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WORK AND NECK/SHOULDER PAIN

RISK AND PROGNOSTIC FACTORS

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ABSTRACT

This thesis presents the results from a population-based cohort study on risk and prognostic factors for neck/shoulder pain. The four papers in the thesis were based on a four to six year follow-up of both the cases and the referents from the MUSIC-Norrtälje baseline study, n = 2329. The main goals of this thesis were 1) to identify work-related exposures involved in the onset, and 2) to identify work-related exposures of importance for the prognosis of neck/shoulder pain.

In Paper I, the study group consisted of employed subjects who at baseline and follow-up reported consistently pain in either the neck/shoulder or low back region. Four groups were identified: solely neck/shoulder pain, solely low back pain, concurrent neck/shoulder and low back pain, and migrating neck/shoulder and low back pain, n = 817. The results showed that the odds ratio for sickness absence was 1.69 (95% CI = 1.32-4.66) for those with concurrent neck/shoulder and low back pain, compared to the group with solely neck/shoulder or solely low back pain.

In Paper II, the study group consisted of employed subjects who had not sought medical care due to neck/shoulder pain at baseline, n = 1213. The results showed that 18% of the men and 29% of the women sought medical care due to neck/shoulder pain during the study period. For men, two single risk factors were identified. The relative risk (RR) for the onset of neck/shoulder pain was increased for manual handling $\geq$ 50 N $\geq$ 60 $^{min}/_{day}$ (RR = 1.7, 95% CI = 1.0-2.9), and for night work/shift work (RR = 1.7, 95% CI = 1.0-2.8). Moreover, the RR increased with an increasing number of exposures (RRs between 1.7 and 4.8). For women, no risk factors were identified.

In Paper III, the study group consisted of employed subjects with self-rated neck/shoulder pain at baseline, n = 803. The results showed that at the follow-up 44% of the men and 33% of the women had recovered. For subjects exposed to sitting $\geq$ 75% of the working time, the relative chance for recovery (RC) was enhanced (RC = 1.32, 95% CI = 1.0-1.7), and hampered for those simultaneously exposed to at least two of the following three biomechanical exposures: manual handling $\geq$ 50 N $\geq$ 60 $^{min}/_{day}$, work with hands above shoulder level $\geq$ 60 $^{min}/_{day}$, or work with vibrating tools $\geq$ 30 $^{min}/_{day}$ (RC = 0.61, 95% CI = 0.4-0.9).

In Paper IV, the study group consisted of employed subjects who had sought medical care due to neck/shoulder or low back pain at baseline, n = 492. The aim was to study the effect of ergonomic interventions. The results showed that, in terms of pain intensity and pain-related disability, the prognosis for individuals who received educational worksite interventions was poorer than for those not receiving any interventions. The prognosis for individuals who received workplace interventions was similar to those not receiving any interventions.

In conclusion, for men, work-related exposures influenced the onset of neck/shoulder pain, but no risk factors were identified for women. Work-related exposures influenced the prognosis, but ergonomic interventions were ineffective concerning the reduction in pain intensity and pain-related disability.

KEYWORDS: *biomechanics, epidemiology, ergonomics, incidence, low back pain, neck/shoulder pain, occupational health, physical load, prognosis, psychosocial factors, sickness absence, work, work organization.*

SAMMANFATTNING

Denna avhandling presenterar resultat från en populationsbaserad kohortstudie om riskfaktorer och prognostiska faktorer för nacke/skulderbesvär. De fyra delarbeten baseras på en 4-6 års uppföljning av både fallen och referenter från MUSIC-Norrtälje studien, n = 2329. Huvudsyfte var att identifiera arbetsrelaterade faktorer som påverkar risken att drabbas och prognosen av nacke/skulderbesvär.

I det första delarbetet bestod studiepopulationen av personer i arbete som både vid baslinjen och uppföljningen hade besvär i nacke/skuldra eller ländrygg. Fyra grupper identifierades: enbart nacke/skulderbesvär, enbart ländryggsbesvär, samtidiga besvär i nacke/skuldra och ländrygg och migrerande besvär, n = 817. Resultaten visade att oddskvoten för förekomst av sjukskrivning under uppföljningstiden var 1.69 (95% CI = 1.32-4.66) för de med samtidiga besvär i nacke/skuldra och ländrygg jämfört med de med enbart nacke/skulder- och enbart ländryggsbesvär.

I det andra delarbetet bestod studiepopulationen av personer i arbete som vid baslinjen inte hade sökt vård på grund av nacke/skulderbesvär, n = 1213. Resultaten visade att under uppföljningstiden sökte 18 % av männen och 29 % av kvinnorna vård på grund av nacke/skulderbesvär. De exponeringar som innebar en ökad relativ risk (RR) att drabbas av nacke/skulderbesvär var manuell hantering $\geq$ 50 N $\geq$ 60 $^{\text{min}}/_{\text{dag}}$ RR = 1.7 (95% CI 1.0-2.9) och natt/skiftarbete RR = 1.7 (95% CI 1.0-2.8). Den relativa risken ökade med antalet exponeringar (RRs 1.7-4.8). För kvinnor identifierades inga riskfaktorer.

I det tredje delarbetet bestod studiepopulationen av personer i arbete med självskattade nacke/skulderbesvär vid baslinjen, n = 803. Resultaten visade att vid uppföljningen hade 44 % av männen och 33 % av kvinnor blivit av med besvären. De med sittande arbete $\geq$ 75 % av arbetstiden hade en ökad relativ chans (RC) att återhämta sig (RC = 1.32, 95% CI = 1.0-1.7). Chansen att återhämta sig var lägst för de med minst två av följande tre biomekaniska exponeringar: manuell hantering $\geq$ 50 N $\geq$ 60 $^{\text{min}}/_{\text{dag}}$, arbete med händer över axelhöjd $\geq$ 60 $^{\text{min}}/_{\text{dag}}$, och arbete med vibrerande verktyg $\geq$ 30 $^{\text{min}}/_{\text{dag}}$ (RC = 0.61, 95% CI = 0.4-0.9).

I det fjärde delarbetet bestod studiepopulationen av personer i arbete som vid baslinjen hade sökt vård på grund av besvär i nacke/skuldra eller ländrygg, n = 492. Syftet med studien var att studera effekten av olika ergonomiska åtgärder med avseende på smärta och funktionsnedsättning. Resultaten visade att prognosen var sämre för dem som fick individåtgärder jämfört med dem som inte fick några ergonomiska åtgärder alls under uppföljningstiden. Prognosen var densamma för dem som fick arbetsplatsåtgärder jämfört med dem som inte fick några ergonomiska åtgärder alls.

Sammanfattningsvis identifierades i denna avhandling exponeringar i arbetet som ökade risken att drabbas av nacke/skulderbesvär. Den ökade risken sågs bara hos män. Däremot visade avhandlingen att exponeringar i arbetet påverkar prognosen för såväl män som kvinnor. Ergonomiska interventioner verkar vara ineffektiva med avseende på smärta och funktionsnedsättning.

NYCKELORD: *arbete, arbetsorganisation, biomekanik, epidemiologi, ergonomi, fysisk belastning, incidence, ländrygg, nacke/skuldra, prognos, psykosociala faktorer, smärta, sjukskrivning, yrkesmedicin.*

LIST OF PUBLICATIONS

I. Sickness absence and concurrent low back and neck-shoulder pain. Results from the MUSIC-Norrtälje study. Nyman T, Grooten WJA, Wiktorin C, Norrman L, and Liwing J. *Eur Spine J* 2006 June 2; [Epub ahead of print]

II. Seeking Care for Neck/Shoulder Pain: A Prospective Study of Work-Related Risk Factors in a Healthy Population. Grooten WJA, Wiktorin C, Norrman L, Josephson M, Wigaeus Tornqvist E, and Alfredsson L, for the MUSIC-Norrtälje Study Group. *J Occup Environ Med*. 2004;46:138–146

III. Work-Related Exposures and Recovery from Neck/Shoulder Disorders. Grooten WJA, Mulder M, Josephson M, Alfredsson L, and Wiktorin C. *Submitted*

IV. The Effect of Ergonomic Intervention on Neck/Shoulder and Low Back Pain. Grooten WJA, Mulder M, and Wiktorin C. *Work (Accepted for publication)*

Werken is ongezond
Werken, ik wou dat het niet bestond
Wie het werken heeft uitgevonden
was een enorme ….eikel!

Pater Moeskroen, 1992

CONTENTS

LIST OF ABBREVIATIONS

AP%	Attributable Proportion
BMI	Body Mass Index
95% CI	95% Confidence Interval
CPs	Chiropractors
GP	General practitioners
LB	Low back pain
%MVC	% of maximal voluntary contraction
NS	Neck/shoulder pain
OR	Odds Ratio
PT	Physiotherapists
RC (see below)	Relative chance of recovery= recovery proportion in exposed subjects / recovery proportion in unexposed subjects
RCT	Randomized controlled trial
RFV	Riksförsäkringsverket (National Social Insurance Board)
ROM	Range Of Motion
RPE	Rating of Perceived Exertion
RR (see below)	Relative Risk for onset = incidence in exposed subjects / incidence in unexposed subjects
RTW	Return to work
SCB	Statistics Sweden
TWA-MET	Time weighted averages of multiples of the resting metabolic rate
VAS	Visual Analogue Scale

Calculation of incidence/recovery proportion and relative risk/chance

		Disease / Recovery		
		Yes	No	Total
Exposure	Present	a	b	a + b
	Absent	c	d	c + d
	Total	a + c	b + d	a + b+ c + d

Incidence/recovery proportion = (a + c) / (a + b + c + d)
Relative risk/chance = a/(a + b) / c/(c + d)

1 INTRODUCTION

Neck/shoulder pain is a worldwide health problem; on average roughly 50% of the working population has at least one episode of neck/shoulder pain during their lifetime (range 14%-71%) (44). Neck/shoulder pain leads to high costs for the individual and society, as many individuals with neck/shoulder pain seek medical care and cannot continue their work (20, 57). Together with low back pain, neck/shoulder pain accounts for a large proportion of the total sickness absence in Sweden during the last decade (113). The proportion with a new episode of neck or shoulder pain during a 12-month period is around 5% (7, 103) but the incidence varies largely between the studies. Neck/shoulder pain is highly recurrent (95). Only every other individual with neck/shoulder pain become pain-free after a longer period of time (18, 26, 70, 75, 95, 97, 103, 153, 161). Also in this respect there is a large variation between different studies. Thus, additional epidemiology data on incidence and recovery proportions is highly warranted. The main focus of the present thesis is to identify work-related risk and prognostic factors for neck/shoulder pain, including the effect of ergonomic interventions on neck/shoulder and low back pain.

Neck/shoulder pain is multi-factorial. Individual factors are reported to be of importance for the onset and also for the prognosis, e.g. age (34), and sex (68). There is less evidence concerning work-related factors. Biomechanical factors such as repetitive movements, manual handling, and awkward postures have been pointed out as important risk factors for getting neck/shoulder pain (15). However, the results are still contradictory for these and other biomechanical factors (10). Some studies have identified some psychosocial factors as risk factors for neck/shoulder pain, e.g. job demands, job control and social support at the workplace (3, 8), but consistent evidence is lacking (96, 160). Many workers are simultaneously exposed to several risk factors for neck/shoulder pain, but studies on combinations of risk factors are very few. The most common risk factors are also thought to influence the prognosis for those already in pain, but the evidence is still limited (28).

Knowledge on the risk and prognostic factors for neck/shoulder pain is important for patients and for health-care professionals in occupational and clinical settings. In a public health context, awareness of the work-related factors is important for primary and secondary prevention since work-related factors can be adjusted more easily than can individual factors. Ergonomic interventions are thought to attack the problem at its source and could, at least theoretically, be an effective way to reduce neck/shoulder pain. There exists some evidence for the effect of ergonomic interventions on the return to work after a period of sickness absence due to low back pain (92). However, very few studies have been performed that have studied the effect of such interventions on pain intensity and pain-related disability in the neck/shoulder and low back regions.

For these reasons, it is of interest to estimate the incidence and recovery proportions for neck/shoulder pain in a working population. Moreover, it is necessary to identify the work-related factors influencing the onset of and recovery from neck/shoulder pain.

2 BACKGROUND

Epidemiology is the study of the distribution and determinants of disease in human populations (14). In the last decades the attention of epidemiology has expanded from infectious and dietary diseases to degenerative disorders. The two central tasks in epidemiologic research are to quantify the occurrence (and disappearance) of disease in populations and to detect/estimate the effects of exposures (125). The title of the thesis “Work and Neck/Shoulder Pain” refers to respectively the exposures and the disease of interest and thus illustrating the epidemiological approach in the thesis.

Neck/shoulder pain

In the thesis, neck/shoulder pain is a term used to describe complaints or disorders related to pain, or pain-related disability in the neck- and/or one of the shoulder regions, e.g. pain, ache, ailments or trouble from muscles, tendons, or skeleton of the cervical spine and shoulders. The neck and shoulder make together a “functional unit”: the movements of the upper extremity highly involve movements of the neck as a result of the hand/eye coordination. Several muscles have their origin in the neck and attach at the shoulder. Neck pain 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 column (17). Shoulder pain may arise in or around the shoulder from the glenohumeral, acromioclavicular, sternoclavicular, subacromial, and scapulothoracic articulations, and the surrounding soft tissues (134). For many individuals, it is not easy to discriminate between neck or shoulder pain (26, 121). In the majority of the patients with neck/shoulder pain there is no patho-anatomic explanation available, and thus very difficult to set a specific diagnosis (131).

Côté et al. stated that neck/shoulder pain is “a disabling condition with a course marked by periods of remission and exacerbation” (32). This makes it difficult to distinguish incident cases from recurrent cases over a longer period of time (91). For that reason, mostly the *prevalence* of neck/shoulder pain is reported, i.e. the proportion of subjects who have the disease during a specific period of time (125). A review of a large number of studies from different countries showed that the prevalence of neck/shoulder pain ranged between 6%-76% (44). The enormous variation indicates a lack of methodological concordance between the studies. For example, some studies concerned the lifetime prevalence, whereas other showed the point-prevalence. The *point-prevalence* can be viewed as a “snapshot” capturing those with ongoing pain. These could be individuals with a new pain episode (for the first time), those with recurrent episodes (those that have had pain before) and those with continuous pain.

Neck/shoulder pain is associated with many negative consequences for the individual. Around 25% of those in pain seek medical care for their problems (30, 171). A lesser proportion even has to stop working due to their complaints, but it is this minority that stands for the majority of the socio-economic costs related to neck/shoulder pain (89).

Low back pain

The difficulty to set an appropriate patho-anatomical diagnosis accounts as well for low back pain. Similar to neck/shoulder pain, the prevalence of low back pain varies between different studies. Andersson showed that in different countries the point prevalence varied between 13% and 30%, whereas the life-time prevalence varied between 49% and 70% (5). The vast majority of workers off work due to low back pain return to work within three months. Concerning pain intensity and pain-related disability, most individuals recover quickly (29, 40, 106), but lower levels of pain may still exist. The recurrence of low back pain is high (145). Concerning the work-related factors, there are more studies available on low back pain compared to neck/shoulder pain. There is a moderate to strong evidence that there exist a relationship between work-related biomechanical factors and low back pain, but concerning the psychosocial and individual factors, the evidence is somewhat contradictory (86).

Pain-intensity

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" (102). There exist several ways to measure an individual's pain intensity level and location of the pain. For example, different visual analogue scales (VAS) are used to quantify the level of pain-intensity, whereas pain-drawings often are used to specify the location of the pain. Also pain-questionnaires and indexes are used for these purposes. All measurement methods have their pros and cons, and the development of valid and reliable scales should continue (129).

Pain-related disability

"Disability" is a widely used term including several components ranging from personal care, lifting, concentration, working, sleeping, and leisure time activities. The WHO International Classification of Functioning, Disability and Health make a distinction between *activity limitation* and *participation restrictions (173)*. Activity limitations are difficulties an individual may have in executing activities, while participation restrictions are difficulties an individual may experience in involvement in life situations. Most disability measurement instruments cover both activity limitation and participation restrictions of the whole body due to pain in one specific body region, e.g. the Neck Disability Index (NDI), the Oswestry score, or the scales by von Korff (43, 159, 172). Several of these instruments were found reliable and valid, i.e. they were successful in quantifying the level of disability as a result of pain sensations. One should remember that these scales aim to measure "pain-related disability", although there could also be concurrent reasons for that disability, e.g. a reduced range of motion (ROM), low muscular strength or co-morbidity. Moreover, Schierhout & Myers (1996) state that, referring to Bigos and Battie (1987), disability evaluations in back pain are possibly more influenced by social context than by the disease attributes (129).

