletal pain.[31,129] Bingefors and Isacson (2004) recently reported a strong relationship between psychiatric problems and the number of pain complaints.[15] However, the direction of causality between pain and mental health is not straightforward and different researchers disagree about the direction of causality.[177,234] Several different explanations for the association between musculoskeletal pain and mental health have been proposed. Firstly, that mental health problems either cause pain or are expressed as pain; secondly, that pain causes mental health problems; and thirdly, that psychiatric disorders such as depression may share common pathogenetic mechanisms with pain. Further research in this area is needed to extend and consolidate knowledge. On the other hand, it is rather clearer that psychological factors play a crucial role in the transition from acute to chronic pain problems, and that these psychological factors may enhance or catalyze the problem.[129,176] This means that the experience of pain interacts with the psychological factors that influence emotion and behavior, and these in turn shape the course of pain development.

Co-morbidity of pain with a number of other disorders or diseases in other body systems has also been shown. There are, for example, associations between shoulder and/or back pain and cardiovascular and respiratory disorders,[15,81,82,158] as well as ulcer and dyspepsia.[15]

Care seeking

People seek healthcare for musculoskeletal pain not only for diagnostic evaluation and symptom relief, but also because pain interferes with daily activities, causes worry and emotional distress, and undermines confidence in one's health and one's abilities. Two Dutch studies found that roughly 30–45% of people reporting musculoskeletal pain in the past year had contacted their GP for these complaints.[156,175] The South Manchester Back Pain Study reported that the 12 month cumulative incidence of new "non-consulting episodes" was 31% in males and 32% in females.[169] In Finland musculo-skeletal pain in general was found to be the reason for approximately 18% of the visits to healthcare center physicians.[184] Molano et al. (2001) found that while general co-morbidity played a limited role in care seeking, musculoskeletal co-morbidity was not associated with care seeking.[156] However, very few studies have looked at the number of consultations attributable to complaints in specific regions of the body. An exception is a study by Bot et al. (2005) of GP consultations due to neck and upper extremity symptoms, which found an incidence of 23.1 per 1000 person-year for neck symptoms and 19.0 for shoulder symptoms.[21]

Individuals seeking healthcare are likely to have higher prevalence rates of persistent pain than a general population sample. A longitudinal study by IJzelenberg and Burdorf (2005) found that healthcare use was strongly associated with a history of severe symptoms, and that 40% of the workers who had sought care for their symptoms at baseline visited a healthcare provider again for the same symptoms within 6 months.[94] In the MUSIC-Norrtälje Study, Vingård et al. (2002) reported that exposure to occupational physical and psychosocial factors had a moderate impact on healthcare use for low back pain in a general working population.[229] In addition, Grooten et al. (2004) reported a moderate increase in the likelihood of healthcare use for neck/

shoulder pain among males with regard to manual material handling, night/shift work, hindrances at work, and solitary work; however, among females, healthcare use was not influenced by work-related factors.[65]

Sick leave and disability pension

Approximately 30% of European workers claim that their work causes back pain.[53] In Sweden, musculoskeletal disorders (MSDs) account for about 30% of all sick leaves. Although much attention has been paid to work-related and demographic risk factors for the onset of musculoskeletal symptoms, the influence of work-related factors on the occurrence of sick leave attributable to such symptoms has been less extensively studied.[73] However, a review and a couple of recent longitudinal studies found that the work-related physical and psychosocial factors which are well-known to be associated with the occurrence of musculoskeletal symptoms are quite similar to those which can be associated with sick leave.[73,94,211] A Finnish study reports that negative changes in job control, job demands, and social support, especially in combination, increases the risk for sickness-related absence.[206] Other factors that increases the likelihood of an individual taking sick leave are being female (neck/shoulder pain), being older (low back pain), and living alone (both neck/shoulder and low back pain).[94] Another recent study found that employees who did not participate in sporting activities bore an increased risk of absenteeism and a decreased risk of recovery.[212] It has also been shown that previous sick leave due to MSDs is a predictor for recurrence of sickness-related absence.[73,139]

The number of Swedes claiming disability pension for musculoskeletal problems increased from 147,641 in December 1991 to 186,781 in December 2002 – a 27% increase over eleven years.[198] In comparison, the number of people claiming disability pension for psychiatric problems increased by 61% during the same period. Musculo-skeletal problems were the most common reason for disability pension among females while psychiatric problems were the most common reason among males (Table 3). About two-thirds (66.9%) of those claiming disability pension for musculoskeletal problems were females. A review by Hansson and Jensen (2004) found that female gender and higher age were both risk factors for disability pension due to back and neck disorders.[73] From a longitudinal study Hagen et al. (2002) reported that the strongest predictors for future pain-related disability in the back were the occupational risk factor of "physically demanding work", and the co-morbidity factor of "poor general health".[68] In addition, "feeling worn out", being a smoker, and high BMI were all predictors for disability pension due to back pain.[68]

Table 3. Number of females and males with disability pension in Sweden December 2002: the four largest diagnosis groups are presented.[198]

Diagnosis group	Females		Males		All disability
(disease/disorder)	2002	(1991-2002)	2002	(1991-2002)	pensions 2002
Musculoskeletal	124,921	(+36%)	61,860	(+11%)	39.1%
Psychiatric	75,357	(+68%)	69,255	(+55%)	30.3%
Circulatory	10,944	(+13%)	18,428	(- 4%)	6.1%
Neurological	13,732	(+62%)	11,068	(+54%)	5.2%
Total number (all diagnoses)	277,291	(+49%)	200,599	(+31%)	100%

Economic aspects

Reported estimates of the total cost of back pain in various countries indicate that these costs amount to 1–2% of GNP.[165] In 1995, the total societal cost of back pain in Sweden was estimated to be approximately 30 billion SEK per year, i.e., 1.7% of GNP, or about 3,500 SEK per inhabitant per year. MSDs seem to be one of the most expensive categories of disease.

Approximately 90% of the cost is *indirect costs*, due to loss of productivity, sick leave, and prolonged disability.[165] Disability pension is one example of an indirect cost. In December 2002, about 10% of the working-age population in Sweden was receiving disability pension. Among these, 39.1% had been rewarded their pension because of MSDs (see Table 3). Further, it has been reported that the 10% of workers with chronic occupational low back pain account for 90% of all medical and indemnity costs attributable to occupational low back pain.[78] In a study of the burden of illness in Sweden, the total per-patient annual indirect cost for chronic low back pain was estimated to be 17,600 Euros at 2002 prices.[51]

The remaining 10% of the cost is *direct costs*, due to inpatient or outpatient care and pharmaceuticals.[165] The total per-patent annual direct cost for chronic low back pain was estimated to be 3,100 Euros at 2002 prices.[51] One example of direct costs is analgesic use. Analgesics are the most commonly used non-prescription drugs and are also among the most commonly used prescription medications. Isacson and Bingefors (2002) reported that sales of different types of analgesics, as measured in Defined Daily Doses per 1000 inhabitants per day, were sufficient for approximately 10% of the Swedish population to use a full dose of analgesics every day.[97]

Sex differences and a gender perspective

Sex and gender differences in musculoskeletal morbidity have been reported in studies of the general population as well as in different occupational groups. The differences in morbidity seem to be more distinct for neck/shoulder pain, where the prevalence is consistently higher for females than for males.[28,42,44,199] A review of 56 articles on upper extremity disorders (including neck and shoulder disorders) concluded that females do have significantly higher prevalence than males for many types of upper extremity musculoskeletal disorders, even after controlling for the type of data source — self-reporting, plant/worker compensation records, physical examination — and con-

founders such as age.[202] For low back pain, there is a less pronounced gender gap, with markedly or slightly higher prevalence for females in some studies,[42,130,199] but also slightly higher prevalence for males in others.[66,119]

A summary of data from epidemiological studies in the general population found a median ratio between males and females of 1.4 for neck pain, 1.3 for shoulder pain and, 1.2 for low back pain.[121] The reason behind these differences between the genders are poorly understood, and some researchers have suggested that the female sex is a risk factor in itself,[202] while others have criticized this theory as being too simplistic, proposing instead a more gender-sensitive approach to research.[104,106,121,155,180]

In order to analyze and understand the differences in musculoskeletal pain between males and females a gender perspective is essential. The terms "sex" and "gender" (or "genus" in Swedish) are sometimes used interchangeably and synonymously, and sometimes in order to express different aspects of the concept of sex. However, the term "gender" is neither an expression of biology nor a fixed dichotomy in human life or character. It is a pattern in our social arrangements and in the everyday activities and practices, governed by those arrangements. The Australian sociologist R.W. Connell (2002) has suggested the following definition of gender: "*Gender is the structure of social relations that centers on the reproductive arena, and the set of practices (governed by this structure) that bring reproductive distinctions between bodies into the social process*".[34] This means that a gender analysis must go beyond the idea that our cultural patterns simply express bodily or reproductive differences. Gender is a matter of social relations within which individuals and groups act. It reflects the interplay between sex-related biological and social factors and the many consequences of that interplay for the individual and for the society.[34,45,99] Central concepts in gender theory are the construction and re-construction of gender, and the relations between males and females in social structures of power and hierarchy.[99] In a public health context, disadvantages in influence, autonomy, and power relations are associated with and may cause inequalities in health for both females and males.[70] Several different explanations for gender differences in musculoskeletal morbidity have been proposed. The four that follow are more or less interconnected, and most likely operate simultaneously.

Biological differences in such things as body size, muscular capacity, aerobic capacity, and hormonal conditions are thought to make women more susceptible to the onset of musculoskeletal pain. The idea of a biological basis for gender differences dates back to Darwinism, and has been influential ever since.[34] It has been suggested that there are several biological factors that directly pertain to musculoskeletal gender differences and hence to gender differences in susceptibility to musculoskeletal pain. For instance, sex hormones may play a role in regulating connective tissue function as both tendons and ligaments have receptors for estrogen which may respond to changes in hormonal levels.[76] Thus, hormonal fluctuations that occur in the menstrual cycle or during pregnancy may contribute to differences in regulation of these tissues. Another example is the average differences between males and females in body strength. Women's total body strength is estimated to be, on average, about two-thirds that of men's. However, the differences are smaller when women and men have similar industrial experience or athletic training.[29] Despite the average differences, there is also substantial overlap in

strength distribution by gender, especially as many muscle strength values are not normally distributed. Moreover, gender, age, weight, and height only explain about one-third of variability in human strength data.[180] In all, and particularly with respect to neck/shoulder and low back pain, the health implications of biological differences are not clear, and further research in this area is needed.

Differences in working conditions may also help to explain the higher prevalence of musculoskeletal pain in females. Working conditions may, in turn, be divided into labor market factors and workplace factors. The labor market in Sweden and in most other countries is strongly segregated by gender and occupation. In occupational gender segregation two main principles can be distinguished: horizontal segregation and vertical segregation.[16,30] It is interesting to find that this phenomenon was first noted already almost a hundred years ago in Olive Schreiner's book published 1911, "Woman and Labour" which presented an analysis of the "parasitism" of bourgeois women and the refusal of the bourgeois society to recognize the exploitation of working women – though the conceptual and theoretical framework has developed since (available on Project Gutenberg at www.gutenberg.org/etext/1440).[34] The term *horizontal segregation* refers to the concentration of female and male workers in different sectors of the labor market and in different types of occupations, and the term *vertical segregation* to the power structures that place "male as the norm" in our society, and to the concentration of women and men in different hierarchical positions.

Horizontal gender segregation is one of the most enduring features of the labor market.[150,179] In Sweden only about 10% of men and women work in gender-integrated jobs.[220] The choice of a "traditional" occupation is probably a result of the socialization process and of gender coding of behavior and work tasks, and even things like work tools and personal possessions.[34,220] Women are often recommended for jobs requiring "female abilities" (usually socially demanding jobs in the service and healthcare sectors), and jobs involving repetitive tasks of low task variety.[179,180] It is possible that horizontal segregation could result in different exposures and different exposure levels for male and female workers and, thus, different risk for musculoskeletal pain, but a study by de Zwart et al. (2001) did not find any support for this theory.[44] However, Leijon et al. (2004) found that sickness-related absence due to musculoskeletal diagnoses was associated with the level of horizontal occupational segregation, and showed that workers in gender-segregated jobs had higher cumulative incidence of sick leave due to neck/shoulder or low back pain than workers in gender-integrated jobs.[118] This finding was more apparent for female workers and also for workers in extremely gender-segregated jobs.

Vertical gender segregation, or "male as the norm", can result in "male qualities" being encouraged and rewarded to a greater extent than "female" or "soft abilities". Because of this, female workers are more likely to hold subordinate positions with low influence over working conditions and few opportunities for job task modifications, and to work under conditions with, for example, constrained work postures and repetitive and monotonous tasks.[106,136] Two important aspects of vertical gender segregation are position and income. In Sweden, three out of four managers are men, with the gender gap being even more pronounced in the private sector, where men occupy four out of five managerial positions.[197] Females are less likely than males to be promoted above

certain levels (the "glass ceilings" phenomenon). Moreover, many female workers never manage to move beyond entry-level jobs (the "sticky floor" effect), a situation which can result over a lifetime in a high accumulated exposure to physically demanding work. Jobs which are predominantly held by females are often regarded as being of low-status and are valued less highly than jobs in more male-dominated sectors. Low status and lack of authority in the work sphere have been identified as potential risk factors for ill-health.[180,190] When it comes to income, women again lose out; the wage or salary paid to a female worker in Sweden is only 92% of that paid to a male worker, after adjustments are made for age, educational background, full-time work versus part-time work, sector, and occupational group.[197]

Vertical segregation need not to be explicit. Even within seemingly identical jobs, female and male workers may perform different tasks, resulting in differences in power and status as well as in work load and exposure patterns.[148,151,180] Examples of work task differentiation by gender and differences in physical as well as psychosocial exposure, have been reported in studies of fish processors,[162] automobile assemblers,[60] healthcare workers,[100] and several other occupations.[85,153]

Another factor in the higher prevalence of musculoskeletal pain among females could be the mismatch between their anthropometric dimensions and the workplace.[106,180,200] Many workstations and work tools are designed for the male frame, putting the (typically) smaller and weaker woman at a disadvantage. Postural strain may develop in female workers who adopt different work techniques to those of male workers in order to compensate for the misfit, an effect that has been observed in VDU work,[102,126] the metal industry,[39] and manual handling and lifting work.[123]

Differences in domestic conditions and in the interaction between conditions at home and at work can also have an effect on the risk of musculoskeletal pain.[93] Although in Sweden and other Nordic countries participation in working life by males and females is almost even, domestic activity, like work activity, is largely gender-segregated.[69] Females are not only likely to bear the main responsibility for caring for the family, but they also spend more time on domestic chores, a situation that has not unreasonably been described as the "double work" or the "second shift". Domestic and family work makes physical and mental demands which are likely to add to the risk factors for musculoskeletal pain.[106] Social life stress, child (parental) stress, environmental stress, and family health stress have all been shown to affect long-term health in females but not males.[149] Moreover, the additional hours spent on domestic chores over and above the working day will decrease the time available for recreation and rest. It is hypothesized that when insufficient time is devoted to rest, the reparative processes which heal the micro-ruptures involved in the development of musculoskeletal pain will be disrupted. Fatigue and sleep disturbance are more commonly reported among females than males.[106]

Investigations into the effect of marital status have produced varying results. A large study of the US general population concluded that differences in marital status had only a modest effect on the prevalence of low back pain.[189] Other studies have shown that single working mothers may be at greater risk for developing chronic medical problems, possibly because of the burden of housework and child-rearing.[10,50] While in

general the most healthy females are the full-time paid workers and the least healthy are those without paid employment, for females with children the pattern is reversed.[10] Studies have also suggested that parenthood among male workers may be an independent risk factor for back pain.[58,187] The taking on of multiple roles – employee, spouse or partner, parent – has been proposed as both a potential health promoting factor, "role enhancement", and a risk factor, "role strain".[90] However, there is still a lack of investigations into the association between multiple roles and musculoskeletal pain.

Differences in expressing and reporting musculoskeletal pain are another potential factor. It has been hypothesized that the underlying biological mechanisms of pain as well as the cognitive and emotional experience of pain may differ for females and males, resulting in different approaches to coping with pain.[204] One example of biological mechanisms is pain tolerance. Pain tolerance is often measured by pressure pain thresholds (PPT), and PPT values are generally higher in males than females.[180] However, it has also been shown that the variance in PPT between males with and without symptoms was much smaller than the corresponding variance in females, suggesting either that male reporting of symptoms was less accurate (denial of symptoms?) or that PPT does not reflect the same pain phenomena in the two genders.[25,180]

Another widely held theory is the differential childhood socialization as well as different adult role expectations and obligations can influence pain-related behavior, including reporting.[121,142] The social acceptability of admitting pain, discussing symptoms, and seeking help seems to differ for females and males. Boys are socialized to be self-reliant, whereas girls learn that it is acceptable to be dependent and seek help. However, the results of studies that have examined males and females with the same conditions or symptoms are contradictory, and lend little support to the hypothesized greater propensity for females to express and report pain.[64,142] Females are however more likely than males to seek healthcare for many conditions, including pain problems.[204] Vingård et al. (2002) also found that females tended to seek traditional care-givers such as physicians and physiotherapists to a larger extent than males, who preferred experts like chiropractors and osteopaths.[229] The reasons behind these differences warrant further research.

In conclusion, the relationship between gender and pain is far from simple. Persistence of a pain condition may be related to the effect of gender in the context of the workplace, the family, the healthcare delivery system, and the welfare system. When attempting to identify modifiable causes of pain and develop understanding of pain mechanisms, it may be more productive to think of sex and gender as a marker for more specific risk factors, or, in other words, those risk factors that are likely to have a more direct effect on pain. This is often described as a gender-sensitive approach.

A CONTEXTUAL APPROACH

> *Context*, noun from Latin contextus, from past participle of contexere, to join together: com- + texere, to weave.
> 1. Discourse that surrounds a language unit and helps to determine its interpretation
> 2. The set of facts or circumstances that surround a situation or event
>
> (www.thefreedictionary.com)

The high prevalence and colossal related costs of non-specific neck/shoulder and low back pain both underscore the significant societal importance of the problem, and emphasize the urgent need for effective strategies to address it. When planning intervention and prevention strategies, the complex and multifactorial etiology of such pain symptoms must be considered. Holistic and contextual approaches in epidemiological research as well as in preventive work may help to pinpoint those groups most at risk for neck/shoulder and low back pain, and to identify arenas and situations in which preventive efforts may be most cost-effective. Moreover, public health research increasingly acknowledges the interaction of social and environmental factors in the distribution and causes of disorders. Other arguments for the contextual approach include methodological aspects, pedagogical and utilitarian aspects, and the necessity for a holistic perspective.

Methodological aspects

Epidemiological studies of musculoskeletal pain have traditionally had the primary aim of using a variable-oriented approach to identify and quantify risk factors.[93,133] The many work-related and non-work-related risk factors thus isolated can be used to establish threshold limit values for use in specific quantitative guidelines, or in legislation, aimed at protecting vulnerable groups within the labor market. However, such an approach reinforces an individualistic perspective when applied to risk factor modification.[125] The "traditional" epidemiological studies do not produce information about where the risk factors are located in working life or where they are located in the private sphere, and they do not take into account the effect of context on risk factors, for example, the different accumulation of risk factors found in different sectors of the labor market and in different structures within the workforce. Moreover, since modifying or even protective factors may interact both at and outside work, the relationship between risk factors and pain symptoms or ill health may not be the same for all workers.[62] Findings also indicate that physical and psychosocial stressors within the workplace share common variance.[141]

It seems clear that the risk-identification approach can be very usefully complemented by the collection of, and the search for patterns in, data covering a broad range of individual conditions.[1] However, the sheer number of potential interactions within such complex data can make it very difficult to apply analytical methods such as logistic regression. Previous studies have shown that cluster analysis may be an alternative and effective method for detecting the complex patterns of combined risk indicators and risk moderators.[93] Other types of contextual analyses include qualitative case studies and multi-level analysis, the latter is a technique that can be used for hierarchically ordered data such as data organized at individual and workplace levels.