Seeking medical care

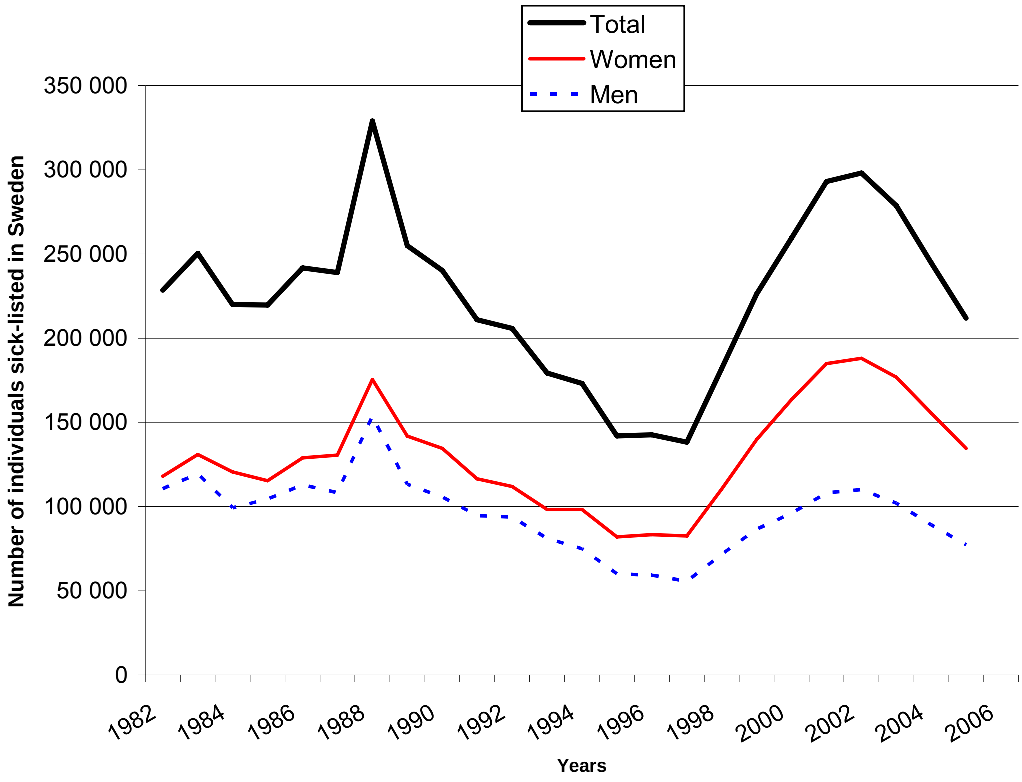
Neck/shoulder or low back pain and pain-related disability of such a degree that individuals cannot cope with them by their selves could lead to a decision to seek medical care. Relatively many of these patients seek relieve for their pain, especially those with high pain intensity and pain-related disability (30, 104). Individuals might seek medical care also due to other reasons; for example due to a decreased functioning such as a decreased ROM. There could be some individuals that seek medical care although the medical caregivers believe that there was no medical reason for it. A large amount of individual and non-individual factors are involved in care-seeking behavior. For instance, the economic possibility to seek medical care, the geographic distance to the medical caregiver, the types of medical caregivers available, the amount of time available, and previous experiences with the medical caregiver, among other factors (104).

2.1 SICKNESS ABSENCE

Societal costs for sick leave have since 1997 increased dramatically in Sweden, Norway and the Netherlands during the last decade, while in other countries the number of sick-listed people were low (114). The total costs for disbursed sickness benefit and disability pension reached in Sweden an all point high of 9.5 billion EUR in 2002 (108). Musculoskeletal disorders and psychological distress stands for 60%-80% of all sickness absence (98, 107).

Sickness absence depends on many factors that interact with each other and also act at different levels: national, workplace/community, or individual level (2). At a national level, factors such as the sickness insurance system (25), level of unemployment (13), or the state of the market are of importance. Many work-related factors push or pull the individual towards or away from sickness absence (73). Individual factors related to the family situation are of importance for the decision to be on sick-leave: gender (127), individual’s health (23), psychological traits , lifestyle, age, attitude, e.g. fear-avoidance believes, etc. (137). The number of sick-listed individuals rose enormously between 1997 and 2002 (Figure 1). Plausible explanations for this increase could be a decrease in unemployment during this period or an increase of demands at the workplace and at the same time a decreased tolerance for individuals with low work ability (98). After 2002, the increase in the number of sick-listed individuals has stopped. Still, increased knowledge on the determinants for sickness absence is warranted (2).

Figure 1. Total number of individuals (women and men) sick-listed in Sweden during the years 1982 –2006. Individuals with sickness benefit, rehabilitation benefit, or disability pension. (Source: Försäkringskassan).



Although an increasing number of empirical studies in this area, the influence of the underlying pathology on the decision to stay away from work remains unknown (59). Moreover, it seems to be very significant to understand whether the neck/shoulder pain perceived by a patient is a separate and distinctive entity or just a refection of a more general musculoskeletal pain syndrome (72, 120). For that reason, a logical first step to make is to study the pattern of sickness absence in subjects with co-morbidity, with emphasis on spinal pain.

2.2 INCIDENCE

In epidemiology, there are several measures that describe the occurrence of a disease episode. The term *incidence* concerns the onset/occurrence of a disease episode in a population initially free from the disease. All these individuals should potentially be at risk to get the disease during a defined period of time. More specific measures of incidence are the incidence rate and the incidence proportion. The *incidence rate* is the number of cases of disease in relation to the size of the study base, that is the total time during which the individuals in the study population are at risk of getting the disease (1). The incidence rate is calculated by dividing the number of disease onsets by the sum of all time spent in population and usually expressed in person-years. The *incidence proportion* measures the proportion of people who becomes diseased within a given period of time, and is calculated by dividing the number of subjects who develop the disease during this given period of time by the number of individuals in the population without the disease at the beginning of the period, after excluding the drop-outs (125). This quantity is often called the *cumulative incidence*. Note, that each subject can only be counted once, despite the fact that each individual could have had numerous new episodes of neck/shoulder pain during the follow-up period.

In many studies, data on current disease status is collected only at study start and at the end of the study. There is then often not enough data available to calculate the incidence rate or the cumulative incidence, since the exact time of disease occurrence is unknown. In order to be able to quantify disease occurrence somehow, the number of subjects that have the disease at the end of the study is simply divided by the total number of subjects, after excluding the drop-outs. Note that only individuals in the population without the disease at the beginning of the period are selected. This practical way of calculating an incidence should merely be seen as a special kind of prevalence and not as an exact measure of incidence proportion. Note that a subject that have developed the disease during the study period, but becomes disease-free again at the end of the study period, is then not registered an incident case.

The incidence of neck/shoulder pain

In epidemiology, calculating the incidence is the first step to make to be able to identify risk factors. For health professionals, policy makers and many others, it is also of interest to know how many new episodes of neck/shoulder pain during a specified period of time can be expected. For that reason, a review of the literature concerning the incidence of neck/shoulder pain was performed. This review included only large (n > 100) prospective population-based studies from the last ten years that covered neck pain, shoulder pain or neck/shoulder pain. In all studies, the population of interest was pain-free at study-start.

In this review, the simple term *incidence* was used, because the review enclosed both studies that calculated incidence proportions and studies that calculated prevalences of neck and/or shoulder pain at the end of the study out of a population without neck and/or shoulder pain at study start. The results are presented in Table I.

The incidence for neck and/or shoulder pain varied enormous between the different studies (Table IA-1C). The lowest incidence, 1.5%, was found by Brandt et al. (2004). They calculated the prevalence of moderate or severe neck pain at the end of the study (22). The highest incidence, 43.1%, was found by Nordlund et al. (2005) and concerned self-rated neck/shoulder pain, i.e. those with light or severe pain/symptoms that interfered with work over an eight year period (112). In all studies that presented separate incidences for men and women, women had a higher incidence than men, except for the study by LeClerc et al. (1999), in which the incidence for shoulder pain for men with repetitive work was higher than women with repetitive work (85).

Only one study was found in which the *incidence rate* was presented and was not included in the Table 1. This register study was performed in the primary care in the Netherlands (21), in which the incidence rate was calculated by taking the number of patients with a new episode of neck or shoulder complaint, i.e. those that consulted a general practitioner, divided by the sum of person-years at risk. ICPC-codes (international classification of primary care) were used to define the anatomical location. The incidence rate for neck symptom/complaints or syndromes was estimated to 14.3 and 23.4 per 1000 person-years for men and women, respectively. Concerning shoulder symptom/complaints or syndromes, these figures were 20.4 and 25.5 per 1000 person-years for respectively men and women.

Researchers have put forward that it is somewhat meaningless to compare incidences between different studies, without a uniform outcome measure (128). To some point I can agree with that, also because the calculation methods differed between the studies. Moreover, there are several other reasons for differences in incidence:

- The incidence depends on the study population; for example the country studied, the proportion women, the age group, or the profession of the subjects.
- As discussed above, the incidence depends on the operationalization used; in most cases, a more detailed case definition leads to a substantially lower incidence. A larger location for pain leads to a higher incidence, e.g. pain located in solely the neck region or solely the shoulder region compared to pain located in the neck and shoulder region.
- The length of the follow-up period is of importance when calculating the *incidence proportion*. It is difficult to compare different studies that have different follow-up periods, since an increase of the incidence proportion can be expected when the length of the follow-up period increased. Note that, if the follow-up period is longer than 6 months, the length of the follow-up period seems not to influence the prevalence of neck/shoulder pain at the end of the study out of a population without neck/shoulder pain at study start.

Table I. The incidence for neck/shoulder pain presented in recently published cohort studies with large populations (n > 100). IA) neck pain, IB) shoulder pain and IC) neck/shoulder pain.

IA) Incidence of neck pain

Authors/ Country	Population	Outcome	Follow-up	Incidence
Ariens (2001) The Netherlands (7)	n = 977 (24.6% women) workers in different occupations	Adapted version Nordic Questionnaire: on a 4-pointed scale: "Regular or Prolonged pain (>1 day)" during the last year	3 years	14.4%
Ariens (2002) The Netherlands (9)	n =758 (25.2% women) workers in different occupations	Register data on sickness absence >3 days due to neck pain (ICD-codes 722-723)	3 years	4.7% (cumulative incidence)
Brandt (2004) Denmark (22)	n = 4548 (% women not specified) all computer users	Current pain (last 7 days) of at least moderate degree and that the pain had bothered them quite a lot, much or very much	1 year	1.5%
Côté (2004) Canada (31)	271 men and 242 women from the general population	Any neck pain	1 year	Men 10.0%[1)] Women 16.9[1)]
Luime (2005) The Netherlands (95)	n = 271 (84% women) workers in health care (nursing homes)	Pain almost every day during the last year, at least 3 months Pain for at least a few hours during the last year	3 years	12.3% 33.8%
Eriksen (1999) Norway (42)	221 women and 355 men, nurses aides	Nordic Questionnaire previous 7 days previous 12 months	4 years	Men 8.8% Women 14.0% Men 23.4% Women 33.0%
Korhonen (2003) Finland (79)	n = 144 (% women not specified) workers with VDU work > 4 hours/ week	Local or radiating neck pain for at least 8 days during the preceding 12 months	1 year	18.1%
Krause (1998) USA (80)	n = 1449 (% women not specified) transit vehicle operators	A workers' compensation claim due to strain, sprain, contusion or pain of the spine not otherwise specified	5 years	2.8%
Van den Heuvel (2005) The Netherlands (150)	n = 787 (% women not specified) workers in different occupations	Adapted version Nordic Questionnaire: on a 4-pointed scale: "Regular or Prolonged pain (>1 day)" during the last year. 3 follow-up questionnaires	3 years	24%
Viikari-Juntura (2001) Finland (161)	n = 1850 (% women not specified) blue and white collar workers in the forest industry	Radiating neck pain Severe: > 30 days during the preceding 12 months Mild: 8-30 days during the preceding 12 months	3 years	Severe 6.4% Mild 9.2%
Wahlström (2004) Sweden (146)	344 men and 327 women, all computer users	Neck (upper back) pain for three days or more the preceding month	Median 10.9 months	Men 22.1% Women 31.5%
Östergren (2005) Sweden (115)	2649 men and 2270 women from the general population	Modified Nordic questionnaire Neck pain "often" or "all the time" during the last 12 months	1 year	Men 6.0% Women 8.1%

1) age adjusted

IB) Incidence of shoulder pain

Authors/ Country	Population	Outcome	Follow-up	Incidence
Brandt (2004) Denmark (22)	n = 4764 (% women not specified) Computer users: technical assistants and machine technicians	Current pain (last 7 days) in the right shoulder of at least moderate degree and that the pain had bothered them quite a lot, much or very much	1 years	1.9%
Luime (2005) The Netherlands (95)	n = 273 (84% women) health care workers (nursing home/elderly care)	Pain almost every day during the last year, at least 3 months Pain for at least a few hours during the last year	3 years	11.5% 33.6%
Harkness (2003) USA (61)	n = 803 (35% women) newly employed workers	Pain at least 24 hours during the past month	1 year	14.7% - 15.4%
Miranda (2001) Finland (103)	n = 2094 (% women not specified). Workers in the forest industry	≥ 7 days of shoulder pain during the last year ≥ 30 days of shoulder pain during the last year	1 year	5.9% 7.7%
Östergren (2005) Sweden (115)	2649 men and 2270 women from the general population	Modified Nordic questionnaire Shoulder pain "often" or "all the time" during the last 12 months	1 year	Men 5.9% Women 8.9%

IC) Incidence of neck/shoulder pain

Authors/ Country	Population	Outcome	Follow-up	Incidence
Andersen (2003) Denmark (4)	n =3123 (58.4% women) Unskilled blue collar workers	Clinical cases: Self-reported pain combined with palpation tenderness Symptom cases: based on self-reported pain	4 years	 1.7% 14.1%
Cassou (2002) France (26)	9028 men and 6100 women representing a general working population	Chronic pain: pain lasting at least 6 months with functional limitations	5 years	Men 7.3% Women 12.5%
Feveile (2002) Denmark (48)	1261 men and 1859 women from the general population	Neck/shoulder pain during the last year (Nordic questionnaire)	5 years	Men 28% Women 39%
Hannan (2005) USA (56)	337 subjects (77% women) newly-employed computer users	Discomfort such as pain, aching, burning, numbness or tingling (>6 on a scale 0-10 at least one day in the week) or medication to control the pain	6 months	33.8%
LeCLerc (2004) France (84)	112 men and 214 women with repetitive work	Shoulder pain at least one day during the preceding six months	3 years	Women 20.6% Men 28.6%
Nordlund (2004) Sweden (112)	197 referents (% women not specified) from a case-referent study with no symptoms or diagnosed disorder. Population-based	Nordic questionnaire Light symptoms Light/ severe pain or symptoms that interfered with work	8 years	 28.9% 43.1%
Smedley (2003) England (132)	587 hospital nurses, only women	Neck/shoulder pain longer than one day during the last year (Nordic questionnaire)	2 years mean 13 months	Women 34%

2.3 RECOVERY

Linguistic matters make the issue of recovery difficult. When an individual reports that he/she feels “recovered”, this can mean “having less complaints than before”, or maybe “totally cured”. This individual could also have developed a strategy to handle the pain and might not longer be limited in function. Has he/she recovered or not? To make things more complex, if an individual with neck/shoulder pain after some time becomes symptom-free, but in a later stage re-develops neck/shoulder pain, is that individual “recovered” during the symptom-free period, or should the individual being considered as a chronic patient with a symptom-free period? Thinking pragmatically, most of these matters can be handled by calculating the *recovery proportion*. The recovery proportion is calculated by dividing the number of recovered subjects, i.e. those that reported recovery or were free from their diagnosis at the time of follow-up, by the number of subjects with pain at study start, after excluding the drop-outs.

The recovery from neck/shoulder pain

Prior beliefs were that most individuals with neck/shoulder pain do recover relatively fast, similar to individuals with low back pain (106). For example, for acute unspecific low back pain, recovery proportions of 90% after three months are often mentioned (145). However, many individuals with neck/shoulder pain do not experience complete resolution of their symptoms and the prognosis for those suffering from neck/shoulder disorders can be considered to be relatively poor considering the levels of pain.

Table II shows the recovery proportions in 19 large (n > 100) prospective cohort studies performed during the past ten years. In studies that report the number of subjects with persistent symptoms, the recovery proportion was calculated by taking 100% minus the proportion still in pain. In all, there are large differences in recovery proportions between the studies. In most of the studies the prognosis of neck/shoulder pain is poor; only around 25%-50% of the women and 30%-60% of the men were recovered six months to five years later.

In contrast to the incidence proportion, the recovery proportion seemed to be rather unaffected by the outcome measure used. Moreover, the recovery proportion did not seem to be influenced by the length of the follow-up period if the follow-up period is longer than six months. Most subjects recover within six months and after this period the proportion recovered stays constant, independently of the outcome measure or study population (118). The differences in *recovery proportions* between the studies seemed predominantly influenced by the proportion women included: the more women included, the poorer the prognosis. Also the setting of the study influenced the results to some extent. Studies based on medical care-seekers (usually primary care) report lower recovery proportions than studies in which cases are selected on base of their work-site.

Table II. Recovery proportions presented in prospective cohort studies (primary care, population- or occupation based) concerning the prognosis of neck pain, shoulder pain or neck/shoulder pain that were published during the past 10 years and had more than 100 subjects included, IIA) Neck pain, IIB) Shoulder pain, IIC) Neck/shoulder pain.

IIA) Neck pain

Authors/ country	Population	Outcome	Follow-up	Recovery proportion
Côte (2004) Canada (31)	587 subjects (The proportion recovered was adjusted for age and sex). Population-based	Neck pain/disability Resolution of the pain	1 year	36.6%
		Improvement but not totally recovered		32.7%
Luime (2004) The Netherlands (96)	164 subjects (84% women) working in nursing homes or in elderly care	Pain for at least a few hours during the last year	3 years	56.1%
Eriksen (1999) Norway (42)	252 men and 403 women Population based	Nordic questionnaire. previous year	4 years	Men: 28.2% Women: 13.6%
		previous 7 days		Men: 58.5% Women: 37.8%
Hill (2004) England (65)	481 women and 305 men aged 18-75 from two primary care practices	≥ 1 day during the last month	1 year	Women: 51% Men: 52%
Hoving (2004) The Netherlands (69, 70)	183 consecutive recruited patients (61% women) who consulted their GP for neck pain	Self-perceived recovery from neck pain: “Completely recovered” or “much improved”	7 weeks 13 weeks 1 year	51% 57% 63%
Kjellman (2002) Sweden **(77)**	156 patients (76%) from primary care (GP, PT, CPs)	Pain intensity (VAS)	1 year	13%
		No disability		13%
Leclerc (1999) France (85)	230 workers in four different occupations (49% women): hospital workers, warehouse workers, office workers and airport workers	“At any time during the last 6 months ache, pain discomfort”	1 year	28%
Viikari-Juntura (2001) Finland (161)	907 blue and white collar workers (% women not specified) from a large forest industry enterprise	The total number of days with “radiating neck pain” during the last year (Modified Nordic questionnaire)	3 years	39%

IIB) Shoulder pain

Authors/ country	Population	Outcome	Follow-up	Recovery proportion
Bonde (2003) Denmark (18)	113 industrial and service workers (61% women) with tendinosis	At least one criterion no longer fulfilled: Pain index[1)] $\geq$12 (0-36) Direct tenderness (palpation) Indirect tenderness (resisted abduction)	Around 10 months	Around 50%
Croft (1996) England (33)	125 patients (% women not specified) that consulted a GP	"Complete recovery", that is not having a positive response to 22 items of disability	6 months 18 months	21% 49%
Luime (2004) The Netherlands (96)	192 subjects (84% women) working in nursing homes or in elderly care	Pain for at least a few hours during the last year	3 years	41.9%
Kuijpers (2006) The Netherlands (81)	587 patients (50% women) that consulted a GP with a new episode of shoulder pain	Perceived recovery or very much improvement	6 weeks 6 months	30% 54%
Miranda (2001) Finland (103)	Forestry workers (% women not specified) n= 740 > 7 days of pain n= 419 > 30 days of pain	$\geq$ 7 days of shoulder pain during the last year	1 year	59%
		$\geq$ 30 days of shoulder pain during the last year		45%
Vd Windt (1996) The Netherlands **(153)**	335 patients (56% women) that consulted a GP with a new episode of shoulder pain	Being without symptoms: Capsular syndrome, acute / chronic bursitis, rotator cuff tendonitis, other	1 months 3 months 6 months 1 year	23% 44% 51% 59%
Winters (1999) The Netherlands (170)	101 patients (59% women) that consulted a GP with a new episode of shoulder pain	"Feeling cured" = disappearance of shoulder complaints totally or to such extent that the complaints were no longer inconvenient, did not require therapy, or no longer interfered with normal work duties	26 weeks 12-18 months	49% totally cured and 32% cured with complaints 58% totally cured and 21% cured with complaints

1) Pain severity at worst (0-9), average pain within the last 3 months (0-9), pain-related disability within the last 3 months (0-9), average pain within the last 7 seven days (0-9).

IIC) Neck/shoulder pain

Authors/ country	Population	Outcome	Follow-up	Recovery proportion
Bot (2006) The Netherlands (21)	443 patients (63% women) that consulted a GP with a new episode of neck or shoulder problems	Perceived recovery	3 months 12 months	24% 32%
Cassou (2002) France (26)	759 men and 1063 women (58% women). A random sample from occupational physicians lists	Neck/Shoulder pain on the day of the medical examination, chronic pain $\geq$ 6 months, and self-reported functional limitations	5 years	Women: 53% Men: 65%
Fredriksson (2005) Sweden (52)	126 women and 92 men (58% women). Population based	Pain for at least 3 months during the last year	4 years	Women: 58% Men: 76%
Juul-Kristensen (2005) Denmark (75)	1008 women and 284 men, all office workers with at least eight days of musculoskeletal symptoms during the last 12 months at baseline	A reduced frequency of symptoms at follow-up than at baseline	2 years	Women: 34% Men: 54%
Nordlund (2004) Sweden (112)	a) 182 referents with light symptoms b) 79 referents with severe symptoms or symptoms that interfered with work c) 79 cases (diagnosed disorder)	Nordic questionnaire	8 years	No symptoms a) 22.0% b) 9.2% c) 7.8%

2.4 WORK-RELATED EXPOSURES

Work-related exposures can be categorized into biomechanical, psychosocial and organizational exposures: *Biomechanics* is the science that deals with forces applied to biological systems. In this context, work-related biomechanical factors are exposures that physically influence an individual at his/her work: external forces (e.g. manual handling), repetitive movements or awkward postures. *Psychosocial* exposures derive from the work environment, specifically constraints imposed by the organization of work, such as task specialization, low utilization of the workers skills, technological systems that interfere with worker performance, and multiple supervisors without prioritization of conflicting demands. One widely used model of psychosocial stress at work comprises two primary domains: mental workload (psychological job demands) and decision latitude (76). Psychological job demands reflect both physical pace of work and time pressure in processing or responding to information. Decision latitude is based on the worker’s latitude to control his or her own work process in response to those demands and to choose which skills to utilize to accomplish the job. *Organizational* exposures are in some studies considered as being a part of the psychosocial factors. Examples of job characteristics that may result from the organization include working schedules, machine-pacing, or incentive wages. Thus, the organizational exposures might to a high degree both influence the biomechanical and psychosocial exposures.

Many individuals perform different work tasks during his/her typical working day. Moreover, many work-related exposures occur at the same time. This makes it difficult to entangle the effect of single risk exposures. For example, when studying the effect of working with vibrating tools on the onset of neck/shoulder pain in construction workers, it is impossible to separate the effect of vibration from the effect of the weight of the tools, from the effect of handling the materials, and from the effect of awkward postures (54). These combinations of biomechanical exposures during the working day or within one work task – in the thesis further referred as to *simultaneous* biomechanical exposures – are thought to have a large influence on the risk for neck/shoulder pain (3). Moreover, concomitant biomechanical and psychosocial exposures seem to interact and more strongly relate to musculoskeletal diseases than separately, although not many studies have studied this in detail (36).

Physiological pathways

For the origin of musculoskeletal pain due to work-related exposures several patho-physiologic theories have been presented (71). One possible mechanism for the occurrence of musculoskeletal pain due to *biomechanical overload* is that tissue damage occurs when the load exceeds the physiological tissue tolerance. This overload can be due to 1) sudden overexertion: high amplitude, 2) sustained exertion: long duration, or 3) repetitive exertion: high frequency or combinations of these three (124). A plausible patho-mechanism for *psychosocial distress* causing musculoskeletal disorders is that increased neuromuscular tension may change the metabolism of the actual muscle and its surrounding tissues. Prolonged muscle contraction from psychogenic causes may result in an overload of low-threshold motor units and muscle fibers and may result in muscle ischemia that causes pain. Moreover, it is thought that psychosocial work factors may influence physical exposure. For example, the lifting frequency and the duration of working in awkward positions may be higher, if the worker have high mental demands or is working in time pressure. High social support between workers may promote the development of ergonomic strategies to reduce physical exposure (35). Adverse psychosocial and organizational exposures might also lead to an increased perception of pain or a lesser control of occupational constraints, and may even change the likelihood of reporting pain and a change in sickness behavior (24, 35, 85, 139, 160, 174).

Methodological issues

In epidemiological studies, the relationship between a potential risk exposure and a disease is studied. Conceptually, it is necessary to quantify the magnitude, the duration and the frequency of the internal forces to the specific structures that are involved in the pain-provoking process, e.g. the compression or shear forces on the cervical discs. These internal forces are impossible to measure over time and approximated by biomechanical calculations of the external forces (27). However, even approximating the external forces is not feasible in ergonomic epidemiology. Instead, very rough estimations of the external loadings must be made. There are different methods to assess these exposures. These methods should of course be valid and reliable, so that they can discriminate the exposed and unexposed subjects based on a realistic hypothesis of disease occurrence as a result of exposure. For example, all features of biomechanical loading: the level, the duration, and the frequency of exposures, should be taken into account. However, most of the available methods measure the presence or absence of biomechanical load or provide only crude information of these features. In general, these methods permit relative ranking of exposure, rather than quantitative evaluation (136). The most feasible method in large population studies is to use self-administered questionnaires, but these are criticized for lacking precision and for the risk of systematic overestimation of exposure among individuals with musculoskeletal pain (125). Structured task-based interviews may give more valid exposure information than self-administered questionnaires, because any misunderstandings and ambiguity can be resolved (87). One of the limitations is that in these interviews usually only the exposures during "a typical working day" are analyzed. This could lead to an underestimation of the true exposures, since exposures during "atypical working days" are neglected. As exposures within a job differ largely between different individuals using job titles is too crude (99, 110).

The measurement of psychosocial exposure is most feasible with self-administered questionnaires, and widely used, although other measurement methods exist, e.g. structured task-based interviews or observational measurements (147, 148). The contrast between exposed and unexposed subjects is in several studies based on the distribution in the population, and a predefined level of exposure is not often used.

2.5 RISK FACTORS FOR NECK/SHOULDER PAIN

Review of reviews

During the last years of the 19th and the beginning of the 20th century, six reviews of the existing literature on work-related risk factors for neck or shoulder pain were found in books, scientific review articles, and criteria document (9, 10, 15, 58, 106, 131, 154). As a whole, the six different reviews showed different results (Table III). There was hardly any evidence for a causal relation found between work-related exposures and neck/shoulder pain, especially concerning the psychosocial and the organizational exposures. As to the biomechanical exposures, repetitive work was identified as a risk factor for neck/shoulder pain. Four out of the six reviews concluded that there exists evidence for a causal relation. Of the six reviews, only Sluiter et al. (2001) studied the combination of biomechanical exposures and organizational exposures (e.g. the lack of recovery time) (131).

The lack of concordance between the reviews could be due to several reasons. Although they covered partly the same time period, the reviews did not cover the same papers, maybe as they all used different inclusion criteria, e.g. five reviews made a distinction between neck pain, shoulder pain and neck/shoulder pain. Moreover, the differences in results could depend also on the different levels of evidence used. Thus, until 2001, there was no consensus concerning what work-related exposures are associated with the cause of neck/shoulder pain, except for repetitive work (Table III).

Table III. Overview of six reviews on the evidence for a causal relation between work-related factors and the onset of neck pain, shoulder pain, or neck/shoulder pain. Only exposures reported in more than one review are presented. IIIA) biomechanical exposures, IIIB) psychosocial exposures. *Yes*: the review concluded that there is evidence for causality (strong or moderate). *No*: the review concluded that there is no evidence for causality (limited, insufficient or inconclusive). The levels of the evidence used in the different reviews are described below.

IIIA) Biomechanical exposures

	NIOSH (15)	**Hansson & Westerholm** (60)		**Ariens** (10, 11)	**vd Windt** (154)	**SBU** (106)	**Sluiter** (131)	
	Neck/ Shoulder[1]	**Neck**	**Shoulder**	**Neck**	**Shoulder**	**Neck**	**Neck**	**Shoulder upper arm**
Manual Handling								
Manual handling	yes	no	no	no		no		
High physical workload			yes[2] no[3]		no			
Vibrating tools	no	no	no	no	yes			
Repetitive work	yes	no	yes[4] no[3]		yes	yes	yes	yes
Posture					no			
Neck posture	yes	no		no			yes	
Arm posture[5]		no		no				yes
Back posture		no		no				
Sitting work		no		no				
Static work	yes	no				no	yes	yes
Workplace design		no		no				

1) The results for neck/shoulder pain are the same as for separate neck pain and shoulder pain.
2) Arthrosis in acromioclavicular joint
3) All other cases
4) Shoulder tendonitis only, when exposed to repetitive work tasks in combination with 60° abduction/flexion
5) Including working with the hands above shoulder level

IIIB) Psychosocial exposures

	Hansson Westerholm (60)		**Ariens** (10, 11)	**vd Windt** (154)	**SBU** (106)	**Sluiter** (131)	
	Back	**Neck**	**Neck**	**Shoulder**	**Neck**	**Neck**	**Shoulder upper arm**
High Demands			no	no	no	yes	yes
Low Job control			no	no	no		
Job strain	no	no	no				
Low job satisfaction	yes		no	no	no		
Poor social support at work	no	no	no	no	no	yes	yes

LEVELS OF EVIDENCE

NIOSH: (15)
yes: Strong evidence: very likely a causal relationship between intense of long-duration exposure. A positive relationship has been observed in at least several studies in which chance, bias, and confounding could be ruled out with reasonable confidence.
yes: Evidence: some convincing epidemiologic evidence present. A positive relationship has been observed in studies in which chance, bias, and confounding are not the likely explanation.
no: Insufficient evidence: The available studies are of insufficient quality, consistency or statistical power to permit a conclusion regarding the presence of a causal association.

Hansson and Westerholm: (60)
yes: Strong evidence: Consistent findings in multiple high quality cohort or case/referent studies.
yes: Moderate evidence: Consistent findings in multiple cohort or case/referent studies of which at least one is of high quality.
no: Limited evidence: Findings in one cohort or case/referent study or consistent findings in multiple cross-sectional studies of which at least one is of high quality.
no: Insufficient evidence: There is not enough scientific ground for an adequate judgment.

Ariens: (10, 11)
yes: Strong evidence: consistent findings (> 75%) in multiple high-quality cohort or case-referent studies (irrespective of the level of significance).
yes: Moderate evidence: consistent findings in multiple cohort or case-referent studies, of which only one study was of high quality.
no: Some evidence: findings of one cohort or case-referent study, or consistent findings in multiple cross-sectional studies, of which at least one study was of high quality.
no: Inconclusive evidence: all other cases.

vd Windt: (154)
yes: Evidence: *Temporal relation*: prospective cohort studies provide stronger evidence than case-referent or cross-sectional studies, *High methodological quality*, *Strong association*: ORs or RRs > 2.0, significant or dose-response relation, and *Consistent results*: at least 75% of the studies report a strong association.
no: Inconclusive evidence: all other cases.

SBU: (106)
yes: A: Support from metaanalysis or systematic review of good quality of two or more studies.
yes: B: Support from one or more RCTs or good observational study.
no: C: Insufficient of inconclusive evidence (no or poor RCTs or observational studies).
no: D: Lack of studies or support in scientific studies.

Sluiter: (131)
yes: RED: the disorder is “probably work-related”.
no: YELLOW: the disorder is “possible work-related”.
no: GREEN: the disorder is “most likely not work-related”.

Recent studies

To my knowledge, the work-related factors involved in the onset of neck/shoulder pain have not been reviewed since 2001. For that reason, all available population-based cohort-studies from the beginning of the 20th century until February 2006 were summarized. These studies were identified in PUBMED. In this summary, only large (n > 100), "high quality" studies were included, i.e. cohort studies or studies with a case-referent design, studies with appropriate exposure and outcome measurements, and studies that used appropriate (multivariate) statistics. All cross-sectional studies were excluded. Moreover, cohort-studies on selected populations, e.g. only computer users, were also excluded. Only studies that had as main outcome "neck pain", "shoulder pain" or "neck/shoulder pain" (disability, complaints, disorders, diagnosis, etc.) were included. Also studies in which the outcome was "seeking medical care due to neck or shoulder pain" were included, whereas studies with other outcomes, e.g. sickness absence due to neck/shoulder pain, were excluded.

Ten large high quality population-based studies were found (4, 7, 8, 26, 48, 61, 96, 103, 115, 149, 150, 160). Nine of these studies were conducted in the Nordic countries (Denmark, Sweden, Finland) or in central Europe (France, England or the Netherlands), and one study was conducted in the US. In the study by Luime et al. (2004), the results for neck pain and shoulder pain were analyzed separately, but were here treated as neck/shoulder pain (96). The MUSIC-Norrtälje baseline study, a case-referent study, was also included in this summary, and the results of that study can be compared to the results presented later in this thesis (Paper II). In that study, exactly the same outcome and exposure levels were used (160). Similar exposures were grouped into the same category, e.g. heavy work, mechanical exposure (based on 11 items) and high energy expenditure, in spite of different methods and exposure levels used, and independently of what body-region studied. The diversity in exposures, exposure levels, and outcomes made it impossible to calculate pooled risk ratios. Instead, the level of evidence was based on the consistency of the results. Consistent findings implied that the results of at least 50% of the studies investigating the effect of a certain risk factor pointed in the same direction.

Evidence: Significant associations and consistent findings (> 50%).
No evidence: All other cases.

The results are presented in Table IV. The table shows only exposures that were reported in more than one study. Two studies reported significant associations between high physical work and the onset of neck/shoulder pain, whereas one study could not find this relation (103, 115, 160). Three studies found that repetitive work was related to neck/shoulder pain (4, 61, 160), whereas Luime et al. (2004) did not find this relation neither for neck pain, nor for shoulder pain (96). Concerning neck posture, Ariens et al. (2001) could not find associations with neck pain (7). However, van den Heuvel et al. (2006) reported significant findings concerning neck/shoulder pain, reanalyzing the same data (the SMASH study) (149). Also Andersen et al. (2003) found an association with this exposure (4). Awkward back position was associated with neck/shoulder pain in one study (96). Another study found that awkward back positions were associated, but only for men (48). In conclusion, there was *evidence* that high physical load, repetitive work and awkward neck positions were risk factors for the onset of neck/shoulder pain, and (for men) awkward back postures.