When cluster analysis is used, the choice of variables is critical, and should be based on identified, well-known risk factors and supportive factors. If the aim of the cluster analysis is to identify groups and contexts that it is possible to influence or change, the analysis should clearly not include characteristics such as gender, age, and educational level. These individual characteristics should instead be used to investigate which individuals can be found in these groups or contexts. However, it is worth noting that risk factors and supportive factors are not unrelated to individual characteristics, selection or the individual's own choices and experiences may play a considerable role.[46]

Pedagogical and utilitarian aspects

Primary and secondary prevention are contributed to and facilitated by identification of life situations that may predispose groups of individuals to MSDs. One prerequisite for success in this endeavor is that all involved are "on the same page", that is, there is a common understanding between individuals at risk, healthcare staff, occupational health providers, and anyone else engaged in pain management and prevention. It is often easier to communicate the preventive message by describing "risk situations" rather than individual risk factors, since this wider perspective is closer to the reality of those at risk; recognition is an important pedagogic aspect in targeted prevention. Moreover, since all life situations include strain-inducing as well as supportive elements, preventive efforts may be directed both at reducing risks and at strengthening positive factors in the life situation, whether at work or outside work. Considering the overall situation instead of a single risk may help to avoid an unintentional shift of risk from one exposure to another, for example, from heavy material handling to repetitive work, or from one group of workers to another, for example, from permanent full-time employees to "just-in-time" contract employees.[186]

A holistic perspective

A holistic perspective on health research and preventive intervention is one that takes into account the entire situation of an individual, encompassing social, psychological, and physical conditions within and outside work. As a theoretical concept this has often been described as a person-oriented approach. Bergman et al. (2003) summarize its essence as follows: "*The person oriented approach in research (in contrast to a variable centered approach) takes a holistic and dynamic view: the person is conceptualized as an integrated totality rather than a summation of variables*".[11] A holistic perspective also recognizes the context in which the individual acts, for example, the organizational context of work and the workplace, or the family and social context outside work. Moreover, research into job-related stress has emphasized that a holistic perspective must include both the objective structural characteristics of work and the more subjective ones, such as worker perception of said characteristics.[91,103] It has been discussed if such contextual factors interact with exposure, e.g., if organizational factors at work may be a determinant of low level physical or psychosocial exposure, or if they modify the relationship between individual-level exposures and their health effects, or if they affect health directly through pathways other than the established exposure-outcome relationships.[140] However, further research is needed to clarify such interactions and pathways.

ASSESSMENT OF EXPOSURE

Physical and psychosocial exposure must be considered when assessing risk exposure. Physical factors associated with musculoskeletal pain include body posture and movement as well as the forces exerted. Psychosocial factors include factors such as psychological demands, control, and social support. Exposure in the work sphere is determined by the purpose of the job, the design of workstations and work tools, the weight of handled material, and organizational factors such as the design of the work process, the time demands of the job, and the distribution of tasks among workers. Exposure in the private sphere is largely determined by family composition and by the personal obligations or interests of the individual.

Assessment of physical exposure

Assessment of physical exposures requires quantification of the intensity, frequency, and duration of the potential risk factor.[230] The use of job title as an overall proxy for physical exposure has been severely criticized, as exposure level may vary more between individuals holding a given job title than between individuals with different job titles.[23,63] Thus, the most commonly used data collection methods in contemporary research on risk factors for musculoskeletal pain are self-reporting, observation, and direct measurement by means of technical equipment.

The most feasible and cost-effective method for large population studies is the *self-administered questionnaire*. However, questionnaires designed for the quantification of physical exposure have been criticized for lacking precision and accuracy,[24,213] and for the risk of systematic overestimation of exposure among individuals with musculo-skeletal pain.[188] Another method based on self-reporting is the technique of structured interviews. Interviews may give more valid exposure information than a self-administered questionnaire because any misunderstandings and ambiguity can be resolved between the interviewer and the interviewed.

Observation of the worker in the workplace is another option for assessing physical exposure, and several observational methods are available. One of its shortcomings is that it can often be difficult for an observer to distinguish between different work tasks, postures and movements.[122]

The third method, direct measurement using *technical equipment* carried by the worker during normal work, is probably the most reliable and objective method of exposure assessment, since such methods are independent of the researcher. Measurement can be performed over long periods, and in groups of workers with either homogeneous or heterogeneous work tasks. However, like observation, direct measurement is rather time consuming and thus expensive, especially for jobs with day-to-day, month-to-month or seasonal variations in which repeated observation or measurement is necessary to gain a full picture of exposure.

Assessment of psychosocial exposure

Assessment of psychosocial exposures is somewhat more complex and troublesome. There are two main areas of difficulty: firstly, identification and appropriate measurement of relevant variables, and secondly, taking sufficient account of the influence of moderators such as personal trait characteristics and behavioral and psychological processes.[103]

Just as for physical exposure, the most feasible and cost-effective data collection method for large population studies is the *self-administered questionnaire*. The epidemiological tool box contains a large number of questionnaire instruments for assessing job stressors (or exposures), as well as some instruments to measure job strains and the moderators or mediators of the relationship between stressors and strains.[91] Some of the instruments capture global demands, e.g., the Job Content Questionnaire (JCQ),[101] while others provide measures of an array of specific job demands. Negative affectivity has been cited as confounding self-reports of both stressors and strains and exaggerating their correlations. As an individual-difference factor, negative affectivity reflects a pervasive tendency toward negative emotions and self-concepts.[218] However, it has also been argued that negative affectivity is more of a problem with self-reported strains than with self-reported stressors.[91]

Several attempts to develop *observational methods* for identifying job stressors have been made. Because these methods do not rely on the worker's perceptions of the working environment, such an approach is likely to be more objective. Common observational instruments include observation of the worker in the workplace, observation of work processes, and supplementary interviews with supervisors and workers.[91] There are, however, some drawbacks to the observational approach. The gathering of observational data requires trained and experienced observers, and the observation method chosen may require adaptation to the particular job being assessed, which, in turn, may require considerable effort and high related costs.

Considering gender in assessment of exposure

Failure to consider the influence of gender differences on epidemiological exposure estimates may result in biased estimates of risk. Several researchers have argued in favor of the need for a "gender-sensitive" or "gender-based" approach to exposure assessment.[104,106,155,180]

Gender issues in research generally focus on whether females are represented appropriately in research programs or studies; the question of the potential for gender-related differences that may arise in exposure assessment has seldom been raised. One exception is a paper by Kennedy and Koehoorn (2003) that examined the pathway from exposure sources or agents to exposure measures, for ways in which gender might influence the assessment of exposure in epidemiological studies.[104] Careful consideration of possible gender differences along the pathways was recommended, in particular with respect to gender differences in work tasks, differential validity of exposure estimates, and gender differences in the impact of the "healthy worker" effect.

Gender differences in work tasks is perhaps the least controversial and most common source of potential gender influence on measures of exposure. As already discussed, both work tasks and influence over work may be different for female and male workers due to gender-segregation by job title, and even when the job title is the same.[148,151,180] It has, for example, been reported that females have more repetitive work and less task variety, even when male and female workers have the same job title and are employed in the same workplace.[180] Thus, studies relying on job title may attribute prevalence differences between male and female workers to biological differences, when in fact there may be true exposure differences due to differential work tasks. Gender differences in work tasks affect both paid work and unpaid work.

There is some evidence that differential validity of exposure estimates based on questionnaire tools may arise from variance in the degree of concern about, or familiarity with, hazards.[104] However, studies on the validity of self-reported physical activity and physical load found no significant gender differences.[201,225]

Gender differences in the impact of the healthy worker effect, both the healthy worker hire effect (the tendency for the healthier individuals in society to be hired into jobs) and the healthy worker survivor effect (the tendency for the healthier members of the workforce to remain in employment), are possible.[104] However, few studies have investigated such impact, and to our knowledge none of them have investigated it with regard to musculoskeletal pain.

In all, many exposures are more or less closely interrelated and many workplace exposures may be modified by the time spent in leisure and other activities outside work. At the X2001 Exposure Assessment in Epidemiology and Practice Conference held in Göteborg, Sweden in 2001, several prominent researchers called for a broadened view of exposure assessment (summarized by Hagberg et al., 2001).[1] A broader, multidisciplinary, and contextual approach in assessment of exposure taking into account factors such as work organization and both paid and unpaid work, would improve gender sensitivity in analysis

ASSESSMENT OF MUSCULOSKELETAL DISORDERS

Outcome measures used in epidemiological studies of neck/shoulder and low back pain include administrative data such as injury reports or absenteeism, clinical examinations or diagnoses, and self-reported symptoms. Administrative data is often incomplete because not all MSDs are compensable and so may not be reported by the affected individual. Additionally, some individuals may not require sick leave for their pain problems. Clinical examinations and diagnoses suffer from lack of standardized diagnostic criteria and are often inconsistent from one examiner to another.

Self-reporting of symptoms is an alternative option, and often also a more informative one. While objective measures may be especially useful in establishing a more secure diagnosis, subjective measures may better capture the individual impact.[182] However, the reliance of self-reported symptoms must be carefully considered, especially with regard to “recall bias”, the limited ability of individuals to remember their pain

experience. A retrospective survey covering longer periods will lead to more unreliable answers than one covering shorter periods.[216] Further, the answers given to a question of whether a subject suffers from pain or impairment due to pain may be affected by the wording of the question, for example, the use of different terms such as "pain", "ache", or "discomfort", as well as the alternative answers provided as options. In cross-sectional studies of workplace settings, the healthy worker effect may introduce significant bias if a disproportionate number of workers with musculoskeletal pain have left employment, leading to an underestimate of the relationship between exposure and outcome.[171] Moreover, cross-sectional studies unavoidably over-sample disorders that last for a long time and are less likely to capture those that last only for short periods.[182]

It is important to go into an appropriate level of detail when asking questions about musculoskeletal problems, since such problems vary in intensity from mild symptoms to very severe and incapacitating disorders.[203] Further, it is now well-accepted that the assessment of pain should take into consideration not only the experience of pain but also interference with both occupational and non-occupational activities.[132,231] Some of the commonly used instruments, such as the Nordic Musculoskeletal Questionnaire,[111] only capture the experience of pain, while others capture interference with activities. Deyo et al. (1998) recommended the Roland Morris Disability Questionnaire,[47,185] or its adaptation,[170] or the Oswestry Disability Questionnaire,[54] to assess back pain's interference with activities. An alternative instrument to assess both intensity and limitation of activity has been developed by von Korff et al. (1992).[232]

Non-specific neck/shoulder and low back pain are usually classified according to the duration of symptoms in the individual. Pain is traditionally defined as acute when it persists for less than 6 weeks, subacute for duration of between 6 weeks and 3 months, and chronic when it lasts for longer than 3 months. However, this classification has been criticized for being inadequate; neck and back pain typically have a recurrent, intermittent, or episodic course characterized by variation, change, or fluctuations,[37,131,160,233] although such intermittent and episodic symptoms are probably more common in the early stages. Moreover, this classification does not take limitations in function and activity into account.

PREVENTION OF NECK/SHOULDER AND LOW BACK PAIN

The basic idea of prevention is that since only limited resources available, they should be used at an early stage to prevent development of problems and thus avoid unnecessary suffering and costs.[132] The multifactorial etiology and complexity of pain problems suggest that this strategy should be the most effective one, since it is neither feasible nor desirable to propose generic interventions expected to apply to every industry, job, and individual, nor "once for all" interventions whose effectiveness need not to be regularly assessed.[161]

Definitions

Primary prevention can be defined as efforts directed at preventing injuries, disorders, or diseases before onset. Thus, primary prevention aims to reduce the incidence of problems. Some examples of primary prevention would be educational programs aimed at the general population, and occupational guidelines or regulatory actions relating to the workplace.

Secondary prevention is intervention that takes place only after onset of the problem. Thus, secondary prevention aims to reduce the number of individuals with persistent symptoms and the number of recurrences. Examples of secondary prevention are early medical intervention, job redesign, and adaptation of the workplace for workers with pain or pain-related impairment or disability.

Tertiary prevention strategies are designed for individuals with persistent and chronically disabling pain or pain-related impairment/disability. Intervention is usually made on a case by case basis with the aims of achieving maximal functional capacity within the limitations of the individual's impairments, and restricting disability and handicap.

The distinction between the three levels of prevention initially seems fairly clear-cut. However, there is significant overlap between primary and secondary prevention, and between secondary and tertiary prevention. As already mentioned, most people experience neck/shoulder or low back pain at some point, and many individuals have recurring symptoms throughout their lives. Furthermore, the vast majority of people suffering from their first episodes of pain recover quickly, without involving the healthcare system, and there are often no direct or indirect costs to the society or the employer. Consequently, for common diseases and disorders such as neck/shoulder and low back pain, the distinction between primary and secondary prevention becomes vague and less useful.[132,216] The overlap between secondary and tertiary prevention strategies concerns the complex issues of medical management and workplace accommodations for those with pain symptoms whether the pain is of short or long duration.[161]

Preventive interventions

Approaches to prevention of musculoskeletal pain have largely moved over time from "hands-on" techniques such as massage and manipulation to "hands-off" techniques which place primary emphasis on exercise and re-activation. Similarly, there has been a trend from the widely accepted tenet of "Let pain be your guide" to a greater awareness of the potential for disability associated with fear-avoidance behavior due to pain. The emphasis has shifted from pain relief to pain management, with a parallel shift from a specific focus on pain to the consideration of pain-associated dysfunction.[144]

Although not all approaches to preventive intervention have been adequately assessed yet, the literature suggests that some approaches are more successful than others. A comprehensive review by Linton and van Tulder (2000) addressed three main questions:[132]

- Which interventions are used to prevent neck and back pain?
- Which interventions are effective in preventing the occurrence of neck and back pain?
- Which interventions are effective in preventing the development of long-term neck and back pain?

They concluded that:

- There is consistent, strong evidence that exercise may be effective in preventing neck and back pain.
- There is consistent, strong evidence that lumbar supports and back schools are not effective in preventing neck and back pain.
- There is no good-quality evidence for the effectiveness of ergonomics or risk factor modification.

There are several possible explanations for these relatively discouraging results. Firstly, there are inherent difficulties associated with intervention studies; the identification of individuals at risk, the identification of individuals with recent onset of symptoms, acquisition of sufficient sample size to detect positive effects, provision of follow-up periods sufficient to allow the preventive effect to be detectable, and the difficulty of ensuring compliance. Secondly, most interventions dealt with single-modal programs rather than multidimensional ones, and preventive methods were administered to everyone in a given setting rather than risk factors being altered for vulnerable or at-risk individuals.[131,132,144,216]

Guo et al. (1995) estimated that about 65% of low back pain in the United States is attributable to the combined effects of different occupational exposures.[66] In a more recent study, Punnett et al. (2005) estimated that 37% of low back pain worldwide was attributable to occupation, with twofold variation across regions.[181] In the Europe A region, including Sweden among other countries, it was estimated that 29% of low back pain was attributable to occupation. This estimate corresponds relatively well to that of the annual Swedish Survey on Work-Related Disorders in which 24.4% of Swedish workers reported that they had experienced work-related disorders during the past 12 months.[199] These estimates, together with the knowledge that musculoskeletal symptoms are related to both physical and psychosocial factors at the workplace, highlight the importance of working life, the workplace, and work-life balance as perhaps the most important arenas for preventive actions. Collaborative approaches that combine the proactive efforts of healthcare providers, rehabilitation professionals, and the workplace may hold the most promise for future prevention.[56]

AIMS OF THE THESIS

The overall aim of this thesis was to broaden the understanding of gender and context in both the assessment of physical exposure and the identification of target groups for prevention of neck/shoulder and low back pain.

The specific aims were:

I To assess the reproducibility and validity of the responses to eight questions on physical loads used in public health questionnaires, for males and females.

II To investigate if and how exposure to awkward work postures is associated with occupational gender segregation.

III To identify potential target groups for primary and secondary prevention of neck/shoulder and low back pain, and to describe such groups with regard to working and living conditions.

IV To examine whether different working and living conditions are associated with an increased risk for neck/shoulder and low back pain.

MATERIALS AND METHODS

Papers I and II are based on data from the MOA Study, while papers III and IV are based on data from the MUSIC-Norrtälje Study.

THE MOA STUDY

MOA is an acronym in Swedish for Modern Work and Living Conditions for Women and Men [Moderna arbets- och livsvillkor för kvinnor och män].

The MOA Study was a multidisciplinary study aimed at developing methods for epidemiological studies. The design of the study was cross-sectional, with data being collected between 1995 and 1997 in five Swedish counties. The study took a comprehensive view of work and life situations, and conditions in both paid employment and private life were investigated. Factors assessed in the workplace included organizational, social, and psychological conditions, physical workload, and the chemical and physical environment. Several conditions in the private sphere were also assessed. The study group was selected by means of a stepwise selection process using then-current statistics and reports relating to different branches of the Swedish labor market, and to working conditions within different occupations. Selection followed three steps:

1. Selection of occupational groups fulfilling at least one of the following criteria: groups typical of the majority of the Swedish labor force; groups utilizing new forms of organization or production; groups with either extremely good or extremely poor health.
2. Selection of work sites to achieve variation in employers (private or public), size, and geographical location (urban or rural).
3. Selection of individuals for variation in work tasks, work position, qualification levels, and terms of employment.

A gender-sensitive perspective was central to the study, and whenever possible females and males with the same occupation and work site were chosen. The requirements of the final selection were an even distribution in gender and a similar distribution in age, level of education, and type of work between females and males. To permit gender comparisons in this relatively small sample, more females in male-dominated and more males in female-dominated occupations were chosen than in the general Swedish workforce. Of approximately 8000 employees at 80 work sites, 102 females and 101 males were selected and went on to participate in the study.

The literature emerging from the MOA Study is based on the integration of a person-oriented analysis and a holistic and interdisciplinary approach.[93] At time of writing, there have been ten different papers published from the study; a list can be found on the website www.phs.ki.se/occupmed/research/publications.htm.

The MOA Study received financial support from the Swedish National Institute of Public Health, the Swedish Council for Work Life Research, Stockholm and Örebro County Councils, the Swedish Council of Research, and the National Institute for Working Life.

THE MUSIC-NORRTÄLJE STUDY

The multidisciplinary Musculoskeletal Intervention Center (MUSIC)-Norrtälje Study was initiated in order to identify and quantify risk factors and protective factors for neck/shoulder and low back disorders in the general population. The study had a population-based, case-referent design, and the data was collected between January 1, 1994, and June 30, 1997 in the Swedish municipality of Norrtälje. The study population comprised approximately 17,000 males and females of age 20–59 years, living in the municipality and not working or studying outside the municipality.

The *cases* comprised all persons in the study base who sought care for neck/shoulder or low back pain from one of the approximately 75 care givers in the municipality (n=1,152). The participation rate of the cases is not known.