Five studies identified high mental demands as significant risk factors, whereas in three other studies, the ORs/RRs were increased, but did not reach the levels of statistical significance (4, 7, 26, 96, 103, 115, 150, 160). It was therefore concluded that there was *evidence* that high mental demands is a risk factor for neck/shoulder pain.

Table IV. Summary of large epidemiological studies published 2001-2006 on work-related *risk* factors for neck pain, shoulder pain, or neck/shoulder pain. Only exposures reported in more than 1 study are presented. ++ = significant positive association, -- = significant negative association, +/0 = non-significant association.

RISK FACTORS	**Evidence**	**No evidence**	**Number of studies**
Manual Handling		X	2 studies ++ (4, 61) 2 studies +/0 (96, 160)
High physical load heavy work, high energy expenditure	X		2 studies ++ (103, 115) 1 study +/0 (160)
Repetitive work	X		3 studies ++ (4, 61, 160) 1 study +/0 (96)
Posture			
Neck posture	X		2 studies ++ (4, 149)
Arm posture[4)]		X	4 studies +/0 (61, 96, 103, 160)
Awkward back posture	X[1)]		1 study ++ (96) 1 study[1)] ++ (48) 1 study +/0 (103)
Sitting work ≥ 4 hours/day		X[2)]	2 studies -/0 (103, 160)
High mental demands	X		5 studies ++ (4, 7, 26, 103, 150) 3 studies +/0 (96, 115, 160)
Low decision latitude		X	2 studies ++ (4, 26) 6 studies +/0 (7, 61, 96, 115, 150, 160)
Job strain		X	2 studies[1)] ++ (115, 160) 2 studies +/0 (96, 150)
Poor social support at work		X	1 study ++ (7) 1 study[3)] ++ (160) 1 study[1)] ++ (48) 3 studies +/0 (4, 96, 115)

1) Only men
2) Protective
3) Only women
4) Including working with the hands above shoulder level

Evidence: Significant associations and consistent findings (> 50%).
No evidence: All other cases.

Simultaneous exposures seem to be stronger associated with the onset of neck/shoulder pain compared to single exposures (3, 48, 103, 115, 160). Andersen et al. (2003) constructed a physical index based on the repetition of shoulder movements, force requirements, percentage with neck flexion > 20°, and the percentage of time with lack of recovery. It turned out that the OR to become a "clinical case" was 3.2 (95% CI = 1.6-6.6) for subjects with at least three of these four exposures (3). Wigaeus (2002) et al. studied the effect of being exposed to simultaneous risk indicators, i.e. those exposures that were associated or tended to be associated with seeking care due to neck/shoulder pain in the univariate analyses (160). For men, the adjusted risks were increased to 5.5 (95% CI = 1.8-14.6) for being exposed to four simultaneous risk indicators, and 4.7 (95% CI = 1.7-13.1) for women that were exposed to six simultaneous risk indicators. Östergren et al. showed that the combination of mechanical exposure and job strain roughly doubled the ORs (1.64 to 2.25). However, only 182 out of 2605 men (7%) and 212 out of 2217 women (10%) studied were exposed to these two exposures simultaneously (115). Feveille et al. (2002) showed that the OR for the development of symptoms in the neck and shoulder region for subjects with a combination of heavy lifting and seldom-sedentary work was 2.35 (95% CI = 1.10-5.00), compared to those that did not have heavy lifting and sedentary work (48). In conclusion, exposures that occur simultaneously should be studied to a much larger extent, as many exposures co-occur and there might be an additive/multiplicative effect.

2.6 PROGNOSTIC FACTORS FOR NECK/SHOULDER PAIN

There is a lack of knowledge about the natural history of musculoskeletal disorders, and especially concerning the influence of work-related exposures on neck/shoulder pain on it (85). In contrast to the literature on risk factors, there are not as many studies performed concerning the prognosis of neck/shoulder pain. The same work-related exposures and levels of exposure involved in the onset of neck/shoulder pain may influence the prognosis of neck/shoulder pain, although this is not yet clearly understood.

Reviews of reviews

Three reviews on the prognosis of neck or shoulder pain were found (19, 82, 130). Borghouts et al. (1998) performed a review of the literature on the clinical course and prognosis of neck pain (19). Of all studies included in this review, there were only three studies found in which "occupation" was found as a potential predictive factor. Out of these, only one study showed that manual workers have a poorer prognosis compared with office workers. Scholten-Peeters et al. (2003) performed a review of prospective cohort studies studying the functional recovery of whiplash injuries (130). Out of the 29 cohorts included, more than 100 prognostic factors were studied, but most of them were related to the individual. Only few exposures were work-related and none of these were found associated with the prognosis of whiplash injuries. Kuijpers et al. (2004) performed a review of prognostic cohort studies on shoulder disorders (82). Sixteen studies were reviewed, out of which only five examined the prognostic value of work-related psychosocial exposures, e.g. job demands, and job control. None of these studies showed ORs/RRs above 2.0 or below 0.5, or a statistically significant association. In conclusion, until now, not one review has identified any work-related exposures associated with the prognosis of neck/shoulder pain.

Recent studies

Most prognostic studies aim to identify the clinical signs or symptoms that predict a poor outcome, e.g. (62, 70, 83, 153, 162). Not many recently published studies included work-related exposures as potential predictors. Taken into account only large (n > 100) high quality population-based cohort studies that included work-related exposures, there were four prognostic studies on neck/shoulder pain (3, 18, 26, 52), five studies on neck pain (41, 65, 85, 96, 161), and three studies on shoulder pain (81, 96, 103). In the study by Luime et al. (2004), the results for neck pain and shoulder pain were analyzed separately but treated as neck/shoulder pain in the summary (96). The diversity in measurement methods, levels and outcomes made it impossible to calculate pooled risk ratios. If there were more than one study that reported significant associations between exposure and neck/shoulder pain, the level of evidence was based on the consistency of the results.

Evidence: Significant associations and consistent findings (> 50%).
No evidence: All other cases.

The results are summarized in Table V. Concerning the *biomechanical* exposures, manual handling was in one study found associated with persistent/recurrent neck pain (65). Lifting more than 25kg was also found associated to shoulder pain, but not to neck pain (96). Fredriksson et al. found that women that rated their workload as high (RPE $\geq$ 12) had a higher chance for recurrent/persistent neck/shoulder pain (52), but heavy work was not a prognostic factor for shoulder tendinitis in another study (18). Concerning working with the hands above shoulder level $\geq$ 30 $^{min}/_{day}$, one study found an increased association with radiating neck pain (161). However, in three other studies that had studied this exposure, the ORs/RRs were not significantly increased (52, 96, 103). Kuijpers et al. (2006) found a significant association between repetitive movements and persistent shoulder symptoms six weeks and six months after baseline (81). No studies were found on working with vibrating tools or prolonged sitting. In conclusion, there is *evidence* that manual handling hampers recovery from neck/shoulder pain, but there is *no evidence* concerning the other biomechanical work-related exposures studied.

Concerning the *psychosocial* exposures, subjects exposed to high mental demands (upper tertile) had a four times higher chance to have persistent shoulder pain compared to those in the lowest tertile (18). The study by Cassou et al. (2002) showed similar results (26). Subjects exposed to high mental demands had a lower chance to recover compared to subjects with low mental demands. On the other hand, Luime et al. (2004) could not identify any significant associations concerning high mental demands and recovery from shoulder and neck pain, respectively (96). Concerning low decision latitude, only Erikssen et al. (2004) found that those with “little or very little” influence over their own work had a 2.5 times higher risk for persistent neck pain compared to those with “a great deal” of influence over their own work (42). Neither Bonde et al. (2003) or Luime et al. (2004) could repeat these results using the conventional methods according to Karasek & Theorell for defining low decision latitude (18, 96). Only Luime et al. (2004) examined also the combination of high mental demands and low decision latitude, job strain, but no associations with recovery was found (96). Poor social support was strongly associated with shoulder pain in the study by Bonde (2003); OR = 6.8; 95% CI = 2.0-23.0, but not in the study by Luime et al. (2004) (96). In conclusion, there is *evidence* that high mental demands are associated with a poorer prognosis of neck/shoulder pain, but there is *no evidence* for the other psychosocial factors studied.

None of the studies examined the influence of organizational exposures or *simultaneous* exposures on the recovery from neck/shoulder pain.

Table V. Summary of large epidemiological studies published 2001-2006 on work-related *prognostic* factors for neck pain, shoulder pain, or neck/shoulder pain. Only exposures reported in more than 1 study are presented. ++ = significant positive association, -- = significant negative association, +/0 = non-significant association.

PROGNOSTIC FACTORS	**Evidence**	**No evidence**	**Number of studies**
Manual Handling	X		2 studies ++ (65, 96)
Physical work e.g. heavy work, high self-perceived work load		X	1 study ++[1)] (52) 1 study +/0 (18)
Repetitive work tasks			
Posture Neck posture; Arm posture[2)]; Back posture		X	1 study ++ (161) 3 studies +/0 (51, 52, 96, 103)
Sitting work ≥ 4 hours/day			
High mental demands	X		2 studies ++ (18, 26) 1 study +/0 (96)
Low decision latitude		X	1 study ++ (42) 2 studies +/0 (18, 96)
Job strain			
Poor social support at work			

1) only women
2) Including working with the hands above shoulder level

Evidence: Significant associations and consistent findings (> 50%).
No evidence: All other cases.

2.7 ERGONOMIC INTERVENTIONS

Experimental studies have shown that a change of conditions at the workplace can lead to a reduction in biomechanical load (45, 46, 64, 90). Thus, a better work environment achieved by means of ergonomic interventions can, at least theoretically, enhance the recovery from neck/shoulder pain/disability and thereby reduce the related costs (63). In order to restore the balance between the demands of work and the capacity of the individual, two different strategies can be used (133). One strategy is to increase the capacity of the individual to better fit the demands of the work, for example, by providing ergonomic information, work technique or job training programs at the worksite, such as neck/back schools, hereafter referred to as *educational worksite intervention*. The other strategy is to adjust the workload to better fit the capacity of the individual, for example, by the use of technical aids or reorganization of work tasks, hereafter referred to as *workplace intervention* (135). These two kinds of ergonomic interventions can also be combined in order to simultaneously optimize the workload and increase the workers' capacity. This combined *workplace and educational worksite intervention* is commonly used as an ingredient in rehabilitation aimed to return the disabled worker to his/her work.

Review of reviews

During the years, the literature on the effectiveness of ergonomic interventions is reviewed several times. Eleven reviews were found enclosing RCTs and observational studies on different ergonomic interventions used for primary, secondary or tertiary prevention of musculoskeletal disorders. Several of these reviews examined different ergonomic interventions within each respective intervention strategy. For each intervention strategy, the authors' conclusions were dichotomized into *yes* and *no* evidence concerning the effect on RTW and the prevention of pain or pain-related disability (Table VI).

In summary, there were contradictory results found concerning the effect of educational worksite intervention (Group I) on RTW. There were more negative results than positive results. Concerning the effect on the prevention of pain or pain-related disability, there was not one review that concluded that these interventions were effective. Note, that there was no evidence that these interventions were harmful; they were just ineffective. Concerning workplace interventions (Group II), these interventions were found effective concerning RTW, i.e. were able to reduce the number of days spent on sick leave after a back injury. On the other hand, there is no evidence concerning the effect on the prevention of pain or pain-related disability and not many reviews included the prevention of pain or pain-related disability as outcome measure in their analyses. The effect of workplace interventions on RTW can differ from their effect on pain intensity and pain-related disability; patients can return to work despite the presence of pain (66, 67). Return to work could also be a component of the therapy in itself and not alone a result of the intervention (116). There were few studies on combined workplace and educational worksite intervention (Group III) and its effect on RTW or the prevention of pain or pain-related disability. In summary, there is evidence that workplace interventions are effective in promoting RTW, but the evidence is inconclusive for educational worksite interventions and combined workplace and educational worksite interventions. Moreover, there is evidence that educational worksite interventions are ineffective in preventing pain and pain-related disability, but the evidence is inconclusive concerning workplace interventions and combined workplace and educational worksite interventions.

Table VI. Review of reviews on the effect of ergonomic interventions on return to work (RTW) and pain/pain-related disability. Bold numbers **I), II) or III)** refers to the ergonomic intervention strategy (see below).

Author (ref) and date of literature search	Number of studies included	Ergonomic intervention	Body region	Outcome measures	Evidence for the effectiveness of ergonomic interventions	
					RTW	Pain/ disability
Franche (49) Dec 2003	10	**II)** Workplace intervention **I)** Educational worksite intervention	Musculo-skeletal disorders	RTW	yes yes	- -
Hlobil (66) Feb 2004	9	**?)** Three different follow-up times (short, medium, long)	Sub-acute low back pain	RTW-rate Short Medium Long Pain Short Medium Long	yes	no
Krause (80) March 1997	29	**II)** Workplace intervention	Any body region	RTW	yes	-
Linton (91) Sept 1998	16	**I)** Educational worksite intervention	Low back and neck pain	Prevention (primary/ secondary)	no	no
Meijer (100) March 2004	26	**I)** Educational worksite intervention	Musculo-skeletal disorders Low back	Duration of RTW	no	-

I) Educational workplace intervention: back and neck schools, lumbar support, behavioural interventions, education/instructions, pamphlet information, work hardening/work conditioning
II) Workplace intervention: Modified work, change of keyboards, work accommodation, ergonomic devices to reduce manual handling.
III) Combined educational and workplace intervention
?) Unknown strategy: RTW interventions

Table VI cont.

Author (ref) and date of literature search	Number of studies included	Ergonomic intervention	Body region	Outcome measure	Evidence for the effectiveness of ergonomic interventions	
					RTW	Pain/ disability
Van der Molen (152) Jan/feb 2003	44	**II)** Workplace intervention	Any body region	Musculo-skeletal symptoms	-	no
	44	**III)** Combined workplace and educational worksite intervention			-	no
Teasel (138) ?	5	**II)** Workplace intervention	Low back and neck pain, musculo-skeletal disorders	RTW-rate	yes	-
Turner (143) April 1995	10	**I)** Educational worksite intervention	Back pain	Pain, pain-behaviour, functional disability, depression	-	no
Tveito (144) June 2002	11	**I)** Educational worksite intervention	Low Back	Sick leave, pain	no	no
	2	**III)** Combined workplace and educational worksite intervention			no	no
Verhagen (158) Nov 2001	1	**I)** Educational worksite intervention	Musculo-skeletal disorders	RTW	-	no
	1	**III)** Combined workplace and educational worksite intervention			no	-
	2	**II)** Workplace intervention	Carpal tunnel syndrome	Pain	-	no
Weir (157) ?	11	**II)** Workplace intervention	Musculo-skeletal disorders, Low back	RTW	yes	-
	9	**I)** Educational worksite intervention	More chronically disabled low back	RTW Function	no	no

I) Educational workplace intervention: back and neck schools, lumbar support, behavioural interventions, education/instructions, pamphlet information, work hardening/work conditioning
II) Workplace intervention: Modified work, change of keyboards, work accommodation, ergonomic devices to reduce manual handling.
III) Combined educational and workplace intervention
?) Unknown strategy: RTW interventions

Recent studies

Studying the literature between 2004 and 2006, five high-quality studies were found, that studied the influence of ergonomic interventions on pain and pain-related disability. Two RCTs and one observational study were carried out in Holland (67, 101, 155) and two observational studies were performed in the U.S. An RCT conducted by Meijer et al. (2006) showed that multidisciplinary treatment in sick-listed patients with upper extremity disorders, an *educational worksite intervention*, was more effective in reducing the severity of the complaints than the usual care, but not in terms of RTW (101). In another RCT that studied a graded activity intervention, i.e. also an *educational worksite intervention*, the results were reversed concerning for patients with low back pain: the intervention had no effect on pain and pain-related disability but was effective concerning short term RTW outcomes (67). A Dutch observational study could not find any effects of modified work, a *workplace intervention*, concerning pain intensity and pain-related disability or RTW (155). The authors discussed that the subjects that needed them most, i.e. those with high physical loads, were not assigned to this intervention. One study performed in the US concerned the effectiveness of a job stress management added to an ergonomic modification of the worksite, *combined workplace and educational worksite intervention* (47). Those that received the additional stress-intervention did not differ from those that received only the ergonomic intervention, concerning pain intensity and pain-related disability. Finally, the effect of a state-wide ergonomic intervention, *workplace intervention*, on healthcare utilization was studied (53). The authors found a significant decrease of the MSD rate over a 2-year period of time (i.e. the number of musculoskeletal diseases/employee-hours worked). The MSD rate was after the intervention lower in this state compared to another state in the US.

In conclusion, these new studies show that ergonomic interventions could in some way be beneficial concerning the reduction in pain intensity and pain-related disability or RTW outcomes. However, it is not clear what intervention strategy is most effective, since the results are still unconvincing.

3 AIMS

The main goals of this thesis were to identify work-related exposures involved in the onset of neck/shoulder pain and to identify work-related exposures of importance for the prognosis of neck/shoulder pain.

SPECIFIC RESEARCH QUESTIONS

- Are there any differences in sickness absence between individuals with consistent pain in solely the neck/shoulder region, solely the low back region, and those with concurrent neck/shoulder and low back pain? *(Paper I)*.