The *referent group* consisted of males and females randomly selected from the study base by means of the population register. At least one referent was chosen for each case, and some additional referents were added. Altogether, the group included 1,707 referents, stratified for sex and age (using a 5-year granularity). Among all referents selected, 69% of the females and 68% of the males took part in the entire investigation. Another 10% of the females and 10% of the males filled out the questionnaires, but were unable to attend the personal interviews. Additionally, individuals were excluded if they had sought care or been treated for neck/shoulder or low back pain during the 6 months preceding enrollment in the study.

Results from the MUSIC-Norrtälje Study on work-related physical and psychosocial risk factors associated with a new episode of neck/shoulder or low back pain have been reported by Wigaeus Tornqvist et al. (2001) and Vingård et al. (2000).[222,229] In all, at time of writing 35 papers have been published from the study; a list can be found on the previously-mentioned website at www.phs.ki.se/occupmed/research/publications.htm.

All participants received a follow-up postal questionnaire 4–6 years after the baseline investigation. The response rate was 82.9% for the study group as a whole, and 82.6% for the referent group.

The MUSIC-Norrtälje Study received financial support from the Swedish Council for Swedish Council for Work Life Research and Stockholm County Council.

SUBJECTS

The subjects of papers I and II comprised the whole or a part of the MOA Study population, while the subjects of papers III and IV were taken from the referent group of the MUSIC-Norrtälje Study (Table 4).

Table 4. Demographic basics of the study samples in papers I–IV.

Females (F); Males (M)	**MOA Study**				**MUSIC-Norrtälje Study** (referents)			
	Paper I		**Paper II**		**Paper III**		**Paper IV**	
	Whole study group		Matched sub-sample[a]		Study group at baseline[b]		Study group at follow-up[b,c]	
	F	**M**	**F**	**M**	**F**	**M**	**F**	**M**
Number of subjects	102	101	78	78	749	592	629	466
Age group (%)								
<31 years	26	24	26	28	12	15	11	13
31–44 years	44	44	42	44	40	37	39	37
>44 years	30	33	32	28	48	48	50	50
Educational level[d] (%)								
low (<2.5 years)	38	42	35	40	22	25	20	26
medium (2.5–5.5 years)	33	37	33	41	53	58	53	57
high (>5.5 years)	28	22	32	19	25	16	27	17
Employment (%)								
regular	87	93	88	94	83	91	85	92
temporary	13	7	12	6	17	9	15	8
Type of work (%)								
working with people	40	36	42	42	63	30	64	33
working with data	34	26	26	26	21	19	22	19
working with things	26	39	32	32	16	51	14	48
Socioeconomic group (%)								
blue-collar worker	37	48	44	47	49	57	47	56
white-collar worker	56	46	47	46	46	34	49	35
self-employed	7	6	9	6	4	9	4	9
Living single (%)	28	29	27	30	21	21	20	21
Children <18 years (%)	43	38	44	38	58	58	58	58

[a] The matched sub-sample included 78 pairs of one female and one male matched on type of work and qualification level within the occupation.
[b] The study group included only referents (not cases) in long term regular or temporary employment, i.e., had worked ≥17 hours per week the 12 months preceding baseline.
[c] The demographic data was recorded at baseline.
[d] Educational level is years of education added to 9 years of compulsory schooling.

Paper I

The first study included all 102 female and 101 male subjects of the MOA Study. The mean age of the females was 38.2 years (SD 10.0, range 20–61), and of the males 39.1 years (SD 11.2, range 19–62). Their occupations covered 85 different jobs from the three-digit Nordic occupational classification (NYK) [Nordisk Yrkesklassificering], with females contributing 62 job titles and males contributing 63.

Paper II

The second study used a sub-sample from the MOA Study comprising 78 matched pairs each consisting of one female and one male subject. The variables used to match the two subjects in each pair were type of work and qualification level within the occupation. The mean age of the females was 38.2 years (SD 10.0, range 20–60), and

of the males 38.3 years (SD 11.4, range 19–61). 71 different job titles from the three-digit NYK were represented, with females contributing 50 and males 53.

Paper III

The subjects of the third study were selected from among the referent group (not the cases) of the MUSIC-Norrtälje Study. Criteria for inclusion were that the individual should be gainfully employed, should work at least 17 hours per week; and should have been working in regular or temporary employment for at least the 12 months prior to enrollment in the study. In total, 749 female and 592 male subjects were selected. This study performed a cluster analysis on the data, using 15 variables. Such an analysis requires that data be present for every variable for each subject. When a subject lacked data for up to two variables, imputation of data was used to fill the gaps. One female subject lacked data on more than two variables, and so was excluded from further analysis. Moreover, the cluster method identified three females and five males as outliers, and these were also excluded from further analysis. After exclusions, 745 female and 587 male subjects remained. The mean age of the females was 42.6 years (SD 9.3, range 20–59), and of the males 42.7 years (SD 10.3, range 20–59). 187 different job titles from the three-digit NYK were represented, with females contributing 109 and males 145.

Paper IV

The fourth study analyzed the answers given by the 745 female and 587 male subjects of the study presented in paper III to a follow-up postal questionnaire. This questionnaire was sent 4–6 years after the baseline measurements, with subjects examined in 1994 or 1995 receiving their follow-up questionnaire in 2000, and subjects examined in 1996 or 1997 receiving theirs in 2001. Two-thirds of the subjects (69%) were followed up 5 years after their baseline investigation, 4% after 4 years, and 27% after 6 years. If a subject did not answer, up to three remainders were posted. The response rate for the whole study group was 82.2% (84.4% for females and 79.4% for males), and varied between 75%–86% for the eleven clusters or groups (P=0.310). Among respondents, the mean age (at baseline) of the females was 43.0 years (SD 9.2, range 20–59), and of the males 43.2 years (SD 10.1, range 20–59). In the non-responding group, the mean age (at baseline) of females was 40.4 years (SD 9.7, range 21–58), and of the males 40.1 years (SD 10.7, range 20–59).

ETHICAL APPROVAL

The studies in papers I and II were approved by the ethics committees of Karolinska Institutet (DNr 95-336) and Örebro läns landsting (kod:500:19, löpnr 1084/95). The studies in papers III and IV were approved by the ethics committee of the Karolinska Institutet (DNr 93-255). All subjects were given written and/or oral information about the studies and all gave their consent to participate.

METHODS

Paper I was a validity study, papers II and III were cross-sectional studies, and paper IV was a 5-year follow-up. The data was collected during three periods: 1995–1997 for papers I and II, 1994–1997 for paper III, and 1994–1997 and 2000–2001 for paper IV. The data collection methods used in the studies were self-administered questionnaires, interviews, observation in combination with interviews, direct measurements with different technical instruments, and the use of register data (Table 5).

Table 5. Overview of study design, period of data collection, and method of data collection used in the studies presented in papers I–IV.

	The MOA Study		**The MUSIC-Norrtälje Study**	
	Paper I n=203	**Paper II** n=156	**Paper III** n=1,332	**Paper IV** n=1,095
Study design	Validity study	Cross-sectional study	Cross-sectional study	5-year follow-up
Period of data collection	1995-1997	1995-1997	1994-1997	1994-1997 2000-2001
Method of data collection				
Questionnaire				
Self-administered questionnaire	X		X	X
Interview				
Interview – physical factors	X		X	
Interview – psychosocial factors		X	X	
Observation/Interview				
ARIA – work content analysis		X		
Direct measurements				
Posimeter		X		
Arm inclinometer		X		
Trunk inclinometer		X		
Register				
Job titles by gender in Sweden[a]		X	X	
Individual income[b]			X	

[a] Swedish Official Population and Residence Investigation.[195]
[b] Register data on income and unemployment benefit was linked to each subject in the study group (Statistics Sweden, LOUISE database).

Demographic data in papers I–IV

Several different demographic variables were used to describe the study samples and in the analyses. The demographic variables are presented in Table 6.

Table 6. Demographic variables collected by personal interview (I), self-administered questionnaire (Q) and register data (R).

Demographics and classification	Paper			
	I	II	III	IV
Educational level *Years of education in addition to 9 years of compulsory schooling* low (<2.5 years) / medium (2.5–5.5 years) / high (>5.5 years)	I	I	Q	
Type of work *Modified classification system by Kohn and Schooler (1983), based on work object and field of activity*[107] working with people / data / things	I		I	I
Qualification level *Socioeconomic group and educational level required in the occupation (years of education in addition to 9 years of compulsory schooling)* low (<2 years) medium (blue-collar ≥2 years; white-collar ≥2 but <6 years) high (≥6 years)		I		
Gender segregation *Gender distribution in occupation/job title, proportion of females and males holding the job title in Sweden* female-dominated (>70% females) male-dominated (>70% males) gender-integrated (30–70% of both females and males)		I R	I R	I R
Position low (without managerial/supervising function) high (with managerial/supervising function or self-employed)		I		
Income low or medium (≤20,000 SEK per month) / high (>20,000 SEK per month)		I	R	R
Age group <31 years / 31– 44 years / >44 years			I	
Labor market sector working in public sector / private sector or self-employed			Q	Q
Terms of employment regular / temporary			Q	Q
Socioeconomic group blue-collar worker / white-collar worker / self-employed		I Q		
Family situation *Civil status and living with children <18 years at home* single, without children single, with children spouse/partner, without children spouse/partner, with children			Q	Q

Paper I

Paper I evaluated eight questions used in a self-administered questionnaire for reproducibility and criterion validity. Seven of the questions concerned different physical loads at work, and the remaining one concerned physical exercise and sporting activity during leisure time.

Self-administered questionnaire

Each subject in the MOA Study answered the same questionnaire twice, with approximately three weeks between each occasion of answering. The questionnaires were completed before any other measurements were performed. The response alternatives of all eight questions evaluated were at ordinal level (see Appendix A, paper I).

At the first response occasion each subject also reported the frequency of symptoms from neck, low back, and shoulder/arm during the last 12 months, with choices of never, a couple of days per year, a couple of days per month, a couple of days per week, and daily. These data was dichotomized into complaints (frequency of a couple of days per week or daily) or no complaints (frequency of never, a couple of days per month, or a couple of days per year).

Interview (reference instrument)

The reference method used for testing criterion validity of the eight physical load questions was a structured personal interview with one of four trained ergonomists. The interview method was one developed by Wiktorin and colleagues.[227,228] It has been tested for reproducibility and validity, with high accuracy, by observations and technical measurements in several studies.[157,174,227]

The interview covered work and activities during the last two months, task by task. Questions were asked about minutes per work task spent in different postures (sitting, hand above shoulder level, bent trunk, bent or twisted work posture), in manual handling of loads, in repetitive movements, and in leisure time training and sports. For each variable, minutes per work task were summed up to minutes per day and then calculated as percentage proportion of a workday. For each task the interviewer also assessed the level of energy expenditure in metabolic equivalent, or MET, a measure defined as the ratio of the metabolic rate associated with a specific activity to the resting metabolic rate.[2] After each interview a time weighted average MET (TWA-MET) was calculated for occupational work. When data collection was complete, each interview was categorized by the four ergonomists according to the response alternatives (see Appendix B, paper I).

Analyis

The reproducibility of the questions was tested by comparing the answers given at the first response occasion with the answers given at the second response occasion (test-retest method).

The criterion validity of the questions was tested by comparing the questionnaire responses from the first round of data collection with the categorized interview data. The interviews were regarded as the "gold standard". In addition, the possible influence of gender, type of work, and musculoskeletal complaints on the validity of the responses to the questions was analyzed.

Paper II

The subject of paper II was the association between awkward work postures and movements and occupational gender segregation.

Direct measurements

Data on work postures was collected for each subject in the MOA Study by two different pieces of equipment, a posimeter and an inclinometer. These instruments were

attached to and carried by the subject during a full "typical" work shift in his/her ordinary workplace.

The posimeter was used for recording duration of sitting work posture and for registration of posture change between sitting and standing.[191] Data was sampled using Testo data loggers with a sampling frequency of two registrations per minute (Testo AG, Lenzkirch, Germay). After the recording period the posimeter data was transferred to a computer for analysis, and the percentage of time spent in sitting work posture was calculated along with the frequency of posture change between sitting and standing or walking.

Three tri-axial accelerometers were used as inclinometers for recording the duration and frequency of forward bending of the trunk and of upper arm elevation in relation to the line of gravity.[13,72] Data was sampled using data loggers with a sampling frequency of 20 Hz (Logger Teknologi HB, Malmö, Sweden). The cutoff points in the analysis of awkward work postures and movements were set to 60º for upper arm elevation, that is, work with one or both hands above shoulder level, and to 40º for trunk flexion, that is, work involving pronounced trunk bend.

Indicators for horizontal and vertical occupational segregation

A single variable was used as an indicator for horizontal occupational segregation; distribution of gender by job title or occupation. Data on job title and occupation was collected by personal interviews and coded to the Nordic Classification of Occupations. Census data from the Swedish Official Population and Residence Investigation was used to gain information on proportions of female and male employees in different occupations in Sweden.[195] Each subject was then categorized into one of three groups according to the proportions of female and male workers in Sweden holding the same job title as the subject: female-dominated job, male-dominated job, or gender-integrated job.

Three variables were used as indicators for vertical occupational segregation. Income levels were classified as low (earning ≤20,000 SEK per month) or high (earning >20,000 SEK per month); data was collected by personal interview. Level of influence was classified as low or high and was gathered by a job analysis including both interview and observation.[207-209] Position was classified as low, for example blue-collar and white-collar employees, or high, for example managers, supervisors, and the self-employed. Subjects with low values on two or three of the indicators were then categorized as having low status and authority, and subjects with high values on two or three of the indicators as having high status and authority.

Analysis

Analysis was made of the association between occupational gender segregation and the duration and frequency of awkward work postures and movements. Comparison was made between female-dominated, male-dominated and gender-integrated jobs as well as within these three groups with regard to level of status and authority at work.

Paper III

Paper III took an exploratory approach to identification of potential target groups for primary and secondary prevention of neck/shoulder and low back pain.

Self-administered questionnaire

In the MUSIC-Norrtälje Study, a self-administered questionnaire was used to collect data on working and living conditions as well as on labor market position, demography, and health-related behavior (Table 7). Three indexes were constructed from 13 variables relating to psychosocial work factors. These psychosocial dimensions were hindrances (unclear goals or work tasks, insufficient resources in terms of equipment, housing, and personnel, work tasks poorly adjusted to the competence of the subject, and hindrances outside the work organization), psychological demands (being required to work very fast, being required to work very hard, being expected to make an excessive contribution to workload, not being given enough time for work tasks, and being subject to conflicting demands), and influence at work (influence on when tasks should be performed, and influence on which tasks should be included in the work assignment).

Interviews

Two personal interviews, conducted by an ergonomist and a behavioral scientist respectively, were used to collect data on working and living conditions and labor market position (Table 7). The interview method used by the ergonomist was developed and has been described by Wiktorin and colleagues.[227,228] The interview method used by the behavioral scientist has been thoroughly described by Waldenström and colleagues.[208,209]

Register data

Register data on income and unemployment benefit was linked to each subject in the study group (Statistics Sweden, LOUISE database).

Outcome

The questionnaire contained a total of twelve questions on pain intensity and pain-related disability.[232] For each of the neck/shoulder and low back regions, subjects were asked to rate current pain, worst experienced pain during the preceding 6 months, and average pain during the same period. These ratings were made on an 11-point scale, where 0 meant “no pain” and 10 meant “pain as bad as could be.” The questions concerning pain-related disabilities were also asked separately for each bodily region. These questions covered the preceding 6 months and asked how much pain had affected everyday activities, social and family activities, and the ability to work (including domestic work). These ratings were also made on an 11-point scale, where 0 meant “not affected at all” and 10 meant “impossible to continue these activities”. For details, see Figure 1, paper IV.

Table 7. Variables in paper III.

	Variables	Assessment method	Scale (range of response alternatives)
	…forming the clusters		
Working and living conditions			
Work time	Total work hours	Interview	Hours per week
	Time of working hours	Questionnaire – 1 item	(1–3)
Ergonomic physical factors	Hand(s) above shoulder level	Interview	Minutes per workday
	Bent trunk	Interview	Minutes per workday
	VDU work	Interview	Minutes per workday
	TWA-MET, work[a]	Interview	Multiples of resting O_2 consumption
Psychosocial factors	Creativity	Interview	Proportion (%) of work hours
	Routine work	Interview	Proportion (%) of work hours
	Hindrances	Questionnaire – 6 items	Summation index (6–18)
	Psychological demands	Questionnaire – 5 items	Summation index (5–20)
	Influence at work	Questionnaire – 2 items	Summation index (2–8)
	Social interaction	Questionnaire – 1 item	(1–6)
Private sphere factors	Domestic and family work	Interview	Minutes per day
	TWA-MET, leisure time[a]	Interview	Multiples of resting O_2 consumption
	Time for recreation	Questionnaire – 1 item	(1–6)
	…describing the clusters		
Labor market position	Type of work	Interview	Working with people/data/things, based on NYK3
	Gender segregation	Interview	Female-dominated/male-dominated/gender-integrated job
	Terms of employment	Questionnaire – 1 item	Regular/temporary employment
	Income	Register	Low/medium or high, cutoff point 18,000 SEK per month
Demography	Gender	Questionnaire – 1 item	Male/female
	Age	Questionnaire – 1 item	<31/31–44/>44 years
	Educational level	Questionnaire – 1 item	Low/medium/high
	Socioeconomic position	Quest. + Interview	Blue-collar worker/white-collar worker/self-employed
	Family situation	Questionnaire – 2 items	Living alone/with child/with partner/with partner and child
Health related behavior	Smoking	Questionnaire – 1 item	Smoker/non-smoker
	Alcohol use	Questionnaire – 1 item	Often or sometimes/never
	BMI	Questionnaire – 2 items	Obese/not obese, cutoff point BMI 30
	Training and sports	Interview	Inactive/active, cutoff point one hour per week

[a] TWA-MET – time weighted average of metabolic demands, assessed by interview.[227] Each task was designated a MET value, i.e., multiples of resting oxygen consumption (1 MET = 3.5 ml O^2 kg * body weight^{-1} * minutes^{-1}).[2] A TWA-MET for one "typical day" was calculated for each participant.

For the pain intensity and pain-related disability questions, an average value was calculated for each body region of each subject. Subjects with an average value ≥3 for pain intensity or an average value ≥1 for pain-related disability for a region of the body were classified as having a disorder in that body region.

Analysis

Fifteen variables were selected for cluster analysis in order to identify groups of individuals in similar situations with regard to working and living conditions (Table 7). These 15 variables were subsequently used to describe "*what* characterizes the clusters?" (Figure 2). Additional variables (not used in the cluster analysis) on labor market position, demography, and health-related behavior were used to describe the clusters with regard to the two questions: "*where* are the clusters found?" and "*who* are (the individuals) in the clusters?" (Figure 2). Different cluster solutions were investigated before the final choice was taken.

WHAT characterizes	**WHERE are**	**WHO are**	
Individual conditions **- in paid work** **- in the private sphere**	**Labor market**	**Demographic data**	**Health-related behavior**
Work sphere Work time - total work hours - location of working hours Ergonomic - physical factors - awkward work postures (2) - VDU work - metabolic load Psychosocial factors - creativity - routine work - hindrances - psychological demands - control - social interaction **Private sphere** - domestic and family work - metabolic load - time for recreation	Sector Type of work Segregation Terms of employment Income	Gender Age Education Class Family situation	Smoking Alcohol use BMI Training and sports
CONSEQUENCES Neck/shoulder pain, Low back pain			

Figure 2. The analysis model: variables in the bold frame were analyzed by means of cluster analysis (note that the remaining variables were only used in the subsequent descriptive analyses).

Paper IV

Paper IV comprised a follow-up assessment of the eleven groups or clusters identified in paper III. The subjects were contacted regarding neck/shoulder or low back pain five years after baseline measurements.

Self-administered questionnaire

A postal self-administered questionnaire was sent to all subjects who had participated in the baseline MUSIC-Norrtälje Study. This follow-up questionnaire included the twelve questions on pain intensity and pain-related disability that were analyzed in paper III, using the same response scales. As in paper III, the average values of the answers to the intensity and disability questions were calculated for each bodily region of each subject, and those with an average value ≥3 for pain intensity or an average value ≥1 for pain-related disability were classified as having a disorder in that body region (for a detailed description, see Figure 1, paper IV). Subjects were also asked whether they had sought care for pain in the neck/shoulder or low back during the follow-up period. Those who responded in the affirmative to either of these two questions were classified as having sought care. Additional data collected were job title at follow-up, work-related changes over the past 5 years, and family situation at follow-up.

The *outcome* was defined by neck/shoulder and/or low back pain at baseline, neck/shoulder and/or low back pain at follow-up, and having sought care for pain during the follow-up period. These three variables together resulted in eight different outcome combinations, from which three outcome groups were constructed for analysis: those with moderate disorders, those with persistent disorders, and those with no disorders. A more detailed description is presented in the results section, Figure 3.

Analysis

The eleven clusters identified in the baseline study (paper III) were analyzed with regard to moderate or persistent neck/shoulder or low back pain at 5-year follow-up.

STATISTICAL ANALYSES

Table 8. Overview of statistical analyses used in the studies presented in papers I–IV.

Statistics	**Paper**			
	I	**II**	**III**	**IV**
Mean (m); Standard deviation (sd)	X	X	X	X
Median (md); Range	X	X	X	X
Cohen's kappa coefficient quadratic weights (κ_w) with 95% CI	X			
Full agreement (%)	X			
McNemar chi-square test statistics (*P*)	X			
including Yates' correction for continuity				
Spearman's rank correlation coefficient (r_s)	X			
Sensitivity; Specificity	X			
Prevalence odds ratio (POR) with 95% CI	X			
One-way analysis of variance (ANOVA)		X		
Cronbach's alpha			X	
Pearson's correlation coefficient (r)			X	
Hierarchical cluster analysis, Ward's method			X	
K-means cluster analysis			X	
Logistic regression analysis, odds ratio (OR) with 95% CI			X	X

RESULTS AND COMMENTS

ASSESSMENT OF PHYSICAL EXPOSURE

Validity of questionnaire data on physical exposure (paper I)

Reproducibility of the responses to the eight questionnaire items on physical work loads was relatively high, with weighted kappa coefficients (κ_w) varying from 0.74 to 0.92 (Table 9). These levels of test-retest agreement provided motivation for continuing the analysis by testing the validity of all eight questions.

The validity analyses showed differing results for the eight questions. The weighted kappa coefficients varied from 0.38 to 0.81 (Table 9). The lowest inter-method agreements were found for the questions concerning bent/twisted work posture (κ_w 0.38) and repetitive movements (κ_w 0.39), while the highest agreements were found for the questions concerning sitting work posture (κ_w 0.81) and physical exercise and sporting activities (κ_w 0.74).

Table 9. Reproducibility (test-retest) and validity of the eight physical load questions in the MOA Study (n=203).

	Reproducibility[a]		Validity[b]	
	κ_w	(95% CI of κ_w)	κ_w	(95% CI of κ_w)
Work				
General physical activity	0.85	(0.81–0.90)	0.66	(0.59–0.74)
Sitting work posture	0.92	(0.89–0.95)	0.81	(0.75–0.86)
Hands above shoulder level	0.79	(0.71–0.87)	0.48	(0.33–0.63)
Bent trunk	0.74	(0.62–0.86)	0.48	(0.33–0.64)
Bent/twisted trunk	0.83	(0.73–0.89)	0.38	(0.26–0.49)
Manual handling of loads ≥10 kg	0.81	(0.75–0.87)	0.54	(0.42–0.66)
Repetitive movements	0.80	(0.73–0.88)	0.39	(0.26–0.51)
Leisure time				
Physical exercise/sports	0.86	(0.79–0.93)	0.74	(0.67–0.80)

[a] Test-retest method (three weeks interval).
[a] Reference method was a structured personal interview.[227,228]

Subsequent analyses stratified on type of work (working with people, data, or things) showed no substantial differences between the groups considering the validity of their responses to the questions. Analyses stratified on musculoskeletal complaints showed only minor validity differences between those with complaints (n=45/prevalence 22%) and those without complaints. In seven of the eight questions, subjects with musculoskeletal complaints responded less accurately than those without such symptoms, but for all questions the confidence intervals were wide and overlapped between the two groups (see Table 4, paper I). This finding, together with analyses at dichotomous level, indicated that there was no systematic over- or underestimation of exposure in the group with musculoskeletal complaints compared to those without such symptoms, i.e., no differential misclassification (see Table 5, paper I). Moreover, the results showed

that the degree of differential misclassification was too small to have any essential effect on the risk estimates.

Gender in assessment of physical exposure (papers I and II)

There were no substantial gender differences considering the validity of the questionnaire responses (Table 10). For one question, manual handling of loads ≥10 kg, the κ_w coefficient was only 0.41 for the females whereas it rose to 0.59 for the males, but the confidence intervals were wide and overlapping (95% CI of κ_w 0.23–0.58 and 0.45–0.74 respectively). Moreover, the distribution of the responses was narrower among the females than among the males. These differences in κ_w could be explained by the difference in exposure distribution; the proportion of subjects exposed to manual handling of loads ≥10 kg was only 8% among females compared with 20% among males. For the remaining seven questions, the κ_w coefficients and the exposure distributions were both relatively similar.

Table 10. Validity of the eight physical load questions for females (n=102) and males (n=101).

	Females[a]		Males[a]	
	κ_w	(95% CI of κ_w)	κ_w	(95% CI of κ_w)
Work				
General physical activity	0.62	(0.49–0.74)	0.71	(0.62–0.79)
Sitting work posture	0.80	(0.73–0.88)	0.81	(0.75–0.87)
Hands above shoulder level	0.46	(0.27–0.66)	0.49	(0.28–0.70)
Bent trunk	0.49	(0.22–0.76)	0.47	(0.30–0.63)
Bent/twisted trunk	0.37	(0.20–0.53)	0.39	(0.22–0.56)
Manual handling of loads ≥10 kg	0.41	(0.23–0.58)	0.59	(0.45–0.74)
Repetitive movements	0.31	(0.20–0.55)	0.39	(0.23–0.57)
Leisure time				
Physical exercise/sports	0.73	(0.63–0.83)	0.73	(0.65–0.82)

[a] Reference method was a structured personal interview.[227,228]

To enable analyses of the effect of occupational gender segregation on the underlying factors involved in exposure, a matched sub-sample of 78 pairs of one male and one female worker from the MOA Study was selected (see Table 4). Two indicator variables were constructed. The indicator variable for horizontal occupational segregation was gender distribution by job title/occupation (female-dominated jobs, male-dominated jobs, and gender-integrated jobs) and the indicator variable for vertical occupational segregation was status/authority (low or high). Data on work postures and movements was collected using two technical instruments. The initial and underlying analyses in the study sample showed no statistically significant differences between male and female workers regarding any of the assessed work postures and movements (P=0.261–0.875; see Table 3, paper II).

With regard to horizontal occupational segregation, workers in female-dominated jobs experienced on average shorter duration of sitting work posture than workers in male-dominated or gender-integrated jobs (Table 11). In female-dominated jobs the mean duration was 40% of the work shift, while in male-dominated jobs it was 54%. There were no statistically significant differences between the three groups with regard to

posture and movement of arms and trunk. However, there was a tendency for workers in female-dominated jobs to have somewhat higher levels of exposure than workers in male-dominated or gender-integrated jobs.

Table 11. Work postures and movements for 156 Swedish workers, stratified on indicators for horizontal segregation and vertical segregation.

(mean values)	Horizontal segregation				Vertical segregation		
	Gender distribution by job title/occupation				Level of status/authority		
	f-d	m-d	g-i	*P*	low	high	*P*
Sitting/standing work posture							
Duration of sitting (%)	39.9	54.3	42.0	*0.029*	41.5	54.8	*0.011*
Posture changes p.h. (freq.)	12.4	10.7	11.0	*0.500*	10.8	12.3	*0.284*
Arm posture (cutoff point 60°)							
Duration of arm elevation (%)							
Dominant arm	5.2	3.7	3.4	*0.096*	4.6	3.0	*0.036*
Non-dominant arm	4.4	4.0	2.9	*0.176*	4.1	2.8	*0.074*
Arm elevations p.h. (freq.)							
Dominant arm	129.6	95.4	82.8	*0.086*	120.2	64.8	*0.003*
Non-dominant arm	99.1	76.5	72.4	*0.229*	97.0	53.3	*0.002*
Trunk posture (cutoff point 40°)							
Duration of trunk bend (%)	9.0	10.8	7.2	*0.202*	8.7	8.3	*0.785*
Trunk bends p.h. (freq.)	119.5	118.4	98.3	*0.317*	116.8	99.1	*0.212*

f-d = female dominated job (>70% females holding job title)
m-d = male-dominated job (>70% males holding job title)
g-i = gender-integrated job (30–70% of both females and males females holding job title)

The analyses of workers with low or high status/authority within the three horizontal segregation groups revealed different patterns within each group (Table 12). For female-dominated jobs, exposure differences between workers were strongly associated with level of status/authority; workers with low status/authority had substantially higher exposures than workers with high status/authority. Workers with low status/authority experienced shorter duration of sitting work posture, longer duration of arm elevation >60° for the dominant arm, higher frequency of arm elevation exceeding 60° for both the dominant and the non-dominant arm, and longer duration of trunk bend >40°. For male-dominated jobs the exposure differences between workers with low and workers with high status/authority were not as pronounced. The only statistically significant differences were for frequency of arm elevation exceeding 60° for both the dominant and the non-dominant arm; workers with low status/authority had higher exposure levels. In contrast to these two gender-segregated groups, gender-integrated jobs had small exposure differences between workers with low and workers with high status/authority, and none of the variables reached statistical significance.

Table 12. Work postures and movements for 156 Swedish workers, stratified on indicator for vertical segregation within the three horizontal segregation groups.

(mean values)	Female-dominated job			Male-dominated job			Gender-integrated job		
	Level of status/authority			Level of status/authority			Level of status/authority		
	low	high	*P*	low	high	*P*	low	high	*P*
Sitting/standing work posture									
Duration of sitting (%)	33.1	59.4	*0.001*	53.6	55.5	*0.817*	35.4	50.4	*0.165*
Posture changes p.h. (freq.)	12.3	12.6	*0.904*	9.3	13.0	*0.084*	10.9	11.1	*0.938*
Arm posture (cutoff point 60°)									
Duration of arm elevation (%)									
Dominant arm	6.1	2.0	*0.023*	4.3	3.3	*0.388*	3.5	3.1	*0.773*
Non-dominant arm	5.0	2.1	*0.073*	5.1	3.3	*0.182*	3.0	2.5	*0.651*
Arm elevations p.h. (freq.)									
Dominant arm	153.6	43.6	*0.028*	133.2	70.3	*0.020*	87.2	69.8	*0.504*
Non-dominant arm	113.6	47.3	*0.040*	109.6	54.4	*0.009*	78.0	55.4	*0.375*
Trunk posture (cutoff point 40°)									
Duration of trunk bend (%)	9.7	6.4	*0.197*	10.5	9.6	*0.788*	7.1	7.4	*0.889*
Trunk bends p.h. (freq.)	132.7	68.9	*0.035*	122.6	115.2	*0.777*	100.1	93.1	*0.760*

TARGET GROUPS FOR PREVENTION OF NECK/SHOULDER AND LOW BACK PAIN

Cluster analysis of 15 variables relating to working and living conditions was performed in order to identify potential target groups for prevention of neck/shoulder and low back pain. Different cluster solutions – seven, eight, nine, and eleven clusters – were investigated. The final choice of cluster solution was based on two criteria, firstly that all clusters in the cluster solution should be easy to interpret and recognize, and that cluster solutions must be associated with the presence or absence of neck/shoulder or low back pain.

Identification of groups with similar working and living conditions (paper III)

The chosen cluster solution had eleven clusters, with 53–194 subjects in each cluster. Each group was named after its main characteristics (Table 13). One subject was excluded from further analysis due to missing data on more than two of the 15 variables, and eight others were excluded after being identified as outliers. Test statistics showed that the eleven groups differed with regard to all 15 variables that formed the clusters (P <0.001). The groups also differed with regard to all the variables used to describe *where* they were found, that is, the labor market variables (P <0.001). Moreover, they differed with regard to demographic data, but not with respect to health-related behavior; there were no statistically significant differences between the groups with regard to smoking, alcohol use or BMI (P=0.158–0.186). By contrast, the

groups differed with regard to physical training and sports (P=0.037). Gender-specific analyses showed similar results for all variables.

Table 13. The eleven clusters named after their main characteristics, and distribution of subjects in the groups.

	Females[a,b]		Males[b]		All subjects[a,b]	
	n	(%)	n	(%)	n	(%)
1 Onerous human service job	114	(15)	49	(8)	163	(12)
2 Free agent	18	(2)	74	(13)	92	(7)
3 Family burden	137	(18)	20	(3)	157	(12)
4 Sedentary work	64	(9)	56	(10)	120	(9)
5 Passive	58	(8)	37	(6)	95	(7)
6 Mentally stretched	80	(11)	76	(13)	156	(12)
7 Balanced	105	(14)	89	(15)	194	(15)
8 Physically active	24	(3)	29	(5)	53	(4)
9 Manual colorless labor	80	(11)	57	(10)	137	(10)
10 Shift work	54	(7)	32	(5)	86	(6)
11 Physically strained	11	(2)	68	(12)	79	(6)
Total	745		587		1,332	

[a] One female was excluded due to missing data.
[b] Three females and five males were excluded as "outliers" due to extreme values.

Identification of risk groups for neck/shoulder and low back pain (papers III and IV)

The eleven clusters were also analyzed with regard to prevalence of neck/shoulder and low back pain. Separate analyses for females and males and of the full study group showed rather similar results, in analyses of the baseline data as well as of the 5-year follow-up data. The following figures relate to the analysis of the full study group.

The baseline investigation showed that the groups differed with regard to the prevalence of low back pain (P=0.008; see Table 5 in paper III). Subsequent analyses showed that the "onerous human service job", the "free agent", and the "family burden" groups (clusters 1–3) were associated with low back pain (OR 2.1–2.5; see Table 6 in paper III). The groups did not differ with regard to the prevalence of neck/shoulder pain (P=0.713; see Tables 5 and 6 in paper III). An additional analysis made for this thesis is presented in Table 14, which shows odds ratios, adjusted for gender, for the association between cluster and neck/shoulder or low back pain. In this analysis the "free agent" and the "family burden" groups (clusters 2 and 3) were found to be associated with such pain (OR 1.7 and 1.6 respectively).

The eleven clusters were followed up five years after the baseline investigation. The outcomes were "moderate disorders", "persistent disorders", and "absence of disorders" (Figure 3).

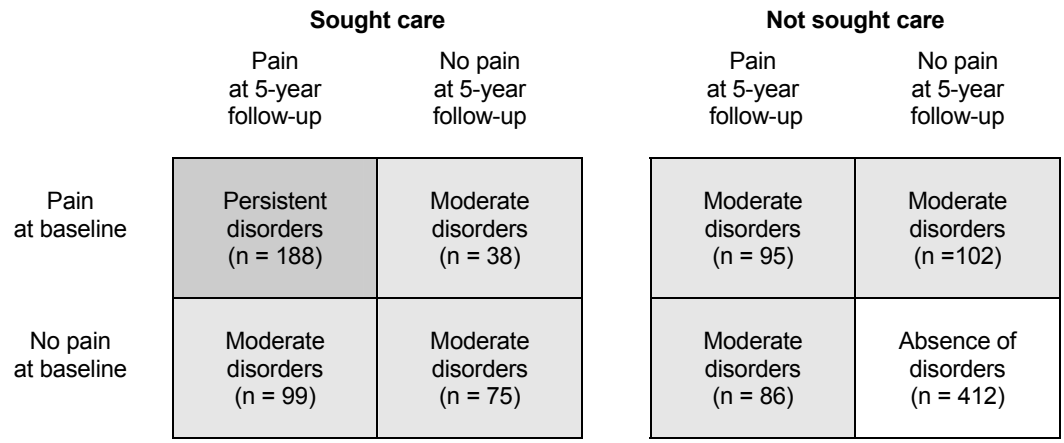

Figure 3. The presence or absence of pain in the neck/shoulder or low back at baseline and at follow-up, among those who had sought care or not sought care during the follow-up period, resulted in eight different combinations. From these eight combinations, three outcome groups were constructed for analysis, the moderate disorders, the persistent disorders, and the absence of disorders groups.

At baseline, 423 of the 1,095 subjects (39%) had neck/shoulder or low back pain. At follow-up, 468 subjects (43%) had neck/shoulder or low back pain and 400 (37%) had sought care for such pain during the follow-up period (Figure 3). The distributions differed for females and males (not shown). A larger proportion of females than males had neck/shoulder or low back pain at baseline (40% and 35% respectively), a larger proportion of females (47%) than males (38%) had pain at follow-up, and a larger proportion of females (41%) than males (31%) had sought care for pain during the follow-up period.

When classified into outcome groups, 45% of all subjects had moderate disorders and 17% had persistent disorders (Figure 3), while disorders were not present in the remaining 38%. The distributions differed for females and males (not shown). A larger proportion of females (20%) than males (13%) had persistent disorders, while the proportions of subjects with moderate disorders were almost equal between females and males (46% and 45% respectively). Consequently, a smaller proportion of females (34%) than males (42%) enjoyed absence of disorders. For the eleven groups with different combinations of working and living conditions, the proportion of subjects with moderate disorders varied from 36% to 52%, while that of subjects with persistent disorders varied from 7% to 22%, and that of subjects with absence of disorder varied from 30% to 50% (see Table 1, paper IV).

Logistic regression analysis, adjusted for gender, showed that three of the groups, the "onerous human services job", the "free agent", and the "family burden" groups, had an increased risk for moderate disorders (OR 1.94–2.44) as well as for persistent disorders (OR 2.39–2.65) compared with the "sedentary work" group (Table 14). One of the groups, the "mentally stretched" group, had an increased risk only for persistent disorders (OR 2.38). Two of the groups, the "manual colorless labor" and the "physically strained" groups, had an increased risk only for moderate disorders (OR 2.05 and 2.35, respectively). There was a tendency for the "physically strained" group to also have an increased risk for persistent disorders (OR 2.70, 95% CI 0.96 to 7.62).

Table 14. Association between different combinations of working and living conditions and neck/shoulder or low back pain at baseline (n=1,332, paper III) and 5-years after baseline (n=1,095, paper IV), adjusted for gender.