- What are the incidence and recovery proportions for neck/shoulder pain over a four to six year period? *(Papers II and III)*.

- Are work-related exposures of importance for the onset of neck/shoulder pain? *(Paper II)*.

- Are work-related exposures of importance for the prognosis of neck/shoulder pain? *(Paper III).*

- Are ergonomic interventions effective in terms of a reduction in pain and pain-related disability in the neck/shoulder and/or low back regions? *(Paper IV)*.

4 MATERIAL AND METHODS

4.1 DATA COLLECTION

The thesis is based on the MUSIC-Norrtälje study. MUSIC is an acronym for MUSculoskeletal Intervention Center. The MUSIC-Norrtälje study consists of a *baseline case-referent study* and *a follow-up study* of all subjects. Data was collected at two points in time (baseline and follow-up). Moreover, *census data* from the National Social Insurance Board (RFV) and from Statistics Sweden was linked to each of the 2329 subjects who participated in both the baseline and the follow-up study.

Baseline case-referent study

The MUSIC-Norrtälje baseline study was designed as a case-referent study. The source population in the baseline study comprised all men and women of ages 20 to 59 years, who were living in the municipality and rural district of Norrtälje (Sweden) during 1994 and 1997 and did not work or study outside this area. This criterion was set up in order to control for the possibility that the cases probably would consult caregivers outside the region if they were working or studying outside the region. In total 2859 cases and referents were investigated.

The *cases* were defined as subjects from the study-base who sought medical care or treatment for neck/shoulder pain (NS) or for low back pain (LB) or for both neck/shoulder pain and low back pain (NS + LB) from any of the approximately 70 caregivers in the area. All types of medical caregivers were included, i.e. physicians and physiotherapists from the Swedish public health system (traditional caregivers) and chiropractors, doctors of naprapathy, massage-therapists, homeopaths, osteopaths, etc. from outside the public health system (non-traditional caregivers). The *referents* were selected as a random sample, stratified by sex and age from the study-base. At least one referent was chosen for each case, but when time permitted additional referents were invited. Both the referents and the cases should speak Swedish and should not have sought care at any of the approximately 70 medical caregivers in the municipality for either neck/shoulder pain or low back pain during the preceding six months before their enrolment. This last criterion was used in order to study "new episodes" of disorders. The participation rate for the referents was estimated to around 69% (160, 167).

For both cases and referents, data concerning perceived neck/shoulder pain, low back pain, co-morbidity, work-related biomechanical, psychosocial, and organizational exposures was collected by means of task-oriented interviews and self-administered questionnaires. A standardized clinical examination was also performed.

Follow-up study

A self-administered postal questionnaire was sent to both the cases and the referents who were still living in Sweden. At the time for the follow up, 28 subjects had moved abroad and 19 were dead. To the remaining 2812 study-subjects a postal questionnaire was sent. Eighty-three percent responded after up to three reminders;

n=2329. The proportions males and subjects < 45 years were higher in the group of non-responders compared to responders. The subjects who were examined from 1994 to 1995 received their follow-up questionnaire during the year 2000 and the subjects examined from 1996 to 1997 during 2001. Thus, the follow-up period varied between four to six years (Figure 2).

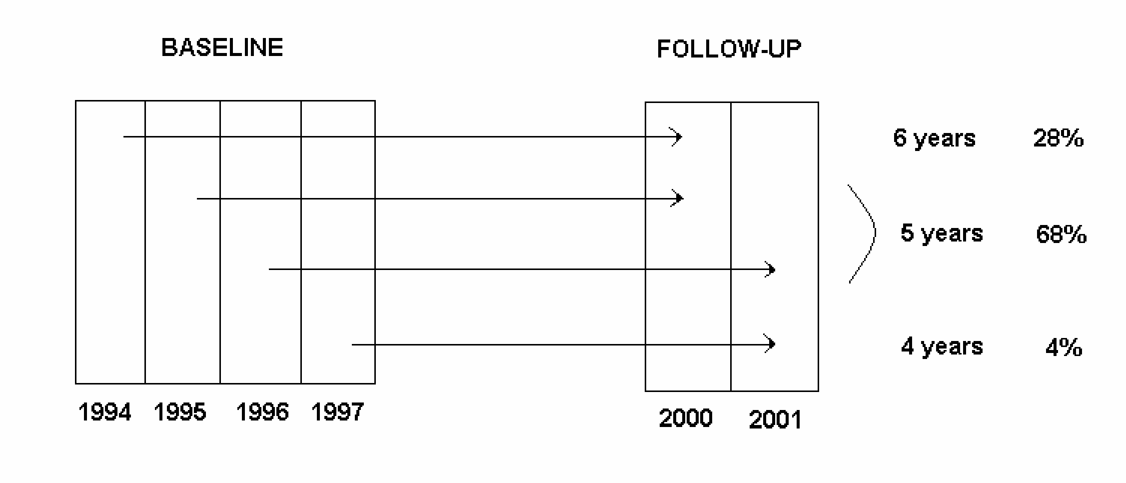


Figure 2. The MUSIC-Norrtälje baseline and follow-up study. Percentage of subjects with a follow-up time of 4, 5 or 6 years. (n=2329).

Information on perceived neck/shoulder pain and low back pain, co-morbidity and on work-related exposures was collected with the same questions as in the baseline questionnaires.

Census data

Register data from the National Social Insurance Board (RFV) and Statistics Sweden (SCB) were linked to each study-subject who participated in both the baseline study and the follow-up study. For each year 1994-2001, and for each subject, data about two types of benefit due to illness were received; (1) sickness benefit, and (2) disability pension. The data did not include any specified information about the reason for sickness absence. Data concerning sickness benefit was received as reported number of sick spells per year, number of days per year, and as partial or full benefit. Received disability pension data complied; (a) date for newly allowed disability pension, and (b) partial or full benefit[1].

4.2 DEFINITION OF NECK/SHOULDER PAIN (AND LOW BACK PAIN)

Conceptionally, the definition of neck/shoulder pain should be based on specific patho-anatomic or patho-physiologic diagnoses. However, in most of the individuals with neck/shoulder pain, it is not possible to put a specific diagnosis to the complaints

[1] The official health insurance responsibility in Sweden is divided between the employer and the Insurance Office. If a person falls ill, he/she is entitled to sick pay from the employer for the first 14 days. After that, the Insurance Office is responsible for disbursing sickness benefit or disability pension (partial or full). From the social insurance offices at regional and local level, the National Social Insurance Board receives data containing the number of days a subject has drawn benefit from the Insurance Office, where the period is longer than 14 days (longer than 28 days for the period between 1st January 1997 until 1st April 1998 due to a temporary change in the legislation).

perceived by the individual (131). Therefore, two different ways for the operationalization of neck/shoulder pain were used in the thesis: self-rated neck pain/disability and seeking medical care due to neck/shoulder pain. These definitions, and corresponding operationalized definitions for low back pain, were used as a base for identifying the study subjects in the four different studies.

Self-rated pain/disability

The first operationalization of neck/shoulder pain was the use of self-rated pain intensity and self-rated pain-related disability, as described by von Korff (172). Concerning pain-intensity, three questions covered levels of 1) current pain, 2) worst pain experienced during the previous six months, and 3) average pain during the previous six months. The ratings were made on an 11-point scale, where 0 meant "no pain" and 10 meant "pain as bad as it could be". For each subject, a pain intensity score was created by calculating the mean rating for these three questions. A pain intensity score for the low back region was also received with the help of corresponding three questions.

The pain intensity questions were followed by three questions about pain-related disability in the neck/shoulder region, and corresponding three questions about pain-related disability in the low back region. The time period covered by these questions was the previous six months (172). The questions asked how much the pain had affected 1) everyday activities, 2) social and family activities, and 3) ability to work (including domestic work). The ratings were made on 11-point scales, where 0 meant "not affected at all" and 10 meant "impossible to continue with these activities". For each subject and each body region, a pain-related disability score was created by calculating the mean rating for these three questions. Thus, both the pain intensity scores and the pain-related disability scores could range from 0 to 10. In the thesis (Papers I and III), a subject with a neck pain intensity score $\geq$ 3 or a neck pain-related disability score $\geq$ 1 was considered as having *self-rated neck/shoulder pain/disability*. Subjects with a neck/shoulder pain intensity score < 3 and a neck/shoulder pain-related disability score < 1 was considered as *not* having self-rated neck/shoulder pain/disability. The same cut-off points were used for low back pain.

Seeking medical care

The second definition of neck/shoulder pain used in the thesis was *seeking medical care* due to neck/shoulder pain (NS). Those who sought medical care due to low back pain were defined as having low back pain (LB). These definitions were used for identifying the study subjects in Papers II and IV.

4.3 SUBJECTS

Dependent of the specific research question, different sub-samples from the MUSIC-Norrtälje study were selected. In all papers, only subjects with employment at baseline were included. Employment was defined as having a job at least 17 $^{hours}/_{day}$. The number of subjects and the demographic features in Paper I-IV are summarized in Table VII.

Table VII. Description of the subjects at baseline: criteria for inclusion, demographic data, Illness-related data, and socio-economic status.

	PAPER I	PAPER II	PAPER III	PAPER IV
	n=817	n=1213	n=803	n=492
Criteria for inclusion: Employment at baseline and …	… self-rated neck/shoulder- or low back pain/disability at both occasions	… not sought medical care for neck/shoulder pain or low back pain at baseline	… self-rated neck/shoulder pain/disability at baseline	… sought care for neck/shoulder pain or low back pain at baseline, and employed at follow-up
Demographic data				
Women	525	697	524	294
Men	292	516	279	198
Mean age (SD)[2)]	42 (10)	42 (10)	42 (10)	41 (10)
Employed at follow-up	617 (81%)	994 (82%)	603 (75%)	492 (100%)
Illness-related data				
With self-rated **neck/shoulder** pain/disability	586 (72%)	324 (27%)	803 (100%)	288 (59%)
With self-rated **low back pain**/disability	638 (78%)	333 (28%)	510 (64%)	367 (75%)
Sought medical care[1)]				
Yes due to NS	151 (18%)	0	216 (27%)	156 (32%)
Yes due to LB	312 (38%)	0	218 (27%)	305 (62%)
Yes due to NS + LB	46 (6%)	0	54 (7%)	31 (6%)
No	308 (38%)	1213 (100%)	315 (39%)	0 (0%)
Neck/shoulder pain intensity score (0-10)				
Mean (SD)	3.5 (2.4)	1.4 (1.9)	4.4 (1.9)	2.9 (2.3)
Median (range[2)])	3.3 (0.0-7.7)	0.7 (0.0-5.7)	4.3 (1.0-8.0)	2.7 (0.0-7.0)
Neck/shoulder pain -related disability score (0-10)				
Mean (SD)	1.7 (2.0)	0.4 (1.1)	2.2 (2.0)	1.5 (1.9)
Median (range[2])	1.0 (0-6.3)	0.0 (0.0-2.7)	1.7 (0.0-6.3)	0.7 (0.0-5.9)
Socio-economic status				
Blue collar workers – production jobs	138 (17%)	206 (17%)	127 (16%)	86 (18%)
Blue collar workers – service jobs	338 (41%)	419 (35%)	334 (42%)	179 (36%)
White collar workers – lower positions	106 (13%)	153 (13%)	105 (13%)	69 (14%)
White collar workers – medium/higher positions	164 (20%)	336 (28%)	169 (21%)	118 (24%)
Self-employed or employer	38 (5%)	69 (6%)	40 (5%)	30 (6%)
Labor-market programs	33 (4%)	30 (2%)	28 (4%)	10 (2%)

1) NS: neck/shoulder pain, LB: low back pain, NS + LB: concurrent neck/shoulder and low back pain.
2) P05-P95

Paper I

Included in the study were employed subjects with self-rated neck/shoulder or low back pain at both the baseline and follow-up (Figure 3). Those without self-rated pain/disability at one or at both occasions in the neck/shoulder or low back region (No NS or no LB) were excluded (dark-shaded area). According to the location of the self-rated pain/disability, the subjects were classified into mutually exclusive groups both at baseline and follow-up: pain in the neck/shoulder region (NS), pain in the low back region (LB), or pain in both the neck/shoulder and low back region (NS and LB). Subjects that gave consistent answers concerning the location of pain on the two occasions were classified into: (1) solely consistent LB, (2) solely consistent NS, or (3) concurrent and consistent LB and NS (white areas). Subjects that gave inconsistent answers concerning the location of pain on the two occasions were assigned a fourth group, (4) migrating LB/NS (light-shaded areas). In the study group (n=817), 33% of the subjects suffered from concurrent and consistent LB and NS, 15% suffered from solely consistent LB, 12% suffered from solely consistent NS, and 41% suffered from migrating LB/NS. In this last group, the majority of the subjects in this group, 83%, suffered from concurrent LB and NS at one of the test occasions, but not at both.

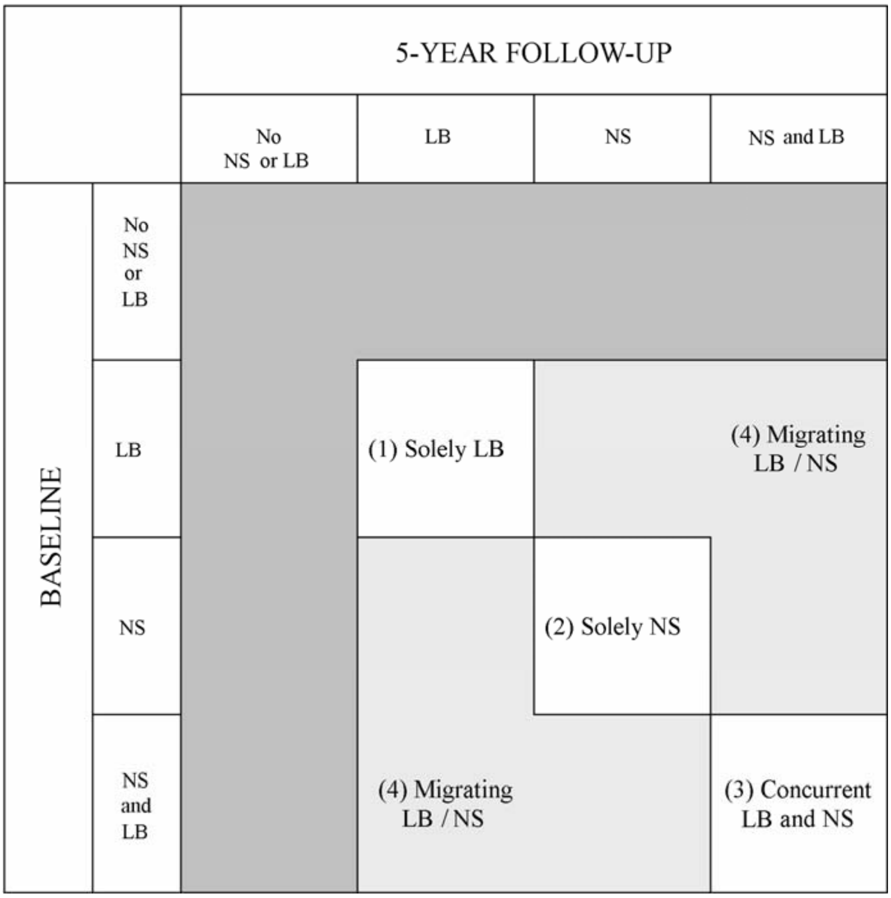


Figure 3. The study group in Paper I. According to the location of self-rated pain/disability scores measured at two baseline and follow-up, four groups were identified and included in the present study: (1) solely consistent low back pain (LB) (n=120), (2) solely consistent neck/shoulder pain (NS) (n=94), (3) concurrent and consistent LB and NS pain (n=271), and (4) migrating LB and/or NS (n=332). All other subjects (dark-shaded area) were excluded.

Paper II

Included in this study were the employed referents from the baseline study, i.e. subjects that *not* had sought medical care for either neck/shoulder pain or low back pain either at baseline or six months preceding the baseline study, (n=1243). Thirty-one subjects had missing data on the main outcome variable, thus in total 1213 subjects were included in this study. Around two-thirds of the study group reported at baseline that they had never sought medical care for their neck/shoulder pain, (375 men and 447 women). There were no differences in terms of age or socio-economic status between those who at baseline reported that they had never sought medical care for neck/shoulder pain and those who had not sought care during the six last months.

Paper III

Included in this study were employed subjects with self-rated neck/shoulder pain/disability; i.e. those who at baseline had a neck pain intensity score of ≥ 3 or a pain-related disability score of ≥ 1, (n=844). Due to internal missing values for the outcome variable, 41 of these could not be classified as recovered or not recovered at the follow-up; these subjects did not differ in sex or age from the participating subjects. Thus, the present study consisted of 803 subjects, 524 women and 279 men.

Paper IV

In this study, only the employed "cases", i.e. those who at baseline had sought medical care due to neck/shoulder or low back pain were included. Additional inclusion criteria for the present study were that subjects also should be employed for at least 17 hours per week at the follow-up, (n=656), and that they should have provided answers to the questions concerning ergonomic interventions introduced during the follow-up period. These questions were directed only to those who had experienced neck/shoulder or low back pain for more than seven consecutive days during follow-up. Of these, 164 subjects did not answer these questions and were excluded from the main analysis. Thus, the study group consisted of 492 subjects: 294 women and 198 men.