	Baseline		5-years after baseline			
	Neck/shoulder or low back pain		Moderate neck/shoulder or low back pain		Persistent neck/shoulder or low back pain	
	OR	(95% CI)	OR	(95% CI)	OR	(95% CI)
1 Onerous human service job	1.32	(0.86–2.02)	1.97	(1.12–3.47)	2.39	(1.08–5.31)
2 Free agent	1.66	(1.00–2.77)	2.44	(1.22–4.88)	2.55	(1.36–9.30)
3 Family burden	1.58	(1.02–2.44)	1.94	(1.08–3.49)	2.65	(1.19–5.90)
4 Sedentary work	0.80	(0.50–1.30)	1.00	Reference	1.00	Reference
5 Passive	0.91	(0.54–1.52)	1.40	(0.74–2.64)	1.84	(0.75–4.51)
6 Mentally stretched	1.09	(0.70–1.69)	1.57	(0.89–2.79)	2.38	(1.07–5.32)
7 Balanced	1.00	Reference	1.40	(0.82–2.40)	1.83	(0.84–3.98)
8 Physically active	1.07	(0.57–2.01)	1.31	(0.61–2.80)	0.75	(0.19–2.98)
9 Manual colorless labor	1.26	(0.80–1.97)	2.05	(1.14–3.71)	1.97	(0.84–4.66)
10 Shift work	1.06	(0.62–1.78)	1.00	(0.50–1.97)	1.49	(0.58–3.81)
11 Physically strained	1.30	(0.76–2.25)	2.35	(1.15–4.79)	2.70	(0.96–7.62)

Potential target groups for primary/secondary prevention (papers III and IV)

Six potential target groups for prevention of neck/shoulder or low back pain were identified. The three clusters with an increased risk for both moderate and persistent neck/shoulder or low back pain (clusters 1–3) were among those with the most skewed distribution of females and males, and all three clusters had working and living conditions that were rather gender-specific (see Table 15).

In the "onerous human service job" group (cluster 1), 70% of subjects were female. This group was characterized by high psychological demands, many hindrances at work, and jobs requiring a relatively high level of creativity. These individuals were mainly found in the human services; most of them worked with people and were employed in the public sector.

In the "free agent" group (cluster 2), 78% of subjects were male. This group was characterized by long work hours, high physical and psychological demands at work, and relatively little time for recreation in the private sphere. The majority worked with things, in gender-segregated jobs, and in the private sector. Many were self-employed, and many were physically inactive with regard to training and sports. This group had the smallest proportion of individuals with a high income.

In the "family burden" group (cluster 3), 87% of subjects were female. This group was characterized particularly by factors external to paid work, such as a great deal of time spent on domestic and family work and relatively high metabolic demands in the private sphere. Many worked in the human services; a majority worked with people and in female-dominated jobs. Moreover, this group had the largest proportion of individuals with temporary employment, and one of the smallest proportions of individuals

with a high income. Like the “free agent” group, many subjects in the “family burden” group were not physically active with regard to training and sports.

The three clusters with an increased risk for either only persistent pain (cluster 6) or only moderate pain (clusters 9 and 11) had different features. In two of these groups, the “mentally stretched” and the “manual colorless labor” groups, the distribution by sex was fairly even, while the “physically strained” group contained a majority of males.

The “mentally stretched” group (cluster 6) was mainly employed in the public sector, and of all groups had the highest psychological demands and the most hindrances at work. This group also had long work hours and the shortest time available for private recreation.

The “manual colorless labor” group (cluster 9) had high physical demands, low influence, and many routine tasks at work. Most individuals in this group worked in the service branch and in production, and the majority worked with things.

The “physically strained” group (cluster 11) was characterized by high physical workload during long work hours. Most subjects worked in production and in male-dominated jobs within the private sector.

Table 15. Ranking of the "*what* characterizes", "*where* are" and "*who* are" variables for the eleven clusters, from 1=highest mean value or largest proportion, to 11=lowest mean value or smallest proportion. Grey shadings indicate the three highest exposures or proportions.

	Cluster number											
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	***P***
***What* characterizes the clusters?**												
– in paid work												
Total work hours	7	1	11	4	8	2	5	6	9	10	3	<0.001
Not office hours	4	6	5	10	2	7	8	3	11	1	9	<0.001
Hands above shoulder level	8	2	9	11	10	6	3	4	7	5	1	<0.001
Bent trunk	9	1	6	11	7	10	3	4	7	5	2	<0.001
VDU work	6	11	4	1	9	2	7	5	8	3	10	<0.001
TWA-MET work	9	2	7	11	8	10	6	5	3	4	1	<0.001
Creativity	2	4	8	3	10	1	5	6	11	9	7	<0.001
Routine work	9	5	7	10	2	11	8	6	1	3	4	<0.001
Hindrances	2	3	6	7	11	1	10	4	9	8	5	<0.001
Psychological demands	2	3	7	5	11	1	10	4	9	8	6	<0.001
Influence at work	4	1	8	6	11	3	2	7	9	10	5	<0.001
Social interaction	5	8	3	7	1	4	2	6	10	11	9	<0.001
– in the private sphere												
Domestic/family work	9	10	1	7	3	5	6	11	4	2	8	<0.001
TWA-MET leisure time	11	9	2	10	6	5	7	1	8	3	4	<0.001
Time for recreation	1	10	8	5	3	11	7	9	2	4	6	<0.001
***Where* are the clusters found?**												
Labor market												
Public sector	1	10	4	9	1	1	7	6	5	7	11	<0.001
Type of work[a]												<0.001
working with people	2	8	3	10	1	5	4	6	9	7	11	
working with data	4	11	3	1	8	2	5	6	7	9	10	
working with things	7	3	8	11	9	10	6	5	2	4	1	
Gender-segregated job	6	1	5	9	3	11	6	10	6	4	2	<0.001
Temporary employment	6	10	1	11	2	9	6	3	4	6	4	<0.001
Low/medium income	7	2	3	8	4	11	6	9	1	10	5	<0.001
***Who* are (the individuals) in the clusters?**												
Demographic data												
Females	2	10	1	7	4	8	6	9	5	3	11	<0.001
Age >44 years	1	6	9	2	7	2	5	11	4	8	10	<0.001
Low educational level	8	2	7	10	4	11	5	9	1	3	6	<0.001
Blue-collar worker	9	5	8	11	4	10	6	7	3	1	2	<0.001
Single	4	10	11	7	6	8	9	3	1	5	1	<0.001
Children <18 years at home	11	3	1	8	6	2	3	9	10	5	6	<0.001
Health-related behavior												
Regular smoker	4	11	6	3	1	10	4	8	7	1	8	0.171
Uses alcohol	6	5	9	4	3	2	7	11	8	9	1	0.158
Obese	2	9	7	9	2	6	2	7	2	1	11	0.186
Physically inactive	7	1	2	10	3	5	9	11	6	4	7	0.037

[a] Grey frames indicate groups with the largest proportions of individuals working with people, data or things, respectively.

Clusters/groups:

1 Onerous human service job
2 Free agent
3 Family burden
4 Sedentary work
5 Passive
6 Mentally stretched
7 Balanced
8 Physically active
9 Manual colorless labor
10 Shift work
11 Physically strained

DISCUSSION

ASSESSMENT OF PHYSICAL EXPOSURE

Validity of questionnaire data on physical exposure

One purpose of reproducibility and validity studies is to evaluate new instruments for epidemiological studies. For occupational health studies it is also necessary to reevaluate "old" instruments such as questionnaires, since working conditions are liable to change over time.

In the study presented in paper I, eight questions regarding physical load were evaluated with regard to test-retest reliability. The results showed a relatively high reproducibility for the responses to the questions (see Table 9). This reliability gives an upper boundary for the validity of the instrument;[8] an instrument with poor reproducibility will also have a poor validity, but not necessarily vice-versa. Two previous studies on the reproducibility of self-administered questionnaires are comparable with the questions evaluated in paper I, though the questions had somewhat different wordings and response scales.[201,225] The differences found in test-retest agreements might be because of the different response entities or the different response scales (Table 16). Wiktorin et al. used a six-point scale,[225] while Torgén et al. used a continuous scale – percentage of workday – for the questions concerning awkward work postures.[201] The higher reproducibility in our study may imply that a four- or five-point scale is more reliable for such questions.

Table 16. Reproducibility of questionnaire responses on physical exposures: comparison of the results presented in paper I with two previous studies.

	MOA Study (paper I) Leion et al. 2002 n=203		REBUS Study Torgén et al. 1997[201] n=44		MUSIC I Study Wiktorin et al. 1996[225] n=343	
Questionnaire item	**Response entity**	**κ_w**	**Response entity**	**r_i**	**Response entity**	**r_i**
General physical activity	level	0.85	n.a.	n.a.	level	0.87
Work posture (whole body)	time	0.92	time	0.64	time	0.90
Work posture (part of body)	time	0.74–0.83	time	0.61–0.75	time	0.52–0.59
Manual handling of loads	freq.	0.81	time	0.83–0.89	freq./time	0.53–0.63
Repetitive movements	time	0.80	time	0.64	time	0.65–0.71
Physical exercise/sports	level/freq.	0.86	level/time	0.51–0.72	level/freq.	0.83

κ_w is Cohen's kappa coefficient with quadratic weights
r_i is intra-class correlation coefficient

The inter-method reliability testing showed differing results for the eight questions evaluated (see Table 9). The questions concerning general physical activity, sitting

work posture, and physical exercise/sports showed fairly high inter-method reliability. These findings accord with those of several previous studies.[178,223,226]

The question concerning awkward work postures had intermediate inter-method agreement. Two studies support our results concerning work with hands above shoulder level,[178,223] whereas two studies have shown lower inter-method agreements.[71,226] Two studies support our results concerning work with bent trunk,[223,226] whereas two have shown lower inter-method agreements.[72,164] In one of these studies with low agreements, technical measurements with inclinometers were used for validation. However, this study used subjective three-point response alternatives (very little/somewhat/much) with no zero point and without defining the scale in more objective form.[72] The question concerning manual handling of loads ≥10 kg also had moderate inter-method agreement. Several previous studies have shown quite similar results.[178,223,226]

The question concerning bent/twisted work posture has (to our knowledge) not previously been evaluated. Its low inter-method reliability might be explained by the poor formulation of the question, which did indicate what part of the body is presumed to be bent/twisted. Hence, subjects may relate to other parts of the body than the intended low back when responding to the question. Such vaguely-formulated questions should be avoided in self-administered questionnaires.

The question concerning repetitive movements had the lowest inter-method agreement of all questions. This result accords with several previous studies.[71,178,223] Work with repetitive movements is common and varies widely in its details, for example, in what part of the body is used in performing the work task, and in frequency of repetition. Such a complex questions may be difficult to deal with in more general terms, and we argue that they should be avoided in self-administered questionnaires directed to heterogeneous populations, for example in general population studies.

Differential misclassification of exposure

Differential misclassification of exposure can cause problems in epidemiological studies.[188] The present study indicated some differential misclassification of exposure between the groups with and without musculoskeletal complaints. In the full-scale analysis the κ_w coefficients were overall somewhat lower in the group with musculoskeletal complaints, with one exception being the question on bent/twisted work posture. However, the confidence intervals were wide, and overlapped between the two groups. Furthermore, analysis at dichotomous level indicated that the impact of differential misclassification of exposure was too small to have any essential impact on the risk estimates. Nevertheless, a weakness of the study was that the reference instrument (the interviews) also relied on subjective self-reports; such an approach may make it more difficult to detect a differential misclassification. Nevertheless, in our results we could not find either a systematic overestimation or a systematic underestimation of exposure among subjects with complaints. Subjects with musculoskeletal complaints overestimated their exposure for five questions and underestimated it for three.

Gender in assessment of physical exposure

Since most of the questions evaluated were developed for or evaluated using male industrial populations,[105,224,235] we wanted to evaluate them for other groups as well. In our study we investigated whether gender or type of work influenced the validity of the responses to the questions. No substantial influence of gender (see Table 10) or type of work was found, indicating that neither females nor males report their exposures more or less accurately than their opposite sex. This is promising from an epidemiological point of view – at least when exposures are assessed by self-reports.

Few studies in the field of occupational medicine and epidemiology have investigated the association between exposure or disorders/diseases, on the one hand, and occupational gender segregation, on the other.[104,118] In the study presented in paper II, we examined the association between exposure to awkward work postures and occupational gender segregation. The results showed only one association between level of exposure and horizontal segregation (see Table 11). Workers in female-dominated jobs experienced significantly shorter duration of sitting work posture, in other words, longer duration of standing and walking. This is in accordance with previous reports of prolonged standing in female-dominated service jobs, for example among sales clerka, food service workers, and hairdressers.[154] Moreover, a study by de Zwart et al. (2001) investigated whether females' higher risk for upper extremity disorders could be explained by differences in the distribution of male and female workers over occupations with different risks for the onset of such complaints,[43] but, in line with our results, did not find any support for the theory that differential occupational exposure could arise from horizontal segregation.

The lack of exposure differences between female-dominated, male-dominated, and gender-integrated jobs in our study may be explained in part by the changes in the labor market in Sweden. These changes, evident in many sectors of the labor market, include implementation of new technologies and work tools and new types of production methods.[221] Many physically demanding jobs, traditionally regarded as manual jobs, have changed to include more process-monitoring work. As a result, many workers experience lower exposure to awkward work postures. These changes are especially evident in industrial work. However, jobs with high exposure levels still exist, mostly in extremely gender-segregated jobs, for example human services and construction jobs. This assumption is supported by the findings of Leijon et al. (2004) that workers in extremely gender-segregated jobs had the highest cumulative incidence of sick leave due to neck/shoulder and low back pain.[118]

In contrast, we found several associations between level of exposure and vertical segregation (see Table 11). Workers with low status/authority had on average longer duration and frequency of all assessed work postures and movements, although only half of the variables reached significance level. From a general point of view, these results imply a disadvantaged situation – higher exposure levels – for female workers compared to male workers, as more female workers have a low status/authority due to pay and position differentials in the labor market.[197] This result was not unexpected; many earlier studies have indicated such an association.[180,190] However, subsequent

stratified analyses revealed somewhat different patterns for the three horizontal segregation groups.

The stratified analyses showed a strong association between level of exposure to awkward work postures and status/authority within female-dominated jobs and a less pronounced association within male-dominated jobs, while no such association was found within gender-integrated jobs (see Table12). Within female-dominated jobs the largest exposure differences between workers with low status/authority and workers with high status/authority were for the dominant arm (duration of arm elevation $>60^{o}$ and frequency of arm elevations exceeding 60^{o}), with levels among workers with low status/authority being more than three times higher on average. Moreover, workers with low status/authority in female-dominated jobs had shorter duration of sitting work and longer duration and higher frequency of arm elevation, compared with workers in male-dominated or gender-integrated jobs.

The results are in accordance with several related studies showing that a combination of repetitive work tasks and an inability to set one's pace, or regulate the performance of one's work, is in general is much more common among female workers and in female-dominated jobs than among male workers and in male-dominated jobs.[106,154] Moreover, multi-level analyses in the MOA Study have shown that at organizational level, type of structures and extent of gender segregation had the highest associations with job control, routine work, and physical demands at the individual level. The variability in individual working conditions attributable to the organizational level was highest for the ergonomic stressors, but was also high for complexity of work tasks and workers' own control.[92]

Improvements in technology may in general have had greater impact in male-dominated and gender-integrated jobs than in female-dominated jobs.[106] Although in many jobs such improvements may have diminished the differences in exposure between workers with different levels of status/authority, such differences may persist to a larger extent in female-dominated jobs, which in Sweden are predominantly in the "soft sectors", i.e., service, healthcare, and social welfare. In these sectors workers with high status/authority have certainly benefited from the new technologies and diminished their exposure levels with regard to awkward work postures, for example, by increased VDU use among supervisors and managers. On the other hand, the working conditions of those with low status/authority generally remain unchanged; the very nature of these jobs requires the human hand as the primary work tool.

In summary, we found that the level of exposure to awkward work postures was associated with structural factors in the labor market – both for female and male workers. Moreover, the results revealed "concealed" or non-obvious patterns within different occupational settings. The association between exposure and occupational gender segregation was strongest within female-dominated jobs. In these jobs, female ad male workers with a low status/authority had the highest overall exposure levels. This finding has implications for the prevention of work-related MSDs as well as for future research in this field.

Methodological considerations

The test-retest method employed to evaluate intra-method reliability or reproducibility of the responses to the eight physical load questions is well known and often used. We chose to re-administer the questionnaire after three weeks to balance potential sources of errors, such as a true change in working conditions and exposure between the two test occasions, or the possibility that the respondents might remember their responses from the first response occasion and simply repeat them at the second response occasion.[26] However, during the three weeks none of the subjects participating in the study had any extensive change of work tasks, and none changed job title. Moreover, the questions of interest were embedded in a large questionnaire with 158 questions, and we thought it unlikely that many respondents would be able to remember their responses to any single question.

The inter-method reliability study used a structured interview as reference instrument. As already mentioned, it could be argued that since the interviews also relied on subjective self-reports, there could be a systematic bias resulting from replication in the interviews of inaccuracies in the questionnaire responses. However, assessment in the interview was made task by task rather than using the total time per day as in the questionnaire, an approach which makes it easier for the subject to estimate time accurately.[228] Moreover, the interview method has the advantage over a self-administered questionnaire that misunderstandings and ambiguities can be immediately resolved by an expert interviewer, who can adjust subjects' uncertainties about the questions.[227,230] Furthermore, subsequent on-site studies of each individual's working conditions were also in agreement with the categorizations of the interview data into the response alternatives of the questions. The criteria used for these categorizations were established using existing knowledge, assisted by discussion with senior researchers in ergonomics and epidemiology.

Several researchers have recommended using matched samples of females and males in similar situations for studies on work-related health or ill health among women and men.[151,153,155] We argue that such a strategy is also relevant for studies aiming at revealing potential concealed patterns of gender order, such as our study of the association between exposure to awkward work postures and occupational gender segregation (paper II). Consequently, we used a matched sample strategy intended to diminish gender differences in exposure.

When studying occupational gender segregation, the choice of indicator variables is critical. The choice of indicator variable for horizontal segregation, distribution of gender by job title/occupation, is fairly uncontroversial. The literature gives little guidance on the choice of indicator variable for vertical segregation, but several researchers seem to agree that status and authority are two key elements in vertical segregation.[16,30,179] Based on this assumption, we developed a "simple" indicator variable combining income, influence over work and position. We argue that influence over work is a valid indicator of authority, since it reflects the individual's possibility to control her/his own work. It should be noted that this influence is different from self-reported influence, which mainly reflects control within the job.[9]

Direct measurements of exposure with validated instruments and technical devices is known to produce unbiased data of high quality.[122,213,230] However, it is equally crucial to consider variability in exposure,[147] especially in jobs with large variability between different seasons or periods. The cross-sectional design in our study, with one-day technical assessments during the working day, did not take exposure variability into account. However, none of the subjects reported that the workday chosen for assessment was unusual or "extreme" in any sense. Nevertheless, this limitation may theoretically have affected the results and interpretations, at least for the more highly-exposed jobs.

TARGET GROUPS FOR PREVENTION OF NECK/SHOULDER AND LOW BACK PAIN

Identification of groups with similar working and living conditions

A proper risk analysis is one of the basic components of a successful preventive program.[108] In the study presented in paper III, we aimed to extend this foundation by including strain-inducing as well as supportive factors. Moreover, several studies have emphasized the importance of an ecological understanding of workplace exposure situations as critical in formulating both correct inferences about the risk for MSDs and effective prevention strategies.[141,217] Such an understanding requires more knowledge of concomitant exposures, as well as of how exposure to physical and psychosocial factors may be entangled and how work-related factors may be associated with factors and conditions in the private sphere.[62] The primary aim of our study was not to find an answer to these difficult and extensive questions, but they can nevertheless be seen as being related to our search for different patterns of working and living conditions associated with neck/shoulder and low back pain.

Motivated by earlier methodological work in the MOA Study, we applied cluster analysis to individual data on work-related ergonomic-physical and psychosocial factors and conditions in the private sphere.[93] A few other studies in the public health field have applied cluster analysis to identify groups or patterns, e.g., in studies on the clinical course of musculoskeletal pain,[38] in psychological risk factors for chronic spinal pain,[17] and in the accident process in overexertion back injuries.[52] These studies have shown that cluster analysis is very useful for exploration of complex and multivariate data.

The objective of our study was to identify groups with small intra-group differences in working and living conditions. Several different cluster solutions were tested before the final choice was made of a solution that best fulfilled the criterion of being easy to interpret, understand, and recognize. Ease of interpretation was gauged using a model developed within the MOA Study, [93] and interpretations of the solutions were discussed within a multidisciplinary team until consensus was reached. The chosen cluster solution had eleven clusters or groups with different working and living conditions. An additional criterion was that the cluster solutions had to be associated with neck/ shoulder or low back pain (further discussed in the next section). The 15 variables that

formed the groups did not include structural or demographic data. It is therefore interesting to find that the groups differed in almost all the variables describing *where* they were found in the labor market and *who* the individuals in the groups were (see Table 15). The results of the cluster analysis with a combination of different aspects of individual working and living conditions, i.e., a person-oriented approach, thus revealed concealed and latent factors that seem to be associated with either presence or absence of neck/shoulder and low back pain.

Identification of risk groups for neck/shoulder and low back pain

At baseline we investigated the association between cluster and neck/shoulder or low back pain. We found that three of the groups were associated with pain, thus fulfilling the second criteria for the choice of cluster solution. However, due to the cross-sectional design of the study, it was not possible to estimate the risk for pain. To enable an investigation of the risk for pain in groups with different working and living conditions, the eleven groups were followed up five years after baseline (paper IV).

We chose to classify the outcome into three groups, relevant from a prevention perspective: moderate disorders, persistent disorders, and absence of disorders. The results of the five-year follow-up showed that several of the groups had an increased risk for neck/shoulder or low back pain. Three of the groups had an increased risk for moderate as well as persistent disorders. These were the "onerous human service job", the "free agent", and the "family burden" groups. Two of the groups, the "manual colorless labor" and "physically strained" groups, had an increased risk for moderate disorders only, and one group, the "mentally stretched" group, had an increased risk for persistent disorders only (see Table 14). In other words, groups with different life conditions have different risk for pain. This, in turn, strengthens our assumption that different prevention strategies are needed for different groups.

Five of the groups were not associated with either moderate or persistent neck/shoulder or low back disorders. It is noteworthy that these "healthy" groups were found in all branches of the labor market, and that they represented a wide variety of occupations rather than only physically and psychosocially non-strenuous jobs or just one type of situation in the private sphere. Nor did they have reversed working and living conditions in relation to the groups with an increased risk for neck/shoulder or low back pain. Mackenbach et al. (1994) stated more than a decade ago that the determinants of "excellent health" is poorly investigated; [143] and relatively few studies have been conducted since. [124]

Potential target groups for primary/secondary prevention

As discussed in the introduction of this thesis, the period prevalence and the life-time prevalence of musculoskeletal pain are both very high. Together with their generally self-limiting nature, this suggests that these pain conditions could almost be considered to be a natural part of life. However, about 10–20% of individuals suffer from persistent pain, and such individuals account for the greater part of the cost attributable to these pain conditions.[78] Thus, the main objective for prevention strategies ought to be a reduction in the development of persistent pain problems. Even though the multi-factorial causes and complexity of MSDs are frequently stressed, preventive inter-

ventions often focus on reduction in single risk factors or in single domains. The evidence for the effective-ness of such ergonomic or risk-factor modification is very weak.[132] We argue that successful prevention would be best achieved by taking a holistic perspective that encompasses all aspects of the individual's life, and using a contextual approach to identify those arenas and situations in which preventive efforts may be most cost-effective.

The four groups identified above as having an increased risk for persistent disorders should constitute the main targets for prevention. Despite having quite different features, each of these groups was in a situation that was in many respects what could be described as "overstrained".

The "onerous human service job" group (cluster 1) had a strenuous situation with regard to psychosocial work conditions. High creativity requirements, high psychological demands, and many hindrances at work were not counterbalanced by high influence. Previous research has found that high demands and low control increase the risk for MSDs.[18,86] A majority in the group were female, aged >44 years, and of a relatively high educational level. Almost three out of four worked in the public sector.

The "free agent" group (cluster 2) had high physical as well as psychosocial exposures during long work hours, and relatively little time for recreation and leisure. The importance of covariation between workplace physical and psychosocial stressors has been reported previously.[141] A large majority in this group were male, many had a low educational level, and most had a low/medium income. Most subjects worked in the private sector, and this group also had the largest proportion of self-employed individuals.

The "family burden" group (cluster 3) was characterized by an overstrained situation in the private sphere with regard to family and domestic responsibilities. They also had limited time for their own recreation and leisure. This result relates to an earlier study that showed an association between dissatisfaction with leisure time and MSDs.[61] A large majority in this group were female, many were in temporary employment, and most had a low/medium income. Four out of five had children <18 years living at home.

Each of these three groups had a skewed distribution of females and males and thus suggest rather gender-specific working and living conditions. This is in line with the theories of Kilbom et al. (1998), who argued that differences in life situations are probably a more important reason for gender health differences than are any biological factors.[106] It is possible that traditional gender roles and gender-specific conditions preserve, and also conceal, those working and living conditions associated with the risk for MSDs. Although it is very difficult to provide strong evidence for such a relationship, it does appear plausible.

The fourth group with an increased risk for persistent pain was the "mentally stretched" group (cluster 6). This group had the highest psychological demands and the most hindrances at work of all eleven groups – a work situation that may lead to very high levels of stress. Previous studies have shown that a high workload accompanied by

high levels of stress may be associated with symptoms such as MSDs.[109,135] This group had a fairly even distribution of females and males. A majority were aged >44 years and were in regular employment. Almost three out of four had children <18 years living at home, and almost three out of four worked in the public sector.

Although the aim of the studies in papers III and IV was to identify target groups for prevention, and not to investigate which preventive interventions to use, the results may help to provide some general ideas for prevention strategies. Firstly, the results imply that different prevention strategies need to be considered for different groups. Secondly, the different types of overstrained situations show that broad-based interventions are necessary; in other words, that it is necessary to consider what concurrent preventive interventions are needed at different levels, for example, at the individual/family level, the workplace level, and the societal level. Thirdly, a holistic approach needs to be implemented in the planning, accomplishment, and evaluation of preventive efforts. The latter is crucial in order to avoid unintentional shift of risk from one exposure or domain to another.[186]

Methodological considerations

The study population was a sample of 1,341 referents from the MUSIC-Norrtälje Study. The subjects were in long-term regular or temporary employment, and had not sought care or been treated for neck/shoulder or low back pain during the 6 months preceding enrollment in the study. Pain or pain-related disability due to MSDs was not an exclusion criterion and (although they were not considered in the MUSIC-Norrtälje Study as being MSD cases) a fairly large proportion of the subjects had at baseline experienced such problems without having sought care. The selection of the sample was made to (1) resemble a potential target group for primary/secondary prevention, i.e., a group with low-level symptoms or absence of symptoms;[132] and (2) ensure data of high quality by using a group confident of their own exposures. However, other population groups can also be potential target groups for prevention, for example, students, unemployed persons, and persons in short-term employment. These groups were not included in our study sample, since a cluster analysis requires a full set of data on all variables. Another drawback of using cluster analysis is the possible dependency of the results on the sample selected – other clusters may be found in a different sample. Consequently, further studies are needed to validate and verify the results.

The selection of variables for cluster analysis is critical; it was therefore made with great care and with the use of a multidisciplinary team to increase the overall knowledge of the studied conditions. We are aware that the study does not cover all relevant aspects of working and living conditions related to neck/shoulder and low back pain. However, an increased number of aspects (and hence variables) would further increase the complexity of the results and, consequently, also complicate the interpretation of the results. On the other hand, the 15 variables chosen for cluster analysis would have been very difficult to analyze with more "traditional" methods, such as logistic regression models, as they would produce too many potential interactions. Previous studies have shown that cluster analysis is a good method for detecting the complex patterns of combined risk indicators and modifiers.[93] Another critical choice when performing cluster analysis is how many clusters should be extracted. Since there is no

generally accepted statistical criterion for this, the choice was based on a quantitative as well as a qualitative evaluation.

Linton and van Tulder (2000) have recommended the use of multiple outcome variables to reflect different aspects of MSDs, for example, function, pain experience, and sick leave.[132] Our studies employed such a strategy, using six questions on pain intensity and pain-related disability for both neck/shoulder and the low back region.[232] Despite the fact that we used referents from the MUSIC-Norrtälje Study, we found a surprisingly large proportion of subjects with pain and pain-related disability at baseline. However, it is important to bear in mind that neck/shoulder and low back pain are not single disorders, but rather a collection of several problems mostly defined by symptoms, and that it is normal for people to suffer these symptoms. Such pain is not necessarily associated with disease, and therefore most forms do not require medical attention.[132]

In paper IV, the outcomes were defined by pain at baseline, pain at follow-up, and having sought care during the follow-up period. We argue that the classification of the outcome into moderate disorders, persistent disorders, and absence of disorders is relevant from a prevention perspective. However, this classification has a serious shortcoming with regard to the moderate disorders group. This group is very heterogeneous as it includes incident cases, those that have recovered during the follow-up period, and the "worried well" who despite having no pain either at baseline or at follow-up had sought care during the follow-up period. Thus, great caution must be taken in interpreting the results for the moderate disorders group.

CONCLUSIONS AND SOME FUTURE PERSPECTIVES

- In a self-administered questionnaire, individuals estimated their exposure with high accuracy with regard to level of general physical activity, duration of sitting work posture, and level of physical exercise and sports activities; with moderate accuracy to duration of bent trunk, duration of work with hands above shoulder level, and frequency of manual handling of loads ≥10 kg; and with low accuracy to duration of bent/twisted work posture and duration of repetitive movements.

- Gender, type of work, and musculoskeletal complaints did not influence the ability to respond to the physical load questions.

  The questions with high or moderate accuracy can be recommended for questionnaires intended to study health effects in epidemiological studies. However, it may be necessary to redesign the questions with moderate accuracy in the future, or to modify their response scales. The two questions with low accuracy should be avoided, at least in general population studies. Straight-forward questions with relevant response alternatives are recommended.

  Further studies are encouraged to reevaluate old questions, to redesign existing questions, and to formulate new questions relevant to contemporary work situations. This is motivated by the constant changes in the labor market along with changes in workers' attitudes to different working conditions.

- Level of exposure to awkward work postures was associated with vertical occupational segregation, and this appeared to be most prominent in female-dominated jobs.

  Structural factors in the labor market, such as occupational gender segregation, may perpetuate differences in working conditions between different occupational settings and between female and male workers.

  These findings have implications for the prevention of musculoskeletal pain; they motivate broad-based interventions at both the workplace level and the organizational level in order to decrease exposure. Examples could include ergonomic interventions to adapt work stations and work tools to the female frame, or organizational changes aimed at increasing workers' influence over their jobs and work tasks. Female and male workers in female-dominated jobs with low status and authority had the overall highest exposure levels, and should therefore be the primary target group for such efforts.

  Careful consideration of occupational gender segregation in research is recommended in order to avoid bias in epidemiological studies of occupational exposure and musculoskeletal pain.

- Eleven groups with different working and living conditions were identified. Cluster analysis seems to be a practicable method for identifying target groups for primary/secondary prevention.

- Four of the identified groups had an increased risk for persistent neck/shoulder or low back pain, and thus constitute the primary target groups for prevention.

- Gender-specific working and living conditions were associated with an increased risk for persistent neck/shoulder or low back pain.

The necessity of a holistic perspective is widely acknowledged in health care practice such as rehabilitation and secondary and tertiary prevention. In contrast, epidemiological studies often apply a more fragmented approach when studying risk factors for ill health. In research, identification of "risk situations" that could predispose groups of individuals to neck/shoulder and low back pain may be a practicable complement to "risk factor epidemiology", and may help to bridge the gap between research and practice. Moreover, it could also be a useful method for identifying arenas and situations in which preventive efforts may be most cost-effective.

The four groups with increased risk for persistent pain were all characterized by an overstrained situation of some kind, although these situations had quite different features. The results indicate that different prevention strategies are needed for different groups, that is, a selective public health approach in prevention aimed at reducing persistent neck/shoulder and low back pain should be used to match and market the most suitable preventive actions to the most appropriate target group. Moreover, the results imply that strategies taking into account all aspects of the individuals' life should be implemented in the planning, accomplishment, and evaluation of preventive efforts. However, further research is needed to enable practical guidelines for such broad-based strategies.

The finding of gender-specific risk situations emphasizes the need for gender-sensitive methods in research as well as in prevention, including a holistic perspective and an increased awareness of the importance of contextual and structural factors such as factors outside work, work-life balance, and organizational factors.

Groups with working and living conditions not associated with persistent pain were found in all branches of the labor market, and represented a wide variety of jobs and life situations. It is noteworthy that they did not have reversed conditions in relation to the groups with an increased risk for persistent pain. These "healthy" situations are most likely promoted by a sound balance in and outside work and a balanced work-life situation, at least with regard to musculoskeletal pain. However, this research area is still underdeveloped, and further studies are of great importance to gain more knowledge of health-promoting working and living conditions.

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REFERENCES

1. Broadening the view of exposure assessment. *Scand J Work Environ Health* 2001;27:354-7.

2. Ainsworth BE, Jacobs DR, Jr., Leon AS, Richardson MT, Montoye HJ. Assessment of the accuracy of physical activity questionnaire occupational data. *J Occup Med* 1993;35:1017-27.

3. Andersson GB. Epidemiological features of chronic low-back pain. *Lancet* 1999;354:581-5.

4. Andersson R, Kemmlert K, Kilbom Å. Etiological differences between accidental and non-accidental occupational overexertion injuries. *J Occup Accidents* 1990;12:177-86.

5. Ariëns GA, van Mechelen W, Bongers PM, Bouter LM, van der Wal G. Physical risk factors for neck pain. *Scand J Work Environ Health* 2000;26:7-19.

6. Ariëns GA, van Mechelen W, Bongers PM, Bouter LM, van der Wal G. Psychosocial risk factors for neck pain: a systematic review. *Am J Ind Med* 2001;39:180-93.

7. Ariëns GAM. Neck pain. In Crombie IK ed. *The epidemiology of pain*. Seattle, WA.: IASP Press, 1999:235-55.

8. Armstrong BK, White E. Saracci, R. *Principles of exposure assessment in epidemiology*. 1 ed. Oxford UK: Oxford University Press, 1992.

9. Aronsson G. Dimensions of control as related to work organization, stress, and health. *Int J Health Serv* 1989;19:459-68.

10. Bartley M, Sacker A, Firth D, Fitzpatrick R. Social position, social roles and women's health in England: changing relationships 1984-1993. *Soc Sci Med* 1999;48:99-115.

11. Bergman LR, Magnusson D, El-Khouri BM. Introduction. In Bergman LR, Magnusson D, El-Khouri BM eds. *Studying individual development in an interindvidual context: a person-oriented approach*. Mahwah NJ: Lawrence Erlbaum Associates, 2003:4-27.

12. Bernard BP. *Musculoskeletal disorders and workplace factors. A critical review of epidemiologic evidence for work-related musculoskeletal disorders of the neck, upper extremity, and low back*ed. Cincinnati, OH.: US Department of Health and Human Services, 1997.

13. Bernmark E, Wiktorin C. A triaxial accelerometer for measuring arm movements. *Appl Ergon* 2002;33:541-7.

14. Binder A. Neck pain. *Clin Evid* 2005:1501-24.

15. Bingefors K, Isacson D. Epidemiology, co-morbidity, and impact on health-related quality of life of self-reported headache and musculoskeletal pain--a gender perspective. *Eur J Pain* 2004;8:435-50.

16. Blackburn RM, Browne J, Brooks B, Jarman J. Explaining gender segregation. *Br J Sociol* 2002;53:513-36.

17. Boersma K, Linton SJ. Screening to identify patients at risk: profiles of psychological risk factors for early intervention. *Clin J Pain* 2005;21:38-43; discussion 69-72.

18. Bongers PM, de Winter CR, Kompier MA, Hildebrandt VH. Psychosocial factors at work and musculoskeletal disease. *Scand J Work Environ Health* 1993;19:297-312.

19. Bongers PM, Kremer AM, ter Laak J. 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* 2002;41:315-42.

20. Borghouts JA, Koes BW, Bouter LM. The clinical course and prognostic factors of non-specific neck pain: a systematic review. *Pain* 1998;77:1-13.

21. Bot SD, van der Waal JM, Terwee CB, van der Windt DA, Schellevis FG, Bouter LM, Dekker J. Incidence and prevalence of complaints of the neck and upper extremity in general practice. *Ann Rheum Dis* 2005;64:118-23.

22. Bovim G, Schrader H, Sand T. Neck pain in the general population. *Spine* 1994;19:1307-9.

23. Burdorf A. Sources of variance in exposure to postural load on the back in occupational groups. *Scand J Work Environ Health* 1992;18:361-7.

24. Burdorf A, van der Beek A. Exposure assessment strategies for work-related risk factors for musculoskeletal disorders. *Scand J Work Environ Health* 1999;25 Suppl 4:25-30.

25. Byström S, Hall C, Welander T, Kilbom Å. Clinical disorders and pressure-pain threshold of the forearm and hand among automobile assembly line workers. *J Hand Surg [Br]* 1995;20:782-90.

26. Carmines EG, Zeller RA. *Quantitative applications in the social sciences*. Sage University paper series on quantitative applications in the social sciences. Reliability and validity assessment. London: Sage University, 1979.

27. Cassidy JD, Carroll LJ, Cote P. The Saskatchewan health and back pain survey. The prevalence of low back pain and related disability in Saskatchewan adults. *Spine* 1998;23:1860-6; discussion 7.

28. Cassou B, Derriennic F, Monfort C, Norton J, Touranchet A. Chronic neck and shoulder pain, age, and working conditions: longitudinal results from a large random sample in France. *Occup Environ Med* 2002;59:537-44.

29. Chaffin DB. *Occupational biomechanics*. New York, NY.: Wiley, 1991.

30. Charles M. Deciphering sex segregation: vertical and horizontal inequalities in ten national labor markets. *Acta Sociol* 2003;46:267-87.

31. Clyde Z, deC. Williams AC. Depression and mood. In Linton S ed. *New avenues for the prevention of chronic musculoskeletal pain and disability. Pain research and clinical management.* Amsterdam, NL.: Elsevier, 2002:67-82.

32. Cole DC, Hudak PL. Prognosis of nonspecific work-related musculoskeletal disorders of the neck and upper extremity. *Am J Ind Med* 1996;29:657-68.

33. Cole MH, Grimshaw PN. Low back pain and lifting: a review of epidemiology and aetiology. *Work* 2003;21:173-84.

34. Connell RW. *Gender*. Cambridge, UK: Polity Press, 2002.

35. Côté P, Cassidy JD, Carroll LJ, Kristman V. The annual incidence and course of neck pain in the general population: a population-based cohort study. *Pain* 2004;112:267-73.

36. Croft PR, Lewis M, Papageorgiou AC, Thomas E, Jayson MI, Macfarlane GJ, Silman AJ. Risk factors for neck pain: a longitudinal study in the general population. *Pain* 2001;93:317-25.