4.4 INDEPENDENT, DEPENDENT AND CONFOUNDING VARIABLES

Paper I

Independent variable

The independent variable consisted of the four groups: consistent (1) solely consistent LB, (2) solely consistent NS, (3) concurrent and consistent LB and NS, and (4) migrating LB/NS (Figure 3). Since there was no difference in sickness absence between group (1) and group (2), these two groups were merged into one group, solely LB or solely NS, and used as the reference category in the logistic regression analyses.

Dependent variables

Two outcome measures were analyzed in the present study; (1) prevalence of sickness absence, defined as at least one period of governmental compensated sickness absence > 14 consecutive days between baseline and follow-up and (2) long-term sickness absence, defined as > 180 days during at least one of the five one-year periods between baseline and follow-up among those subjects with sickness absence[2].

Confounders

Age (continuous) and non-muscular-related disorders[3] (yes/no) were included in all analyses.

Papers II and III

Independent variables

At baseline, data concerning work-related biomechanical, psychosocial, and organizational exposures were collected by means of task-oriented interviews (i_1 and i_2) and self-administered questionnaires (q_1 and q_2). In the interview concerning biomechanical exposures (i_1), each subject was asked to specify the various work tasks performed during a typical working day and also the time spent on each task (165). In the interview concerning psychosocial exposures (i_2), each subject was asked to describe his or her typical working day in sufficient detail that the interviewer could quantify the requirements of each work task and was able to create a profile of the total work engagement (148). The questionnaire concerning psychosocial exposures (q_2) included several items on social relations and support in the workplace. It also incorporated questions from the Swedish version of the demand/control model by Karasek & Theorell, in order to assess psychosocial demands and decision latitude (76, 140). Several indices were created to assess both the actual job exposure and the perception of these psychosocial conditions. The questions dealt with the terms and job security, the hindrances and available resources at work, the individuals' own competence, and social relations and support at the workplace, all as earlier described by Waldenström et al. (148).

Six biomechanical exposures were analyzed: 1) manual handling $\geq$ 50N[4] $\geq 60\ ^{min}/_{day}$ (i_1); 2) working with hands above shoulder level $\geq 30\ ^{min}/_{day}$ (i_1); 3) working with vibrating tools $\geq 60\ ^{min}/_{day}$ (q_1); 4) sitting $\geq$ 95% (i_1), 75%-94%, 50-74% of the working time versus < 50% of the working time (Paper II), as well as sitting $\geq$ 75% of the working time versus < 75% of the working time (Paper III); 5) repetitive movements (q_1) many times per minute $\geq 2\ ^{days}/_{week}$; and 6) energy expenditure (i_1): $\geq$

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[2] A subject was considered as having sickness absence if he/she had received partial or full sickness benefit or disability pension during at least one period of >14 consecutive days (longer than 28 days for the period 1st January 1997 until 1st April 1998), during the period between baseline and follow-up. Long-term sickness absence was only analyzed among those subjects that had been sickness absent at least 14 consecutive days between baseline and follow up. It was defined as >180 days with disbursed sickness benefit and disability pension during at least one one-year period between baseline and follow-up. Consideration was taken to whether the disbursed benefits were partial or full, in the manner that days with partial benefit were recalculated into whole days.

[3] Physical illness and/or diminished psychological well-being

[4] Newton

3.0 TWA-MET[5] for women and ≥ 3.5 TWA-MET for men. The levels of energy expenditure chosen represented ≥ 30% to 35% of the maximal aerobic capacities of 45- year-old Swedish women and men in average physical condition (74). The same exposure levels as were used in the case-referent baseline MUSIC-Norrtälje Study (160) were consistently applied in the follow-up study, with exception of sitting, where the cut-off points were also established according to Ariens et al. (2001) (7). The exposure variables analyzed have previously been considered to be sufficiently reliable (87, 141, 163-165).

Nine psychosocial exposures were analyzed: 1) low demands in relation to competence ($q_2 + i_2$); 2) few opportunities to learn and develop at work ($q_2 + i_2$); 3) high mental demands; 4) low decision latitude; 5) job strain, i.e. the combination of high mental demands and low decision latitude (q_2); 6) poor general support at work (q_2), i.e. including support from coworkers and supervisors; 7) low meaningfulness (q_2); 8) high time pressure (q_2), i.e. seldom or never having enough time to complete the work task in combination with either working overtime or a constantly high work pace; and 9) high hindrances at work ($q_2 + i_2$), i.e. poor work-task clarity, poor material or personnel resources, and/or leading to regular overtime or neglect of safety rules to accomplish the work. The cut-off points for classifying subjects as exposed or unexposed were based on previous reports from the MUSIC-Norrtälje study (160). The exposure high mental demands was dichotomized according to Wigeaus et al. (160), and trichotomized, i.e. two cut-off points, according to Ariens et al. (8).

Four organizational exposures were identified; 1) non-fixed salary; 2) long working hours, i.e. ≥ 35 $^{hours}/_{week}$; 3) night work/shift work; and 4) solitary work. Subjects that answered “yes” to these questions were classified as exposed, and subjects that answered “no” were classified as unexposed.

Moreover, different exposures occur simultaneously in many jobs and for that reason also combinations of exposures were studied (3). In paper II, combinations of biomechanical, psychosocial and organizational exposures with RR > 1 and p < 0.25 in the final model for men were also tested on their causal association with seeking medical care for neck/shoulder pain: manual handling ≥ 50N ≥ 60 $^{min}/_{day}$, high hindrances at work, night work/shift work and solitary work. It turned out that around ¼ of the men were exposed to at least two of these risk indicators simultaneously.

In paper III, subjects simultaneously exposed to one, two, or three of the biomechanical exposures manual handling ≥ 50N ≥ 60 $^{min}/_{day}$, working with hands above shoulder level ≥ 30 $^{min}/_{day}$, and working with vibrating tools ≥ 60 $^{min}/_{day}$ were compared to those unexposed to all of these three. The reason for making this combination of exposures was that these exposures often occur simultaneously. Of those with sedentary work, i.e. sitting ≥ 75% of the working time, not many were exposed to these biomechanical exposures.

[5] Time weighted average (TWA) of the multiples of the resting metabolic rate (MET)

Dependent variables

In the follow-up questionnaire the subjects were asked whether or not they had sought medical care for neck/shoulder pain during the follow-up period (yes/no). Five questions concerned which medical caregiver(s) they had consulted: traditional caregivers, such as medical doctors or physical therapists, or non-traditional caregivers, such as chiropractors, doctors of naprapathy, massage therapists, osteopaths, or homeopaths. In Paper II, the dependent variable was *sought medical care due to neck/shoulder pain during the follow-up*. The cumulative incidence was then defined as the proportion of the study subjects who reported that they had sought medical care for neck/shoulder pain at any time during the follow-up period. Repeated visits during the follow-up were counted only once. In paper III, the dependent variable was *self-rated neck/shoulder pain/disability*. The recovery proportion was then defined as the proportion of the study subjects who had recovered from neck/shoulder pain. A subject with a pain intensity score < 3 and a pain-related disability score < 1 at the end of the study was considered recovered from neck/shoulder pain.

Confounders

In Paper II, several potential confounders were tested (sex, age (continuous), smoking, BMI, physical activity at leisure time), but only sex, age (continuous) and previous sought medical care turned out to be the confounders of importance. The analyses were stratified for sex and the other two confounders were included in all analyses. In paper III, the number of subjects was too low to perform stratified analyses. Thus, both sex and age were included as confounders in all analyses.

Paper IV

Independent variable

One part of the follow-up questionnaire contained seven questions concerning ergonomic interventions. The individuals with neck/shoulder or low back pain more than seven consecutive days were asked if any ergonomic interventions at their work site had been performed during the follow-up period. Based on the responses to these questions, subjects were classified into four groups: Group 0: *no ergonomic intervention* (n=302), Group I *educational worksite intervention* (n=50), Group II *workplace intervention* (n=91), and Group III *combined workplace and educational worksite intervention* (n=45). The group with no ergonomic intervention, Group 0, was designated as the reference group (see Table I).

Dependent variables

A combined neck/shoulder and low back pain intensity score was calculated as a mean of the six pain intensity questions for both the neck/shoulder and low back regions. Similar to this score, also a combined pain-related disability score for the neck/shoulder and the low back regions was calculated. This was done for each occasion, baseline and follow-up. As dependent variables, two outcome measures were used: *change in pain intensity* and *change in pain-related disability*. These changes were calculated by subtracting the individual pain intensity and pain-related disability scores at baseline from those at follow-up. Thus, a decrease in pain intensity or pain-related disability was indicated by a negative value.

Confounders

Potential confounding from 18 work-related factors (e.g. manual handling ≥ 50N ≥ 60 $^{min}/_{day}$, high mental demands, poor general support) and non-work-related factors (e.g. sex, radiating pain) was considered. Only sought medical care during the follow-up period turned out to be a confounder of importance and was therefore included in all analyses.

4.5 STATISTICAL METHODS

The statistics used in the thesis are presented in Table VIII. All analyses were made using the statistical package SPSS for Windows (SPSS Inc., version 11.5-14.0); Chicago, IL).

Table VIII. Statistical methods used in the thesis. For more details, see papers I-IV.

	Paper I	Paper II	Paper III	Paper IV
Logistic regression (OR)	X			
Chi square (test of proportions)		X	X	X
Cox regression (RR/RC)		X	X	
Attributable proportion (AP%)[1)]		X		
Mann-Whitney U test				X
One-way ANOVA				X
General linear models				X
Tukey post hoc range test				X

1) AP% if RR > 1: ((RR-1)/RR) × (exposed cases/total cases);
AP% if RR < 1: (1-RR) × unexposed cases/total cases (125)

Whatever you do,
you'll always have your buttocks at the back

5 RESULTS

5.1 PAPER I

Sickness absence

In the whole study group, the prevalence of sickness absence (sickness absence at least 14 consecutive days between baseline and follow up) was 49%. In the group concurrent and consistent LB and NS, the prevalence of sickness absence was 59%. This can be compared to 42% in the group solely consistent LB, 41% in the group solely consistent NS, and 46% in the group migrating LB/NS. Using the merged group with solely LB or solely NS as the reference category, the adjusted OR for sickness absence in the group concurrent and consistent LB and NS was 1.69 (95% CI = 1.14-2.51). Migrating LB/NS did not differ from the reference group (Table IX).

Table IX. Adjusted Odds Ratios (OR) with 95% confidence intervals (95% CI) for sickness absence in three disorder groups. The merged group with solely consistent LB or solely consistent NS was set as reference group.

	Number of subjects	Subjects with sickness absence	OR[a)]	95% CI	p value
Solely LB or solely NS	214	89	1.00		
Concurrent and consistent LB and NS	271	159	1.69	(1.14-2.51)	0.01
Migrating LB/NS	332	152	1.00	(0.69-1.46)	0.99

a) Adjusted for sex, age, and other non-musculoskeletal related disorders.

Among the subjects who had been sickness absent for at least 14 consecutive days from baseline to follow up, the prevalence of long-term sickness absence (> 180 days during at least one one-year period between baseline and follow up) was 43% in the group concurrent and consistent LB and NS, compared to 21% in the merged group solely LB or solely NS. In the group migrating LB/NS, the corresponding proportion of subjects with long-term sickness absence was 30%. After adjustments, the OR for having long-term sickness absence during at least one one-year period was 2.48 (95% CI = 1.32-4.66) for the group concurrent and consistent LB and NS compared to the group with solely LB or solely NS. Migrating LB/NS did not differ from the reference group.

Additional analyses

Additional analyses were performed covering all subjects, i.e. including also those without employment at baseline, (n=932). The prevalence of sickness absence was in the group concurrent and consistent LB and NS 58%, compared to 41% in the merged group solely LB or solely NS and 46% in the group migrating LB/NS. Using the merged group with solely LB or solely NS as the reference group, the adjusted OR for sickness absence in the group concurrent and consistent LB and NS was 1.73 (95% CI = 1.20-2.52). Migrating LB/NS did not differ from the reference group.

5.2 PAPER II

Incidence proportion

During the four to six year period, 18% of the men and 29% of the women sought medical care for a new episode of neck/shoulder pain. This sex difference in cumulative incidence was statistically significant ($p < 0.001$).

Risk indicators for seeking medical care during the follow-up

Adjustments for age and previous sought care were made, in all Cox regression analyses. Concerning repetitive work, high physical load, and hands above shoulder level, the adjusted RRs ranged for men from 1.0 to 1.5, and for women from 0.9 to 1.0. For the psychosocial factors, high mental demands, low decision latitude, poor general support and job strain, the adjusted RRs for men ranged between 0.6-0.8 and for women between 0.9-1.1. None of these variables were significantly associated with seeking medical care during the follow-up. For women, none of the work-related exposures turned out to be associated with the outcome.

All risk indicators, i.e. exposures with $p < 0.25$, were included in multivariate models. In the final model for men, manual handling $\geq$ 50N $\geq$ 60 $^{min}/_{day}$ was identified as a risk factor, RR = 1.7 (95% CI = 1.0-2.9; AP% = 12%). Moreover, night work/shift work was also associated with the outcome, RR = 1.7 (95% CI = 1.0–2.8; AP% = 10%). Few opportunities to learn and develop at work had a preventive effect for men, RR = 0.4 (95% CI = 0.2-0.9; AP% = 7%).

For men, the adjusted RRs increased with increasing number of exposures ($p < 0.05$). Of the men unexposed to four risk indicators, only 12% sought care for neck/shoulder pain during the follow-up period, compared to 38% of the men exposed to three or more risk indicators, RR = 4.8 (95% CI = 2.1-10.9) (Table X).

Table X. Cox regression analyses for men: Adjusted relative risks (RR) for seeking medical care for neck/shoulder pain for increasing number of risk indicators. Corresponding 95% confidence intervals (95% CI) and p values.

Number of risk indicators[1)]	Number of subjects	Neck/shoulder pain	RR[2)]	95% CI	p value
0	178	21	**1.0**		
1	166	30	**1.7**	0.9–2.9	0.079
2	83	20	**2.6**	1.4–5.0	0.004
3 or more	29	11	**4.8**	2.1–10.9	0.000
Total number of subjects	**456**	**82**			

1) Included exposures: manual handling ≥ 50N ≥ 60 $^{min}/_{day}$, high hindrances at work, night work/shift work, and solitary work.
2) Adjusted for age, previously sought care for neck/shoulder pain, few opportunities to learn and develop at work, and high mental demands according to Ariens.

Additional analyses

Concerning the variable sitting, two different cut-off points were tested. Sitting $\geq$ 4 $^{hours}/_{day}$, i.e. sitting $\geq$ 50% of the working day, the adjusted RRs were 0.96 and 0.98 for men and women, respectively. Adjustments were made for age and previous sought medical care. When changing the cut-off point to sitting $\geq$ 75% of the working day, the adjusted RR was decreased, RR = 0.69 (95% CI = 0.4-1.0) for men, but not for women, RR = 0.84 (95% CI = 0.6-1.3).

Men simultaneously exposed to two or three of the biomechanical exposures manual handling $\geq$ 50N $\geq$ 60 $^{min}/_{day}$, working with hands above shoulder level $\geq$ 30 $^{min}/_{day}$, or working with vibrating tools $\geq$ 60 $^{min}/_{day,}$ tended to have a higher adjusted RR for seeking medical care during the follow-up, than those unexposed to all three of these exposures, RR = 1.50 (95% CI = 0.9-2.4). For women, no such tendency was found, RR = 0.55 (95% CI = 0.2-1.7).

5.3 PAPER III

Recovery proportion

Concerning self-rated neck pain/disability, the recovery proportion was estimated to 36%. The recovery proportion did not differ between those with a five year follow-up (35%) and those with a six year follow-up (39%) (p=0.25). For men and women separately, the recovery proportions were 44% and 33%, respectively.

Prognostic factors for self-rated neck/shoulder pain/disability

In all analyses, adjustments were made for sex and age. The results from the multivariate analysis showed that subjects exposed to job strain had a higher relative chance of recovery than unexposed subjects, RC = 1.53 (95% CI = 1.02-2.29). The prognosis was also better for the subjects exposed to sitting $\geq$ 75% of the working time relative to those without such exposure, RC = 1.32 (95% CI = 0.99-1.74). In other words, these two exposed groups had a relative recovery chance that was 53% respectively 32% greater, than the corresponding unexposed groups.

Subjects simultaneously exposed to two or three of the biomechanical exposures manual handling $\geq$ 50N $\geq$ 60 $^{min}/_{day}$, working with hands above shoulder level $\geq$ 30 $^{min}/_{day}$, or working with vibrating tools $\geq$ 60 $^{min}/_{day}$ had a lower relative chance of recovery than those unexposed to all three of these exposures; RC = 0.61 (95% CI = 0.40-0.94) (Table XI). In other words, this group had a 39% lower relative chance of recovery than the corresponding unexposed group. The three exposure variables included in this multivariate model were almost mutually exclusive to the fourth biomechanical exposure, sitting $\geq$ 75% of the working time. Of the subjects exposed to manual handling, hands above shoulder level, or vibrating tools, only 10% were also exposed to sitting $\geq$ 75% of the working time.

Table XI. Cox regression analyses for three simultaneous biomechanical exposures: manual handling $\geq$ 50N $\geq$ 60 $^{min}/_{day}$, working with hands above shoulder level $\geq$ 30 $^{min}/_{day}$, and working with vibrating tools $\geq$ 60 $^{min}/_{day}$. The adjusted[1)] relative chance of recovery from neck/shoulder disorders at the time of follow-up (RC) and corresponding 95% confidence intervals (95% CI) for increasing number of simultaneous exposures.

Number of simultaneous biomechanical exposures[2)]	RC[1)]	95% CI	Number of subjects	Number of subjects recovered	(%)
0	1.00		525	196	(37)
1	0.89	0.68-1.18	187	71	(38)
2 or 3	0.61	0.40-0.94	90	26	(29)

1) Adjusted for sex and age.
2) Included variables: manual handling $\geq$ 50N $\geq$ 60 $^{min}/_{day}$, working with hands above shoulder level $\geq$ 30 $^{min}/_{day}$, and working with vibrating tools $\geq$ 60 $^{min}/_{day}$.

Additional analyses

When analyzing men and women separately, there were no systematic differences between men and women concerning the direction of the chance estimates. For job strain, it was impossible to perform sex-separated analyses due to the low number of exposed men, (n=8).

Moreover, there were no systematic differences in the relative adjusted chance estimates, when the cut-off points for the three biomechanical exposures were lowered: manual handling $\geq$ 1 N $\geq$ 30 $^{min}/_{day}$, working with hands above shoulder level $\geq$ 1 $^{min}/_{day}$, and working with vibrating tools $\geq$ 1 $^{min}/_{day}$.

5.4 PAPER IV

The occurrence of ergonomic interventions

Among the 492 subjects included in the study, 10.2% received educational worksite intervention (Group I), 19.3% received workplace intervention (Group II), and 9.1% received combined workplace and educational worksite intervention (Group III). Thus, 61.4% of the subjects did not receive any ergonomic intervention (Group 0) during the four to six year period.

The effect of ergonomic interventions

At baseline, the median levels of pain intensity and the median levels of pain-related disability did not differ between Group 0 and Group I, or between Group 0 and Group II. In the group receiving combined workplace and educational worksite interventions (Group III), the level of pain intensity was higher (median = 3.8) than in Group 0 (median = 3.0) (p = 0.003), as was the level of pain-related disability (Group III median = 2.3, Group 0 median= 1.5) (p=0.011).

Concerning the change in pain-intensity, the educational worksite intervention group (Group I) differed from the reference group (Group 0), (p = 0.006). There was no change in pain intensity in Group I (mean = -0.0, 95% CI = -0.5 – +0.5), whereas in Group 0 there was a reduction in pain (mean = -0.7, 95% CI = -0.9 – -0.5) (Figure 4). In the workplace intervention group (Group II), the average change in pain intensity was also reduced; (mean = -1.1, 95% CI = -1.5 – -0.8), but did not differ from the change in Group 0 (p = 0.568). The mean change in pain intensity in Group III was -0.5 (95% CI = -1.0 – +0.6), and did not differ from the mean change in Group 0 (p = 0.322).

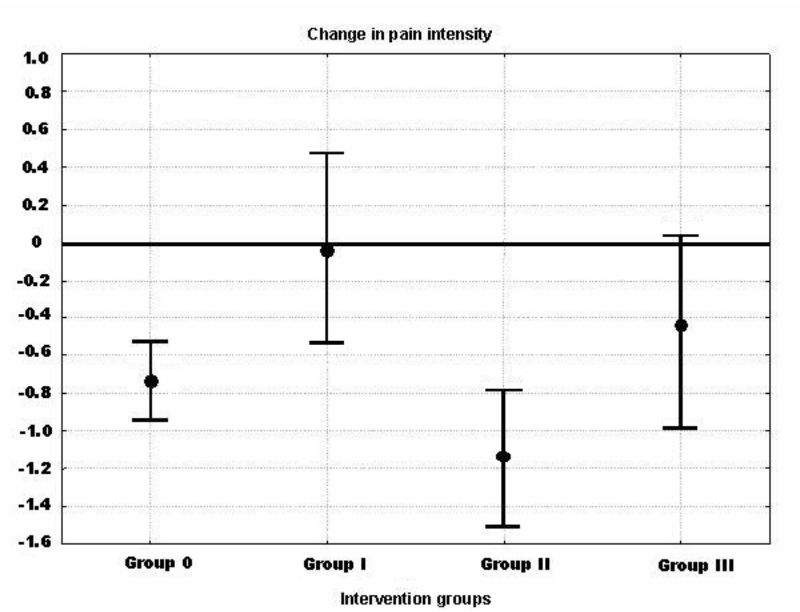

Figure 4. The adjusted[6] changes in pain intensity in each intervention group: no ergonomic intervention (Group 0), educational worksite intervention (Group I), workplace intervention (Group II), and combined workplace and educational worksite intervention (Group III). Mean (filled circle) with corresponding 95% CI (vertical lines). Negative values indicate a decrease in the level of pain-intensity.

The same pattern was found concerning the pain-related disability scores. The educational worksite intervention group (Group I) differed from the reference group (Group 0) (p = 0.017); in Group I there was no change in pain-related disability (mean = +0.0, 95% CI = -0.4 – +0.6), whereas in Group 0 there was a reduction in disability (mean = -0.7, 95% CI = -0.9 – -0.5) (Figure 5). The change in pain-related disability in Group II (mean = -0.8, 95% CI = -1.2 – -0.5) did not differ from the change in Group 0 (p = 0.962). Similarly, the change in Group III (mean = -0.4, 95% CI = -1.0 – +0.1) did not differ from the change in Group 0 (p = 0.609).

[6] Adjusted for *medical care-seeking* during the follow-up period.

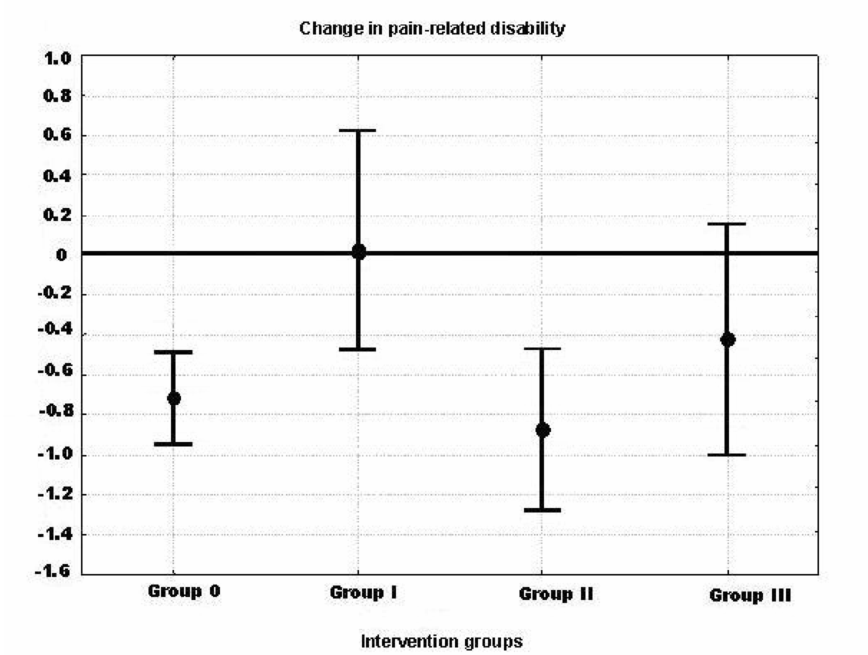

Figure 5. The adjusted[7] *changes in pain-related disability* in each intervention group: no ergonomic intervention (Group 0), educational worksite intervention (Group I), workplace intervention (Group II), and combined workplace and educational worksite intervention (Group III). Mean (filled circle) with corresponding 95% CI (vertical lines). Negative values indicate a decrease in the level of pain-related disability.

Additional analyses

The relative chance to be recovered at the end of the study was also calculated, similar to the methods used in Paper III. The study group was then selected based on the self-ratings of neck/shoulder and low back pain/disability. Of the 926 employed subjects with self-rated neck pain/disability or self-rated low back pain/disability at study start, 11% received educational worksite interventions, 19% received workplace interventions, and 9% received combined workplace interventions and educational worksite interventions. The proportions subjects without self-rated neck pain/disability or self-rated low back pain/disability at the end of the study were lower in the group with educational worksite interventions (21%) and in the group with combined workplace and educational worksite interventions (15%) compared to the group without ergonomic interventions. The proportion subjects recovered, i.e. being without self-rated neck pain/disability or self-rated low back pain/disability at the end of the study, the group without ergonomic interventions did not differ significantly from the group with workplace interventions (35% and 25%, respectively). In the multivariate model, the adjusted RC's for being recovered at the end of the study was 0.55 (95% CI = 0.3-1.0) for the group with educational worksite interventions, 0.79 (95% CI = 0.5-1.2) for the group with workplace interventions, and 0.47 (95% CI = 0.2-1.0) for the group with combined workplace interventions and educational worksite interventions. In the final model, adjustments were made for sex, psychological distress at study-start, and sought medical care during the follow-up period.

[7] Adjusted for *medical care-seeking during the follow-up period.*

5.5 EXTENDED ANALYSES ON THE DEFINITIONS OF NECK/SHOULDER PAIN

The study subjects in the papers were selected on base of the two definitions of neck/shoulder pain (§ 4.2). Could it be so that one of these definitions selected subjects with more severe symptoms compared to the other definition? In that case, the results in the four studies are difficult to compare with each other. To answer this question, additional analyses were performed in order to compare the two definitions. The pain intensity and pain-related disability scores at baseline were compared using the two definitions, and the incidence and recovery proportions were also compared.

Pain intensity and pain-related disability scores at baseline

In total 617 employed subjects had self-rated neck pain/disability at baseline, whereas only 325 subjects had sought medical care due to neck/shoulder pain at baseline. The mean and medians of the pain intensity and pain-related disability scores at baseline did not differ between the two definitions (Table XII). When also those without employment were included, the results did not change (self-rated neck pain/disability: n=700, sought medical care: n=363). Moreover, the pain intensity and pain-related disability scores for low back pain did not differ between the two definitions (Table XII). All this indicates that the two definitions are comparable, at least in respect to disease severity.

Table XII. Mean (SD) and median (p05-p95) of the pain intensity and pain-related disability scores at baseline for the two definitions of neck/shoulder pain and low back pain: 1) self-rated pain/disability, and 2) seeking medical care.

	Number of subjects	Pain intensity (0-10)		Pain-related disability (0-10)	
		Mean (SD)	**Median (p05 - p95)**	**Mean (SD)**	**Median (p05 - p95)**
Neck/shoulder pain					
1) Self-rated pain/disability	617	4.8 (1.9)	4.3 (1.3-8.0)	2.1 (2.0)	1.3 (0.0-6.7)
2) Medical care-seeking	325	4.6 (2.0)	4.7 (1.3-8.0)	2.4 (2.3)	1.7 (0.0-7.3)
Low back pain					
1) Self-rated pain/disability	961	4.4 (1.7)	4.3 (1.7-7.3)	2.6 (2.3)	2.0 (0.0-7.3)
2) Seeking medical care	590	4.5 (1.9)	4.6 (1.0-7.7)	3.0 (2.5)	2.3 (0.0-8.0)

Incidence and recovery proportion

The prevalence of self-rated neck/shoulder pain/disability at the end of the study was calculated in a group of 510 men and 623 women *without* self-rated neck/shoulder pain/disability at study start. At the follow-up 16% among the men and 29% among the women perceived self-rated neck/shoulder pain/disability. This was similar to the incidence proportions using medical care-seeking as definition of neck/shoulder pain: 18% of the men and 29% of the women had sought medical care during the follow-up (Paper II).

The recovery proportion was calculated using seeking medical care as definition for neck/shoulder pain. Selected were then those who had sought care due to neck/shoulder pain at baseline ("cases"). It turned out that for the total group of 314 subjects, 124 subjects (39%) had not sought medical care during the follow-up period. For men and women separately, these proportions were 45% and 37%, respectively (89 men and 225 women). This was similar to the recovery proportions using self-rated neck pain/disability as definition of neck/shoulder pain: 44% of the men and 33% of the women had recovered at the end of the follow-up (Paper III).

6 DISCUSSION

Det är natten som gör dagen ljus

6.1 SICKNESS ABSENCE

Those suffering from consistent and concurrent pain in both the neck/shoulder region and the low back region had the highest prevalence of both sickness absence and long-term sickness absence. No differences in sickness absence were found between individuals with solely low back pain and individuals with solely neck/shoulder pain, indicating that subjects with solely low back pain or solely neck/shoulder pain can to continue their work to a greater extent, in spite of the presence of pain, compared to those with consistent concurrent low back pain and neck/shoulder pain. The results were not altered when 115 unemployed subjects were included in the study population. Thus, consistently having concurrent low back pain and neck/shoulder pain could also reflect a more general musculoskeletal pain syndrome, with a different underlying patho-anatomical cause for solely low back pain or solely neck/shoulder pain. This remains to be investigated further.

According to a systematic literature review of the scientific evidence for causes to and consequences of sickness absence, performed in Sweden in 2003, there was limited published research on causes for sick leave due to low back and neck/shoulder pain (59). Factors that were found to influence the risk for sick leave due to back disorders were self-rated pain, physical impairment, and previous sick leave due to back disorders. The influence of co-morbidity, in terms of poor general health or non-musculoskeletal related disorders such as cardiovascular diseases, has also been reported to affect sickness absence due to low back pain (50, 111, 151). The finding that individuals with concurrent low back pain and neck/shoulder pain have higher sickness absence is supported by Nordin et al. (2002), who found that workers with low back pain and concurrent musculoskeletal complaints from another anatomical region (including spinal co-morbidity) were more likely to remain sick-listed than individuals with solely low back pain (111). On the other hand, IJzelenberg et al. (2004) did not find that concurrent low back pain and neck/shoulder pain increased the risk of sickness absence (72). This discrepancy with present study could be explained by the fact that IJzelenberg et al. (2004) used self-reported sickness absence data, while the present study used official register data, which is more accurate (72, 156). Another explanation could be the use in the present study of two measuring points, which seems to be an appropriate method to account for the highly recurrent nature of these disorders.

Several studies have analyzed the direct and indirect costs related to patients with neck/shoulder and low back pain and reported that 85%-95% of the total costs are indirect costs, i.e. costs related to the sickness absence of these patients (20, 39, 57, 156). None of these studies controlled for a potential influence from the concurrent body region, or co-morbidity. Hence, double counting of the costs could have occurred, and the estimated costs in these studies would probably become completely altered if those with solely neck/shoulder pain and low back pain and those with concurrent neck/shoulder and low back pain were analyzed separately. This could be one practical application of Paper I. Another practical application could be that clinicians should take into account that patients with concurrent neck/shoulder and low back pain are more likely to have a poorer prognosis than patients with solely neck/shoulder or low back pain.

Methodological considerations – Paper I

During the study period, the prevalence of sickness absence was somewhat higher in Norrtälje than in Sweden as a whole. This should not have influenced the odds ratios, as the prevalence of sickness absence was compared between different groups within Norrtälje. However, the fact that the social security system differ between countries might restrict the applicability of the results to Sweden alone.

The independent variable was based on the location and the consistency of the self-rated pain/disability. Using two points of measurements enabled us to identify those individuals that had a higher prevalence of (long-term) sickness absence. Using only one point of measurement was insufficient to identify these individuals; as much as 41% had given inconsistent answers and the prevalence of sickness absence was not increased in this migrating group. Thus, the use of repeated measurements seemed to increase the precision of self-rated pain/disability.

6.2 INCIDENCE OF NECK/SHOULDER PAIN

The results showed that a large proportion of the individuals in the working population had developed neck/shoulder pain during the 4-6 year period. The incidence of neck/shoulder pain was around 20% for men and around 30% for women. These figures are within the range of the incidences presented in other studies (Table I). The ratio between women and men was around 1:1.5, in accordance with other studies (Table I). Several explanations for the higher incidence among women have been suggested, but the reasons are still not clearly understood (68). Women might be more susceptible than men due to differences in strength, anthropometry, or hormones. Moreover, women may be more willing to report pain (88) and seek more often medical treatment than men.

6.3 PROGNOSIS OF NECK/SHOULDER PAIN

The results showed that only around one in three individuals with neck/shoulder pain had recovered 4-6 years later. This proportion is in accordance with other studies, even though the range between the different studies was wide (Table II). The general opinion is that a large majority (90%) of individuals with low back pain recover within a month of a new episode (40, 106, 117). Thus, the prognosis for individuals with neck/shoulder pain seems to be worse compared to individuals with low back pain. One explanation for this difference in prognosis could be that the upper extremity is involved in nearly every work situation, leading to both a higher chance of irreparable tissue damage and a lower amount of recovery time. One other explanation could be that in manual handling jobs, the muscles in the neck/shoulder region have a higher proportional loading (%MVC) than the muscles in the low back region.

6.4 WORK-RELATED RISK FACTORS FOR NECK/SHOULDER PAIN

Due to the multifactorial origin of neck/shoulder pain, it seems to be difficult to find single risk factors when studying a general population, especially among women. Among men, only moderately increased risks were found for some single risk factors; however, the risk estimates increased with the number of simultaneous exposures.