37. Croft PR, Papageorgiou AC, McNally R. Low back pain. In Stevens A, Raffery J eds. *Health care needs assessment*. Oxford UK: Radcliffe Medical Press, 1997:129-82.

38. Crook J, Moldofsky H. The clinical course of musculoskeletal pain in empirically derived groupings of injured workers. *Pain* 1996;67:427-33.

39. Dahlberg R, Karlqvist L, Bildt C, Nykvist K. Do work technique and musculoskeletal symptoms differ between men and women performing the same type of work tasks? *Appl Ergon* 2004;35:521-9.

40. Davis KG, Heaney CA. The relationship between psychosocial work characteristics and low back pain: underlying methodological issues. *Clin Biomech (Bristol, Avon)* 2000;15:389-406.

41. De Vet HC, Heymans MW, Dunn KM, Pope DP, van der Beek AJ, Macfarlane GJ, Bouter LM, Croft PR. Episodes of low back pain: a proposal for uniform definitions to be used in research. *Spine* 2002;27:2409-16.

42. De Zwart BC, Broersen JP, Frings-Dresen MH, van Dijk FJ. Musculoskeletal complaints in The Netherlands in relation to age, gender and physically demanding work. *Int Arch Occup Environ Health* 1997;70:352-60.

43. De Zwart BC, Frings-Dresen MH, Kilbom Å. Gender differences in upper extremity musculoskeletal complaints in the working population. *Int Arch Occup Environ Health* 2001;74:21-30.

44. De Zwart BCH, Frings-Dresen MHW, Kilbom Å. Gender differences in upper extremity musculoskeletal complaints in the working population. *Int Arch Occup Environ Health* 2001;74:21 -30.

45. Denton M, Prus S, Walters V. Gender differences in health: a Canadian study of the psychosocial, structural and behavioural determinants of health. *Soc Sci Med* 2004;58:2585-600.

46. Denton M, Walters V. Gender differences in structural and behavioral determinants of health: an analysis of the social production of health. *Soc Sci Med* 1999;48:1221-35.

47. Deyo RA, Battie M, Beurskens AJ, Bombardier C, Croft P, Koes B, Malmivaara A, Roland M, Von Korff M, Waddell G. Outcome measures for low back pain research. A proposal for standardized use. *Spine* 1998;23:2003-13.

48. Deyo RA, Weinstein JN. Low back pain. *N Engl J Med* 2001;344:363-70.

49. Dionne CE, Von Korff M, Koepsell TD, Deyo RA, Barlow WE, Checkoway H. Formal education and back pain: a review. *J Epidemiol Community Health* 2001;55:455-68.

50. Dixon AM, Gatchel RJ. Gender and parental status as predictors of chronic low back pain disability: a prospective study. *J Occup Rehabil* 1999;9:195-200.

51. Ekman M, Jonhagen S, Hunsche E, Jonsson L. Burden of illness of chronic low back pain in Sweden: a cross-sectional, retrospective study in primary care setting. *Spine* 2005;30:1777-85.

52. Engkvist IL, Hagberg M, Wigaeus Hjelm E, Menckel E, Ekenvall L. The accident process preceding overexertion back injuries in nursing personnel. PROSA Study Group. *Scand J Work Environ Health* 1998;24:367-75.

53. European Foundation for the Improvement of Living and Working Conditions. *Third European survey on working conditions 2000*: European Foundation for the Improvement of Living and Working Conditions, 2001:31-5.

54. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. *Physiotherapy* 1980;66:271-3.

55. Fejer R, Kyvik KO, Hartvigsen J. The prevalence of neck pain in the world population: a systematic critical review of the literature. *Eur Spine J, in press.*

56. Feldman JB. The prevention of occupational low back pain disability: evidence-based reviews point in a new direction. *J Surg Orthop Adv* 2004;13:1-14.

57. Ferrari R, Russell AS. Regional musculoskeletal conditions: neck pain. *Best Pract Res Clin Rheumatol* 2003;17:57-70.

58. Finkelstein MM. Back pain and parenthood. *Occup Environ Med* 1995;52:51-3.

59. Frank JW, Kerr MS, Brooker AS, DeMaio SE, Maetzel A, Shannon HS, Sullivan TJ, Norman RW, Wells RP. Disability resulting from occupational low back pain. Part I: What do we know about primary prevention? A review of the scientific evidence on prevention before disability begins. *Spine* 1996;21:2908-17.

60. Fransson-Hall C, Byström S, Kilbom Å. Self-reported physical exposure and musculoskeletal symptoms of the forearm-hand among automobile assembly-line workers. *J Occup Environ Med* 1995;37:1136-44.

61. Fredriksson K, Alfredsson L, Köster M, Bildt Thorbjörnsson C, Toomingas A, Torgén M, Kilbom Å. Risk factors for neck and upper limb disorders: results from 24 years of follow up. *Occup Environ Med* 1999;56:59-66.

62. Fredriksson K, Alfredsson L, Bildt Thorbjörnsson C, Punnett L, Toomingas A, Torgén M, Kilbom Å. Risk factors for neck and shoulder disorders: a nested case-control study covering a 24-year period. *Am J Ind Med* 2000;38:516-28.

63. Gardner LI, Landsittel DP, Nelson NA, Pan CS. Misclassification of physical work exposures as a design issue for musculoskeletal intervention studies. *Scand J Work Environ Health* 2000;26:406-13.

64. Gijsbers van Wijk CMT, Kolk AM. Sex differences in physical symptoms: the contribution of symptom perception theory. *Soc Sci Med* 1997;45:231-46.

65. Grooten WJ, Wiktorin C, Norrman L, Josephson M, Wigaeus Tornqvist E, Alfredsson L. Seeking care for neck/shoulder pain: a prospective study of work-related risk factors in a healthy population. *J Occup Environ Med* 2004;46:138-46.

66. Guo HR, Tanaka S, Cameron LL, Seligman PJ, Behrens VJ, Ger J, Wild DK, Putz-Anderson V. Back pain among workers in the United States: national estimates and workers at high risk. *Am J Ind Med* 1995;28:591-602.

67. Gureje O, Von Korff M, Simon GE, Gater R. Persistent pain and well-being: a World Health Organization Study in Primary Care. *JAMA* 1998;280:147-51.

68. Hagen KB, Tambs K, Bjerkedal T. A prospective cohort study of risk factors for disability retirement because of back pain in the general working population. *Spine* 2002;27:1790-6.

69. Hall EM. Double exposure: the combined impact of the home and work environments on psychosomatic strain in Swedish women and men. *Int J Health Serv* 1992;22:239-60.

70. Hammarström A, Härenstam A, Östlin P. Gender and health: concepts and explanatory models. In Östlin P, Danielsson M, Diderichsen F, Härenstam A. Linderg, G. eds. *Gender inequalities in health: a Swedish perspective*. Cambridge MA: Harvard University Press, 2001:1-22.

71. Hansson G-Å, Balogh I, Byström JU, Ohlsson K, Nordander C, Asterland P, Sjölander S, Rylander L, Winkel J, Skerfving S. Questionnaire versus direct technical measurements in assessing postures and movements of the head, upper back, arms and hands. *Scand J Work Environ Health* 2001;27:30-40.

72. Hansson GÅ, Asterland P, Holmer NG, Skerfving S. Validity and reliability of triaxial accelerometers for inclinometry in posture analysis. *Med Biol Eng Comput* 2001;39:405-13.

73. Hansson T, Jensen I. Swedish Council on Technology Assessment in Health Care (SBU). Chapter 6. Sickness absence due to back and neck disorders. *Scand J Public Health Suppl* 2004;63:109-51.

74. Hansson TH, Hansson EK. The effects of common medical interventions on pain, back function, and work resumption in patients with chronic low back pain: A prospective 2-year cohort study in six countries. *Spine* 2000;25:3055-64.

75. Harkness EF, Macfarlane GJ, Silman AJ, McBeth J. Is musculoskeletal pain more common now than 40 years ago? Two population-based cross-sectional studies. *Rheumatology (Oxford)* 2005;44:890-5.

76. Hart DA, Archambault JM, Kydd A, Reno C, Frank CB, Herzog W. Gender and neurogenic variables in tendon biology and repetitive motion disorders. *Clin Orthop Relat Res* 1998:44-56.

77. Hartvigsen J, Lings S, Leboeuf-Yde C, Bakketeig L. Psychosocial factors at work in relation to low back pain and consequences of low back pain; a systematic, critical review of prospective cohort studies. *Occup Environ Med* 2004;61:e2.

78. Hashemi L, Webster BS, Clancy EA, Volinn E. Length of disability and cost of workers' compensation low back pain claims. *J Occup Environ Med* 1997;39:937-45.

79. Heistaro S, Vartiainen E, Heliövaara M, Puska P. Trends of back pain in eastern Finland, 1972-1992, in relation to socioeconomic status and behavioral risk factors. *Am J Epidemiol* 1998;148:671-82.

80. Heliövaara M, Mäkelä M, Knekt P, Impivaara O, Aromaa A. Determinants of sciatica and low-back pain. *Spine* 1991;16:608-14.

81. Hestbaek L, Leboeuf-Yde C, Kyvik KO, Vach W, Russell MB, Skadhauge L, Svendsen A, Manniche C. Comorbidity with low back pain: a cross-sectional population-based survey of 12- to 22-year-olds. *Spine* 2004;29:1483-91; discussion 92.

82. Hestbaek L, Leboeuf-Yde C, Manniche C. Is low back pain part of a general health pattern or is it a separate and distinctive entity? A critical literature review of comorbidity with low back pain. *J Manipulative Physiol Ther* 2003;26:243-52.

83. Hildebrandt VH, Bongers PM, Dul J, van Dijk FJ, Kemper HC. The relationship between leisure time, physical activities and musculoskeletal symptoms and disability in worker populations. *Int Arch Occup Environ Health* 2000;73:507-18.

84. Hill J, Lewis M, Papageorgiou AC, Dziedzic K, Croft P. Predicting persistent neck pain. *Spine* 2004;29:1648 -54.

85. Hooftman WE, van der Beek AJ, Bongers PM, van Mechelen W. Gender differences in self-reported physical and psychosocial exposures in jobs with both female and male workers. *J Occup Environ Med* 2005;47:244-52.

86. Hoogendoorn WE, Bongers PM, de Vet HC, Houtman IL, Ariens GA, van Mechelen W, Bouter LM. Psychosocial work characteristics and psychological strain in relation to low-back pain. *Scand J Work Environ Health* 2001;27:258-67.

87. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Physical load during work and leisure time as risk factors for back pain. *Scand J Work Environ Health* 1999;25:387-403.

88. Hoogendoorn WE, van Poppel MN, Bongers PM, Koes BW, Bouter LM. Systematic review of psychosocial factors at work and private life as risk factors for back pain. *Spine* 2000;25:2114-25.

89. Hoozemans MJ, van der Beek AJ, Frings-Dresen MH, van Dijk FJ, van der Woude LH. Pushing and pulling in relation to musculoskeletal disorders: a review of risk factors. *Ergonomics* 1998;41:757-81.

90. Hunt K, Annandale E. Just the job? Is the relation between health and domestic and paid work gender-specific? *Sociol Health Illness* 1993;15:632-64.

91. Hurrell JJ, Jr., Nelson DL, Simmons BL. Measuring job stressors and strains: where we have been, where we are, and where we need to go. *J Occup Health Psychol* 1998;3:368-89.

92. Härenstam A, Bejerot E, Leijon O, Schéele P, Waldenström K, MOA Research Group. Multilevel analyses of organizational change and working conditions in private and public sector. *Eur J Work Organiz Psychol* 2004;13:305 -43.

93. Härenstam A, Karlqvist L, Bodin L, Nise G, Schéele P, MOA Research Group. Patterns of working and living conditions: a holistic, multivariate approach to occupational health studies. *Work & Stress* 2003;17:73 -92.

94. IJzelenberg W, Burdorf A. Risk factors for musculoskeletal symptoms and ensuing health care use and sick leave. *Spine* 2005;30:1550-6.

95. IJzelenberg W, Molenaar D, Burdorf A. Different risk factors for musculoskeletal complaints and musculoskeletal sickness absence. *Scand J Work Environ Health* 2004;30:56-63.

96. Indahl A. Low back pain: diagnosis, treatment, and prognosis. *Scand J Rheumatol* 2004;33:199-209.

97. Isacson D, Bingefors K. Epidemiology of analgesic use: a gender perspective. *Eur J Anaesthesiol Suppl* 2002;26:5-15.

98. Jacob T, Baras M, Zeev A, Epstein L. A longitudinal, community-based study of low back pain outcomes. *Spine* 2004;29:1810-7.

99. Johansson EE, Hovelius B. Begrepp och teorier [Concepts and theories]. In Johansson EE, Hovelius B eds. *Kropp och genus i medicin [Body and gender in medicine]*. Lund: Studentlitteratur, 2004:35-45.

100. Josephson M, Pernold G, Ahlberg-Hulten G, Härenstam A, Theorell T, Vingård E, Waldenström M, Wigaeus Hjelm E. Differences in the association between psychosocial work conditions and physical work load in female- and male-dominated occupations. MUSIC-Norrtälje Study Group. *Am Ind Hyg Assoc J* 1999;60:673-8.

101. Karasek RA. *Job Content Questionnaire and users guide*. Los Angeles CA: University of Southern California, Department of Industrial and Systems Engineering, 1985.

102. Karlqvist LK, Bernmark E, Ekenvall L, Hagberg M, Isaksson A, Rostö T. Computer mouse position as a determinant of posture, muscular load and perceived exertion. *Scand J Work Environ Health* 1998;24:62-73.

103. Kasl S, Jones B. An epidemiological perspective on research design, measurement,and surveillance strategies. In Quick JC, Tetrick LE eds. *Handbook of occupational health psychology*. Washington, DC, 2002:379-98.

104. Kennedy SM, Koehoorn M. Exposure assessment in epidemiology: does gender matter? *Am J Ind Med* 2003;44:576-83.

105. Kilbom Å. *Ergonomisk studie av muskuloskelettala sjukdomar anmälda som arbetsskador [An ergonomic study of notified cases of occupational musculoskeletal disorders]*. Arbete och Hälsa [Work and Health]. Stockholm: National Institute for Working Life, 1984.

106. Kilbom Å, Messing K. Work-related musculoskeletal disorders. In Kilbom Å, Messing K, Bildt Thorbjörnsson C eds. *Women's health at work*. Stockholm: National Institute for Working Life, 1998:203 -27.

107. Kohn ML, Schooler C. *Work and personality: an inquiry in the impact of social stratification*ed. Norwood, NJ.: Ablex, 1983.

108. Kompier MAJ, Geurts SAE, Gründemann RWM, Vink P, Smulders PGW. Cases in stress prevention: the success of a participative and stepwise approach. *Stress Medicine* 1998;14:129-33.

109. Krantz G, Berntsson L, Lundberg U. Total workload, work stress and perceived symptoms in Swedish male and female white-collar employees. *Eur J Public Health* 2005;15:209-14.

110. Kuijpers T, van der Windt DA, van der Heijden GJ, Bouter LM. Systematic review of prognostic cohort studies on shoulder disorders. *Pain* 2004;109:420-31.

111. Kuorinka I, Jonsson B, Kilbom Å, Vinterberg H, Biering-Sorensen F, Andersson G, Jorgensen K. Standardised Nordic questionnaire for the analysis of musculoskeletal sumptoms. *Appl Ergon* 1987;18:233 -7.

112. Leboeuf-Yde C. Alcohol and low-back pain: a systematic literature review. *J Manipulative Physiol Ther* 2000;23:343-6.

113. Leboeuf-Yde C. Back pain--individual and genetic factors. *J Electromyogr Kinesiol* 2004;14:129-33.

114. Leboeuf-Yde C. Body weight and low back pain. A systematic literature review of 56 journal articles reporting on 65 epidemiologic studies. *Spine* 2000;25:226-37.

115. Leboeuf-Yde C. Smoking and low back pain. A systematic literature review of 41 journal articles reporting 47 epidemiologic studies. *Spine* 1999;24:1463-70.

116. Leboeuf-Yde C, Lauritsen JM. The prevalence of low back pain in the literature. A structured review of 26 Nordic studies from 1954 to 1993. *Spine* 1995;20:2112-8.

117. Leclerc A, Niedhammer I, Landre MF, Ozguler A, Etore P, Pietri-Taleb F. One-year predictive factors for various aspects of neck disorders. *Spine* 1999;24:1455-62.

118. Leijon M, Hensing G, Alexanderson K. Sickness absence due to musculoskeletal diagnoses: association with occupational gender segregation. *Scand J Public Health* 2004;32:94-101.

119. Leino-Arjas P, Hanninen K, Puska P. Socioeconomic variation in back and joint pain in Finland. *Eur J Epidemiol* 1998;14:79-87.

120. Leino PI, Berg MA, Puska P. Is back pain increasing? Results from national surveys in Finland during 1978/9-1992. *Scand J Rheumatol* 1994;23:269-76.

121. LeResche L. Epidemiologic perspectives on sex differences in pain. In Fillingim RB ed. *Sex, gender, and pain*. Seattle, WA.: IASP Press, 2000:233-49.

122. Li G, Buckle P. Current techniques for assessing physical exposure to work-related musculoskeletal risks, with emphasis on posture-based methods. *Ergonomics* 1999;42:674-95.

123. Lindbeck L, Kjellberg K. Gender differences in lifting technique. *Ergonomics* 2001;44:202-14.

124. Lindberg P, Josephson M, Alfredsson L, Vingård E. Promoting excellent work ability and preventing poor work ability: the same determinants? Results from the Swedish HAKuL Study. *Occup Environ Med,* 2006;63:113-20.

125. Lindbladh E, Lyttkens CH, Hanson BS, Östergren PO. Equity is out of fashion? An essay on autonomy and health policy in the individualized society. *Soc Sci Med* 1998;46:1017-25.

126. Lindegård A, Wahlström J, Hagberg M, Hansson GÅ, Jonsson P, Wigaeus Tornqvist E. The impact of working technique on physical loads - an exposure profile among newspaper editors. *Ergonomics* 2003;46:598-615.

127. Lings S, Leboeuf-Yde C. Whole-body vibration and low back pain: a systematic, critical review of the epidemiological literature 1992-1999. *Int Arch Occup Environ Health* 2000;73:290-7.

128. Linton SJ. A review of psychological risk factors in back and neck pain. *Spine* 2000;25:1148-56.

129. Linton SJ. Why does chronic pain develop? A behavioral approach. In Linton SJ ed. *New avenues for the prevention of chronic musculoskeletal pain and disability*. Amsterdam, NL.: Elsevier, 2002:67-82.

130. Linton SJ, Hellsing AL, Hallden K. A population-based study of spinal pain among 35-45-year-old individuals. Prevalence, sick leave, and health care use. *Spine* 1998;23:1457-63.

131. Linton SJ, van Tulder MW. Preventive interventions for back and neck pain problems: what is the evidence? *Spine* 2001;26:778-87.

132. Linton SJ, van Tulder MW. Preventive interventions for back and neck pain. In Nachemson A, Jonsson E eds. *Neck and back pain: the scientific evidence of causes, diagnosis, and treatment*. Philadelphia, PA: Lippincott Williams & Wilkins, 2000:127-47.

133. Lomas J. Social capital and health: implications for public health and epidemiology. *Soc Sci Med* 1998;47:1181-8.

134. Luime JJ, Koes BW, Hendriksen IJ, Burdorf A, Verhagen AP, Miedema HS, Verhaar JA. Prevalence and incidence of shoulder pain in the general population; a systematic review. *Scand J Rheumatol* 2004;33:73-81.

135. Lundberg U. Influence of paid and unpaid work on psychophysiological stress responses of men and women. *J Occup Health Psychol* 1996;1:117-30.

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

137. Lyons J. Factors contributing to low back pain among professional drivers: a review of current literature and possible ergonomic controls. *Work* 2002;19:95-102.

138. Lötters F, Burdorf A, Kuiper J, Miedema H. Model for the work-relatedness of low-back pain. *Scand J Work Environ Health* 2003;29:431-40.

139. Lötters F, Hogg-Johnson S, Burdorf A. Health status, its perceptions, and effect on return to work and recurrent sick leave. *Spine* 2005;30:1086-92.

140. MacDonald LA, Härenstam A, Warren ND, Punnett L. Incorporating work organization into occupational health research. *Manuscript*.

141. MacDonald LA, Karasek RA, Punnett L, Scharf T. Covariation between workplace physical and psychosocial stressors: evidence and implications for occupational health research and prevention. *Ergonomics* 2001;44:696-718.

142. Macintyre S, Ford G, Hunt K. Do women 'over-report' morbidity? Men's and women's responses to structured prompting on a standard question on long standing illness. *Soc Sci Med* 1999;48:89-98.

143. Mackenbach JP, van den Bos J, Joung IM, van de Mheen H, Stronks K. The determinants of excellent health: different from the determinants of ill-health? *Int J Epidemiol* 1994;23:1273-81.

144. Main CJ. Concepts of treatment and prevention in musculoskeletal disorders. In Linton S ed. *New avenues for the prevention of chronic musculoskeletal pain and disability*. Amsterdam, NL: Elsevier, 2002:47-63.

145. Malchaire J, Cock N, Vergracht S. Review of the factors associated with musculoskeletal problems in epidemiological studies. *Int Arch Occup Environ Health* 2001;74:79-90.

146. Manek NJ, MacGregor AJ. Epidemiology of back disorders: prevalence, risk factors, and prognosis. *Curr Opin Rheumatol* 2005;17:134-40.

147. Mathiassen SE, Möller T, Forsman M. Variability in mechanical exposure within and between individuals performing a highly constrained industrial work task. *Ergonomics* 2003;46:800-24.

148. McDiarmid MA, Gucer PW. The "GRAS" status of women's work. *J Occup Environ Med* 2001;43:665-9.

149. McDonough P, Walters V, Strohschein L. Chronic stress and the social patterning of women's health in Canada. *Soc Sci Med* 2002;54:767-82.

150. Melkas H, Anker R. Occupational segregation by sex in Nordic countries: an empirical investigation. In Fetherolf Loutfi M eds. *Women, gender and work. What is equality and how do we get there?* Geneva: International Labor Organization, 2001:189-213.

151. Mergler D, Brabant C, Vezina N, Messing K. The weaker sex? Men in women's working conditions report similar health symptoms. *J Occup Med* 1987;29:417-21.

152. Merskey H, Bogduk N. *Classification of chronic pain: description of chronic pain syndromes and definition of pain terms*. Seattle, WA.: IASP Press, 1994.

153. Messing K, Dumais L, Courville J, Seifert AM, Boucher M. Evaluation of exposure data from men and women with the same job title. *J Occup Med* 1994;36:913-7.

154. Messing K, Kilbom Å. Standing and very slow walking: foot pain-pressure threshold, subjective pain experience and work activity. *Appl Ergon* 2001;32:81-90.

155. Messing K, Punnett L, Bond M, Alexanderson K, Pyle J, Zahm S, Wegman D, Stock SR, de Grosbois S. Be the fairest of them all: challenges and recommendations for the treatment of gender in occupational health research. *Am J Ind Med* 2003;43:618-29.

156. Molano SM, Burdorf A, Elders LA. Factors associated with medical care-seeking due to low-back pain in scaffolders. *Am J Ind Med* 2001;40:275-81.

157. Mortimer M, Wigaeus Hjelm E, Wiktorin C, Pernold G, Kilbom Å, Vingård E. Validity of self-reported duration of work postures obtained by interview. MUSIC-Norrtälje Study Group. *Appl Ergon* 1999;30:477-86.

158. Mäkelä M, Heliövaara M, Sainio P, Knekt P, Impivaara O, Aromaa A. Shoulder joint impairment among Finns aged 30 years or over: prevalence, risk factors and co-morbidity. *Rheumatology (Oxford)* 1999;38:656-62.

159. Nachemson A. Introduction. In Nachemson A, Jonsson E eds. *Neck and back pain: the scientific evidence of causes, diagnosis, and treatment*. Philadelphia, PA.: Lippincott Williams & Wilkins, 2000:1-12.

160. Nachemson A, Waddell G, Norlund AL. Epidemiology of neck and low back pain. In Nechemson A, Jonsson E eds. *Neck and back pain: the scientific evidence of causes, diagnosis, and treatment*. Philadelphia, PA.: Lippincott Williams & Wilkins, 2000:167-87.

161. National Research Council, Institute of Medicine. *Musculoskeletal disorders and the workplace: low back and upper extremities*: Washington, DC: National Academy Press, 2001.

162. Nordander C, Ohlsson K, Balogh I, Rylander L, Pålsson B, Skerfving S. Fish processing work: the impact of two sex dependent exposure profiles on musculoskeletal health. *Occup Environ Med* 1999;56:256-64.

163. Nordin M, Hiebert R, Pietrek M, Alexander M, Crane M, Lewis S. Association of comorbidity and outcome in episodes of nonspecific low back pain in occupational populations. *J Occup Environ Med* 2002;44:677-84.

164. Nordstrom DL, Vierkant RA, Layde PM, Smith MJ. Comparison of self-reported and expert-observed physical activities at work in a general population. *Am J Ind Med* 1998;34:29-35.

165. Norlund AI, Waddell G. Costs of back pain in some OWCD countires. In Nachemson A, Jonsson E eds. *Neck and back pain: the scientific evidence of causes, diagnosis, and treatment*. Philadelphia, PA: Lippincott Williams & Wilkins, 2000:421-5.

166. Office for National Statistics. *Social trends 30*.: Office for National Statistics, The Stationary Office, 2000.

167. Palmer KT, Walker-Bone K, Griffin MJ, Syddall H, Pannett B, Coggon D, Cooper C. Prevalence and occupational associations of neck pain in the British population. *Scand J Work Environ Health* 2001;27:49-56.

168. Palmer KT, Walsh K, Bendall H, Cooper C, Coggon D. Back pain in Britain: comparison of two prevalence surveys at an interval of 10 years. *BMJ* 2000;320:1577-8.

169. Papageorgiou AC, Croft PR, Thomas E, Ferry S, Jayson MI, Silman AJ. Influence of previous pain experience on the episode incidence of low back pain: results from the South Manchester Back Pain Study. *Pain* 1996;66:181-5.

170. Patrick DL, Deyo RA, Atlas SJ, Singer DE, Chapin A, Keller RB. Assessing health-related quality of life in patients with sciatica. *Spine* 1995;20:1899-908; discussion 909.

171. Pearce N, Checkoway H, Shy C. Time-related factors as potential confounders and effect modifiers in studies based on an occupational cohort. *Scand J Work Environ Health* 1986;12:97-107.

172. Pengel LH, Herbert RD, Maher CG, Refshauge KM. Acute low back pain: systematic review of its prognosis. *BMJ* 2003;327:323.

173. Pernold G, Mortimer M, Wiktorin C, Wigaeus Tornqvist E, Vingård E. Neck/shoulder disorders in a general population. Natural course and influence of physical exercise: a 5-year follow-up. *Spine* 2005;30:E363-8.

174. Pernold G, Wigaeus Tornqvist E, Wiktorin C, Mortimer M, Karlsson E, Kilbom Å, Vingård E. Validity of occupational energy expenditure assessed by interview. *AIHA J (Fairfax, Va)* 2002;63:29-33.

175. Picavet HSJ, Schouten JSAG. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC(3)-study. *Pain* 2003;102:167-78.

176. Pincus T, Burton AK, Vogel S, Field AP. A systematic review of psychological factors as predictors of chronicity/disability in prospective cohorts of low back pain. *Spine* 2002;27:E109-20.

177. Polatin PB, Kinney RK, Gatchel RJ, Lillo E, Mayer TG. Psychiatric illness and chronic low-back pain. The mind and the spine--which goes first? *Spine* 1993;18:66-71.

178. Pope DP, Silman AJ, Cherry NM, Pritchard C, Macfarlane GJ. Validity of a self-completed questionnaire measuring the physical demands of work. *Scand J Work Environ Health* 1998;24:376-85.

179. Preston JA. Occupational gender segregation – trends and explanations. *The Quarterly Review of Economics and Finance* 1999;39:611-24.

180. Punnett L, Herbert R. Work-related musculoskeletal disorders: is there a gender differential, and if so, what does it mean? In Goldman MB, Hatch MC eds. *Women and health*. San Diego, Ca.: Academic press, 2000:474 -92.

181. Punnett L, Pruss-Utun A, Nelson DI, Fingerhut MA, Leigh J, Tak S, Phillips S. Estimating the global burden of low back pain attributable to combined occupational exposures. *Am J Ind Med* 2005;48:459-69.

182. Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. *J Electromyogr Kinesiol* 2004;14:13-23.

183. Raspe H, Kohlmann T. Disorders characterised by pain: a methodological review of population surveys. *J Epidemiol Community Health* 1994;48:531-7.

184. Rekola KE, Keinanen-Kiukaanniemi S, Takala J. Use of primary health services in sparsely populated country districts by patients with musculoskeletal symptoms: consultations with a physician. *J Epidemiol Community Health* 1993;47:153-7.

185. Roland M, Morris R. A study of the natural history of back pain. Part I: development of a reliable and sensitive measure of disability in low-back pain. *Spine* 1983;8:141-4.

186. Rosenberg BJ, Barbeau EM, Moure-Eraso R, Levenstein C. The work environment impact assessment: a methodologic framework for evaluating health-based interventions. *Am J Ind Med* 2001;39:218-26.

187. Rossignol M, Lortie M, Ledoux E. Comparison of spinal health indicators in predicting spinal status in a 1-year longitudinal study. *Spine* 1993;18:54-60.

188. Rothman K. *Modern epidemiology*. Boston MA: Little, Brown and Company, 1986.

189. Schoenborn CA. Marital status and health: United States, 1999-2002. *Adv Data* 2004:1-32.

190. Schrijvers CT, van de Mheen HD, Stronks K, Mackenbach JP. Socioeconomic inequalities in health in the working population: the contribution of working conditions. *Int J Epidemiol* 1998;27:1011-8.

191. Selin K, Winkel J. Evaluation of two instruments for recording sitting and standing postures and number of foot steps. *Appl Ergon* 1994;25:41-6.

192. Shaw WS, Pransky G, Fitzgerald TE. Early prognosis for low back disability: intervention strategies for health care providers. *Disabil Rehabil* 2001;23:815-28.

193. Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. *Scand J Work Environ Health* 2001;27 Suppl 1:1-102.

194. Speed C, Hazleman B. Shoulder pain. *Clin Evid* 2004:1613-32.

195. Statistics Sweden. *Folk- och bostadsräkningen 1990 [Swedish Official Population and Residence Investigation 1990]*. Statistics Sweden, 1990.

196. Statistics Sweden. *Ohälsa och sjukvård 1980–2000 [Health and medical care 1980-2000]*. Statistics Sweden, 2002.

197. Statistics Sweden. *Women and men in Sweden: facts and figures 2004*: Statistics Sweden, 2004.

198. Swedish Social Insurance Administration. *Sjukdomar som orsakat pensionering. Förtidspensionärerna i december 2002 jämfört med december 1991 [Diseases/Disorders that have caused disability pension. Disability pensioners in December 2002 compared to December 1991]*. Swedish Social Insurance Administration, 2004.

199. Swedish Work Environment Authority and Statistics Sweden. *Work-related disorders 2005*. Stockholm: Swedish Work Environment Authority, 2005.

200. Tissot F, Messing K, Lippel K, Pronovost S. Study 3: Women in non-traditional jobs using ill-adapted tools. In Messing K ed. *Integrating gender in ergonomic analysis: strategies for transforming women's work*. Brussels: European Trade Union Technical Bureau for Health and Safety, 1999:88-96.

201. Torgén M, Alfredsson L, Köster M, Wiktorin C, Smith KF, Kilbom Å. Reproducibility of a questionnaire for assessment of present and past physical activities. *Int Arch Occup Environ Health* 1997;70:107-18.

202. Treaster DE, Burr D. Gender differences in prevalence of upper extremity musculoskeletal disorders. *Ergonomics* 2004;47:495-526.

203. Turner JA, Franklin G, Turk DC. Predictors of chronic disability in injured workers: a systematic literature synthesis. *Am J Ind Med* 2000;38:707-22.

204. Unruh AM. Gender variations in clinical pain experience. *Pain* 1996;65:123-67.

205. Urwin M, Symmons D, Allison T, Brammah T, Busby H, Roxby M, Simmons A, Williams G. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Ann Rheum Dis* 1998;57:649-55.

206. Vahtera J, Kivimäki M, Pentti J, Theorell T. Effect of change in the psychosocial work environment on sickness absence: a seven year follow up of initially healthy employees. *J Epidemiol Community Health* 2000;54:484-93.

207. Waldenström K, Lundberg I, Waldenström M, Härenstam A. Does psychological distress influence reporting of demands and control at work? *Occup Environ Med* 2003;60:887-91.

208. Waldenström M, Josephson M, Persson C, Theorell T. Interview reliability for assessing mental work demands. *J Occup Health Psychol* 1998;3:209-16.

209. Waldenström M, Theorell T, Ahlberg G, Josephson M, Nise P, Waldenström K, Vingård E. Assessment of psychological and social current working conditions in epidemiological studies: experiences from the MUSIC-Norrtälje Study. *Scand J Public Health* 2002;30:94-102.

210. Walker-Bone K, Palmer KT. Musculoskeletal disorders in farmers and farm workers. *Occup Med (Lond)* 2002;52:441-50.

211. Van den Heuvel SG, Ariëns GA, Boshuizen HC, Hoogendoorn WE, Bongers PM. Prognostic factors related to recurrent low-back pain and sickness absence. *Scand J Work Environ Health* 2004;30:459-67.

212. Van den Heuvel SG, Boshuizen HC, Hildebrandt VH, Blatter BM, Ariëns GA, Bongers PM. Effect of sporting activity on absenteeism in a working population. *Br J Sports Med* 2005;39:e15.

213. Van der Beek AJ, Frings-Dresen MH. Assessment of mechanical exposure in ergonomic epidemiology. *Occup Environ Med* 1998;55:291-9.

214. Van der Windt DA, Thomas E, Pope DP, de Winter AF, Macfarlane GJ, Bouter LM, Silman AJ. Occupational risk factors for shoulder pain: a systematic review. *Occup Environ Med* 2000;57:433-42.

215. Van Nieuwenhuyse A, Somville PR, Crombez G, Burdorf A, Verbeke G, Johannik K, Van den Bergh O, Masschelein R, Mairiaux P, Moens GF. The role of physical workload and pain related fear in the development of low back pain in young workers: evidence from the BelCoBack Study; results after one year of follow up. *Occup Environ Med* 2006;63:45-52.

216. Van Tulder M, Koes B, Bombardier C. Low back pain. *Best Pract Res Clin Rheumatol* 2002;16:761-75.

217. Warren N. Work stress and musculoskeletal disorder etiology: The relative roles of psychosocial and physical risk factors. *Work* 2001;17:221-34.

218. Watson D, Clark LA. Negative affectivity: the disposition to experience aversive emotional states. *Psychol Bull* 1984;96:465-90.

219. Webb R, Brammah T, Lunt M, Urwin M, Allison T, Symmons D. Prevalence and predictors of intense, chronic, and disabling neck and back pain in the UK general population. *Spine* 2003;28:1195-202.

220. Westberg-Wohlgemuth H. *Gendering of work and knowledge. Sex marking - a hidden learning process*. Doctoral thesis. Department of Education. Stockholm: Stockholm Universiy, 1996:209.

221. Westberg H. Different worlds - Where are the women in today's workplace? In Kilbom Å, Messing K, Bildt Thorjörnsson C eds. *Women's health at work*. Stockholm: National Institute for Working Life, 1998:17-57.

222. Wigaeus Tornqvist E, Kilbom Å, Vingård E, Alfredsson L, Hagberg M, Theorell T, Waldenström M, Wiktorin C, Hogstedt C. The influence on seeking care because of neck and shoulder disorders from work-related exposures. *Epidemiology* 2001;12:537-45.

223. Viikari-Juntura E, Rauas S, Martikainen R, Kuosma E, Riihimäki H, Takala EP, Saarenmaa K. Validity of self-reported physical work load in epidemiologic studies on musculoskeletal disorders. *Scand J Work Environ Health* 1996;22:251-9.

224. Wikman A. *Att utveckla social indikatorer: en surveyansats belyst med exemplet arbetsmiljö [Development of social indicators: an effort with a survey method illustrated with the example of working environment]*. Stockholm: Stockholm University and Statistics Sweden, 1991.

225. Wiktorin C, Wigaeus Hjelm E, Winkel J, Köster M. Reproducibility of a questionnaire for assessment of physical load during work and leisure time. Stockholm MUSIC I Study Group. Musculoskeletal Intervention Center. *J Occup Environ Med* 1996;38:190-201.

226. Wiktorin C, Karlqvist L, Winkel J. Validity of self-reported exposures to work postures and manual materials handling. Stockholm MUSIC I Study Group. *Scand J Work Environ Health* 1993;19:208-14.

227. Wiktorin C, Selin K, Ekenvall L, Alfredsson L. An interview technique for recording work postures in epidemiological studies. Music-Norrtälje Study Group. *Int J Epidemiol* 1996;25:171-80.

228. Wiktorin C, Vingård E, Mortimer M, Pernold G, Wigaeus Hjelm E, Kilbom Å, Alfredsson L. Interview versus questionnaire for assessing physical loads in the population-based MUSIC-Norrtälje Study. *Am J Ind Med* 1999;35:441-55.

229. Vingård E, Mortimer M, Wiktorin C, Pernold G, Fredriksson K, Nemeth G, Alfredsson L. Seeking care for low back pain in the general population: a two-year follow-up study: results from the MUSIC-Norrtälje Study. *Spine* 2002;27:2159-65.

230. Winkel J, Mathiassen SE. Assessment of physical work load in epidemiologic studies: concepts, issues and operational considerations. *Ergonomics* 1994;37:979-88.

231. Von Korff M, Jensen MP, Karoly P. Assessing global pain severity by self-report in clinical and health services research. *Spine* 2000;25:3140-51.

232. Von Korff M, Ormel J, Keefe FJ, Dworkin SF. Grading the severity of chronic pain. *Pain* 1992;50:133-49.

233. Von Korff M, Saunders K. The course of back pain in primary care. *Spine* 1996;21:2833-7; discussion 8-9.

234. Von Korff M, Simon G. The relationship between pain and depression. *Br J Psychiatry Suppl* 1996:101-8.

235. Ydreborg B. *Utveckling av en metod for kartläggning av aktuell och tidigare belastnings-exponering [Development of a method for assessing present and past exposure to physical load]*. Örebro: Arbets- och miljömedicin [Department of Occupational and Environmental Medicine], 1986.

236. Yeung SS, Genaidy A, Deddens J, Alhemood A, Leung PC. Prevalence of musculoskeletal symptoms in single and multiple body regions and effects of perceived risk of injury among manual handling workers. *Spine* 2002;27:2166-72.