Men

Of the biomechanical exposures, manual handling $\geq$ 50 N $\geq$ 60 $^{min}/_{day}$ was an important risk factor, a result in accordance with other population-based cohort studies (4, 61). There was no association between repetitive work and the onset of neck/shoulder pain. This result is in contradiction to other studies (Table III and Table IV). One of the reasons for the lack of associations could be the low precision in the exposure measurements (87). The question concerning "repetitive work" might have been too complex, as it could have been taken to refer to either the repetition of work tasks or to the frequency of body movements in different work tasks. In accordance with recently published studies, working with the hands above shoulder level $\geq$ 30 $^{min}/_{day}$ was not identified as a risk factor (Table IV). Sitting $\geq$ 50% of the working time was not found to be associated with the onset of neck/shoulder pain, whereas sitting $\geq$ 75% of the working time ($\geq$ 6 $^{hours}/_{day}$) was found to be associated with a decreased risk. In two other studies, in which the cut-off point was sitting $\geq$ 50% of the working day ($\geq$ 4 $^{hours}/_{day}$), the calculated RRs/ORs tended to be associated with a decreased risk for neck/shoulder pain, but did not reach the levels of significance (103, 160). It is possible that the use of different cut-off points was the cause of the difference in results.

Of the psychosocial and organizational exposures, night work/shift work was identified as a risk factor. This exposure has previously been identified as a risk factor for neck/shoulder pain in women (160). On the other hand, Cassou et al. found no association with night work/shift work and the incidence of neck/shoulder pain (26). Moreover, there is an increased risk for the onset of several other diseases, such as peptic ulcer and coronary heart disease (78). Thus, the association between night work/shift work and neck/shoulder pain remains to be studied further. Surprisingly, a decreased risk for seeking medical care during the follow-up period was also found among those with few opportunities to learn and develop at work. One possible explanation is that there could be a difference in care-seeking behavior between the exposed and unexposed subjects, for example due to financial reasons, since three in four exposed subjects were blue-collar workers, such as bus or taxi drivers. High mental demands was not associated with the onset of neck/shoulder pain. Testing different cut-off points, e.g. using the scales according to Ariens (2001), did not alter the results (8).

Adding all these positive and negative results to Table IV, the existing evidence concerning manual handling changed from *no evidence* into *evidence*, and that concerning high physical load from *evidence* into *no evidence* (Table XIII). As these two exposures are highly correlated, these somewhat contradictory results show that the concept of *evidence* is difficult. A simple count of positive and negative studies in order to find evidence has been rightfully criticized earlier (80). Firstly, studies of higher quality need to be given more weight in an evaluation. Secondly, results need to be confirmed by more than one type of study employing different research methods. Thirdly, positive publication bias could result in an overrepresentation of positive findings. The results from Table XIII should thus be used carefully. Note that the summary covered only recently published population-based cohort studies. There is thus a need to conduct a systematic review on the risk factors including all high-quality cohort, case-referent or even cross-sectional studies performed over the years. This review should preferably try to pool the risk estimates.

Table XIII. Adding the results from the thesis into the summary of epidemiological studies published 2001-2006 concerning work-related *risk* factors for neck pain, shoulder pain, or neck/shoulder pain. ++ = significant positive association, +/0 = non-significant association.

	Evidence	No evidence	Adding Paper II	Number of studies
Manual Handling	X[1]	←	++[1] +/0[3]	2 studies ++ 1 study[1] ++ 1 study[3] +/0 2 studies +/0
High physical load heavy work, high energy expenditure	→	X	+/0	2 studies ++ 2 studies +/0
Repetitive work	X		+/0	3 studies ++ 2 studies +/0
Posture				
Neck posture	X		Not studied	2 studies ++
Arm posture[4]		X	+/0	5 studies +/0
Awkward back posture	X[1]		Not studied	1 study ++ 1 study[1] ++ 1study +/0
Sitting work ≥ 4 hours/day		X	+/0	3 studies[2] +/0
High mental demands	X		+/0	5 studies ++ 4 studies +/0
Low decision latitude		X	+/0	2 studies ++ 7 studies +/0
Job strain		X	+/0	2 studies ++ 3 studies +/0
Poor support at work		X	+/0	1 study ++ 1 study[3] ++ 1 study[1] ++ 4 studies +/0

1) Only men
2) Protective
3) Only women
4) Including hands above shoulder level

Evidence: Significant associations and consistent findings.
Inconclusive evidence: All other cases.

Compared to single exposures, the risk for seeking care for neck/shoulder pain was higher among men exposed to simultaneous exposures (Table X). One possible physiological explanation could be that there is a lack of recovery time when exposed to several risk factors simultaneously. Another explanation could be that the muscular loading is increased when exposures occur at the same time. One possible methodological explanation could be that, by combining different exposures, contrast is created. As a result of this, the unexposed category is not exposed to other risk factors.

Women

For women, no work-related exposures were identified as risk factors. One explanation for the difficulty in identifying risk factors could be that the contrast between the unexposed and exposed category was too low in a population-based cohort. Moreover, very few of the women have high levels of exposures. Studies in which the exposure prevalence is low are more easy influenced by misclassification errors, given that the specificity and sensitivity are equal (12). Women could have a lower precision in estimating the exposures at work, compared with men. As women have many different job tasks, it is likely that the task-orientated interview model used in the MUSIC-Norrtälje baseline study did not quantify them all, which will have led to an underestimation of the exposure prevalence. Another reason for the difficulty in identifying risk factors for women could be that the unexposed category is exposed to other concurrent risk factors. Besides risk factors *at work*, women are more highly exposed during the time *off work* compared with men, as women more often work part time and do most of the housework. It must be kept in mind that negative results should not be used as evidence for a lack of association (125). It seems more likely that the lack of risk factors for women is due to the methods used, rather than that neck/shoulder pain is not work-related in women.

Methodological considerations – Paper II

The intention in the baseline study was to investigate risk factors for getting a *new* episode of neck/shoulder pain or low back pain. For this reason, those individuals who had sought medical care during the six months before enrolment were excluded. This could have led to an exclusion of the more severe cases and thus could have resulted in a reduced exposure prevalence (38, 123). The study population used for studying work-related risk factors was a random sample from the general working population in all aspects except for sex; the proportion of women included in this sub-cohort was larger than in the Swedish general working population.

Surprisingly, the results from the baseline study (160), with a case-control design could not be replicated when using a prospective cohort design. This could be due to a differential misclassification of exposures in the baseline case/referent study, or the disappearance of exposures during the follow-up period. It is possible that the difference could also be due to a lower accuracy of the use of self-reports of seeking medical care; a four to six year period might be too long for a subject to remember if he/she had sought medical care due to neck/shoulder pain. The use of a diary is preferred to increase precision, but very impractical during a four to six year period. This potential outcome misclassification might not have lead to an overestimation of the risk estimates in the follow-up study, because it is unlikely that exposed and unexposed subjects differed in terms of memory bias; it is more likely that a dilution of the risk estimates could have occurred.

6.5 WORK-RELATED PROGNOSTIC FACTORS FOR NECK/SHOULDER PAIN

A higher relative chance of recovery was found for both men and women exposed to sitting ≥ 75% of the working time. A sitting work position both hampers the possibility of working with high forces and the possibility of performing prolonged work with hands above shoulder level. Thus, those exposed to sitting ≥ 75% of the working time were not exposed to the other biomechanical loads. The increased chance of recovery among those with a predominantly sitting work position was probably due to the lack of exposure to the other three biomechanical loads rather than to the sitting position itself. In self-reports, the estimated time spent sitting at work has a higher precision than the estimates of other biomechanical exposures (87, 141, 163-165). This could be one possible explanation for why sitting ≥ 75% of the working time turned out to be significant in the univariate analyses while the other three biomechanical exposures did not; a low precision concerning exposures has a dilutive effect on the chance estimates (125).

Subjects exposed to job strain had a higher chance of recovery than those who were not exposed. It is difficult to explain this counterintuitive result. The relationship between job strain and the onset of neck/shoulder pain has been more widely studied than the relationship between job strain and recovery. There are some studies in more homogenous groups that have identified job strain as a risk factor or an effect modifier for neck pain (56, 94, 126, 146, 150). Previous reports from the MUSIC-Norrtälje study reported a lack of association between job strain and the onset of neck/shoulder pain. One earlier study reported a lack of association between job strain and the recurrence of neck or shoulder complaints (96). Further studies are thus needed in order to see if the results were due purely to chance alone.

Manual handling ≥ 50 N ≥ 60 $^{min}/_{day}$ was found to have a moderate negative influence on recovery from neck/shoulder pain, a result in accordance with other prognostic studies on the associations between biomechanical exposures and neck or shoulder pain (26, 103, 153, 161). However, there are other studies in which high physical load did not influence recovery at all (18, 75). This indicates that there is still a need for additional studies on the influence of manual handling on recovery from neck/shoulder pain. The evidence concerning the influence of work-related exposures on the prognosis of neck/shoulder pain, presented in Table V, was not altered by the results of the thesis, except for high mental demands. The negative results in the present study indicated a change from *evidence* to *no evidence*.

A decreased relative chance of recovery was found for subjects simultaneously exposed to at least two of the following three biomechanical exposures manual handling, work with hands above shoulder level, and work with vibrating tools. Thus, it seems that when there are simultaneous exposures, the recovery process cannot begin.

Methodological considerations – Paper III

The subjects of Paper III were those that had self-rated neck/shoulder pain/disability at baseline, thus a mix of "cases" and "referents". It is difficult to see how the age- and sex-matching in the original case-referent study or the mix of care-seekers and non-care-seekers could have introduced a bias of the results, since confounding by age and sex was taken into consideration.

It is possible that a four to six year follow-up was too long to be able to identify potential associations between single exposures and the prognosis of neck/shoulder pain, as much could have happened in between. However, in a public health context, it is important to study the effects of exposures and interventions also over a longer period of time, especially in highly recurrent diseases.

Concerning the outcome, one disadvantage of the use of dichotomizing pain intensity and pain-related disability scores could be that subjects who improved their pain, but did not have a total resolution of the pain, were not considered as recovered. For example, those who changed their pain intensity from 8 to 4 were not regarded as recovered. However, this should not have influenced the chance estimates in Paper III, since there were very few subjects with such high pain intensity scores available in the study group.

6.6 ERGONOMIC INTERVENTIONS

Educational worksite intervention

The purpose of educational worksite intervention is to increase the capacity of the individual to better fit the demands of the work. In terms of pain intensity and pain-related disability, the prognosis for individuals receiving educational worksite intervention was poorer than for those not receiving any intervention, this in spite of the fact that the individuals receiving ergonomic intervention had also sought more medical care during the follow-up period. Individuals that had sought medical care had a poorer prognosis than those that had not sought medical care, and adjustments were therefore made in the general linear models in order to rule this factor out as an explanatory factor. These negative results are in accordance with a number of earlier reviews (Table VI) (90, 144, 158).

One underlying mechanism for the persistence of pain in subjects receiving educational worksite intervention could be the phenomenon known as *medicalization*. Medicalization implies that chronic pain can emerge from negative orientations towards pain even when the acute injury ought to have healed or when no injury was found (55, 167). The educational worksite interventions in the present study might have medicalized the subjects, as focus was probably put more on the incapacity of the individual (negative orientation) than on the biomechanical and psychosocial loading exposures per se (55). The lack of success of educational worksite intervention could also have originated from a discrepancy in perception between employers and employees of the causes of neck/shoulder and low back pain. Employers may be more likely to attribute the employees' pain to the employees' behavior, such as improper lifting techniques or working posture, rather than to an unsafe work environment (24). Thus, they are more likely to try to increase workers' capacity than to change the working conditions. Employees, on the other hand, may believe that work conditions caused the injury. When employees expect different interventions than those which are actually applied, forced attendance may result in a rather low compliance and thus create friction between employer and employee (24). Hence, it seems to be of great importance that before applying ergonomic intervention, employers and employees should both agree on which form of intervention would be most appropriate.

Workplace interventions

The lack of effect of workplace interventions could be due to the interventions having been inappropriate; for exemple, the changes in the work environment could have been incorrect, insufficient, or introduced too late (37, 90, 155). While workplace ergonomic interventions could be effective for preventing the initial occurrence of neck/shoulder or low back pain (primary prevention), they may not be able to cure existing disorders (secondary prevention) (53). In Paper IV, only secondary prevention was investigated.

Based on the evidence for the effectiveness (cost-benefit) of workplace interventions on return to work (Table VI) (6, 67, 80, 93), the workplace intervention strategy seems to be more promising than the educational worksite intervention strategy. However, compliance with workplace interventions is rather low, even in highly motivated workers (16, 37). Knowledge of the barriers to and facilitators of compliance is still limited (37). Most of the earlier studies on the effect of ergonomic interventions were focused on patients with low back pain. Studies on patients with exclusively neck/shoulder pain are rare, especially studies that examine the effectiveness of workplace interventions on the reduction in neck/shoulder pain intensity and pain-related disability. Comparison of Paper IV with other studies is difficult, since other studies were quite different regarding such things as selection of study population, choice of study design, length of follow-up time, definitions of workplace intervention, and method of defining the outcome of interest (66, 144). In Paper IV, the subjects were still at work and the outcomes of interest were the changes in pain intensity and in pain-related disability. This choice of study group in combination with these outcomes has to our knowledge not previously been studied in any RCT or in any high-quality observational study (66).

Methodological considerations – Paper IV

The overall negative results of the ergonomic interventions on pain intensity and pain-related disability could have been due to methodological issues stemming from the observational approach of the study. For example, the subjects who received ergonomic interventions during the follow-up period could have been selected, because it was believed they had a poorer prognosis than others. Reasons for such belief could have been seeking medical care, high illness severity, or different work-related exposures at baseline (14). This selection bias is known as *confounding by* *indication*. In order to control whether this bias had occurred, potential differences in the levels of pain intensity and pain-related disability and the presence of e.g. irradiating pain at baseline were examined. As many as eighteen potential confounders were considered and only one turned out to be significant (medical care during the follow-up period). In all models, adjustments for this particular confounder were made. Moreover, only those that had sought medical care at baseline were included in the study, again in order to rule this potential confounding factor out. Although there could have been other baseline factors that were not controlled for, it seems that confounding by indication was not present in Paper IV.

The questions concerning the ergonomic interventions have previously been used in national and international surveys (6, 109), and were slightly modified to fit the aims of the present study. The low number of subjects did not permit us to study different workplace or educational worksite interventions separately. Grouping effective and non-effective interventions together in one category could have diluted the estimates.

In this paper, there were as much as 164 subjects that did not respond to the questions concerning the ergonomic interventions. Probably, these subjects had not had experienced neck/shoulder or low back pain for more than seven consecutive days during the follow-up. Compared to the reference category, these non-respondents were similar in sex, age, socio-economic status, and pain-related disability at baseline, but had slightly lower levels of pain intensity at baseline. The results should not have been influenced to a high degree, since it is not likely that there were proportional more non-respondents in one particular ergonomic intervention group.

The results remained the same, also when a different analytical method was used in a group with partly different subjects, pointing out that the ergonomic interventions performed during the follow-up seemed not to be effective in either increasing the individual's capacity or reducing the workload to such levels that recovery was attained.

6.7 OVERALL METHODOLOGICAL CONSIDERATIONS

Bias is a systematic error and must be avoided. There are in general three groups of bias; *selection bias*, *information bias* and *confounding*. Selection bias occurs when the population that is studied is not representative of the target population, for example through errors in sampling or selective loss during the follow-up (125). Information bias occurs when the measurements of the exposure and outcomes are inadequate possibly leading to an incorrect categorization of the subjects. Misclassification due to information bias can be non-differential or differential. Using dichotomous exposure variables, *non-differential misclassification* can have two directions: 1) the truly unexposed subjects are wrongly observed as exposed, and 2) the truly exposed subjects are wrongly observed as unexposed; these are issues of specificity and sensitivity. Non-differential misclassification of dichotomous exposure variables leads predominantly to an underestimation of the association between exposure and outcome (125). Given equal specificity and sensitivity, small errors may have apparently large influences on the relative risk estimates, especially when the exposure prevalence is low, as shown by Armstrong (1998) (12). Winkel and Mathiassen (1994) pointed out that the lack of evidence for associations between work and musculoskeletal pain could to a large extent be explained by the lack of quantitative exposure data (168). There are several reasons for non-differential misclassification of exposure, especially when using self-ratings. The individual's internal interpretation of the actual exposures should be correct, and at the same time, the questionnaire should allow the individual to report the actual exposures. The two processes of interpretation and reporting are also essential for classification of the outcome. The individual should, over a long period of time, be able to register the occurrence, the location, and the consequences of the pain and be able to mark the boxes that correspond to these features. In the two processes of interpretation and reporting, the perceptual and cognitive ability and the memory capacity of the subjects thus play important roles (142). *Differential misclassification* of exposure occurs when the classification error differs between those with and without neck/shoulder pain. In dichotomous exposure variables, this type of bias can go in either direction; exaggerating or underestimating the associations (125). The third type of bias occurs when the effect of the exposure of interest is mixed together with the effect of another variable, a confounder. Stratifying the analyses or including the confounder in the analyses could control for this kind of bias.

Choice of study population

The MUSIC-Norrtälje baseline study included only those that were living in Norrtälje. The subjects who were working or studying outside the area were excluded. This criterion was set up in order to control for the possibility that cases would consult caregivers outside the region if they were working or studying outside the region. The Norrtälje region covers agricultural (e.g. farmers), service (e.g. prison, hospital), and production industries (e.g. a paper mill), and the socio-economic distribution in the study sample and in Norrtälje mirrors quite well the socio-economic distribution in Sweden as a whole. More than 100 different occupations were represented in the study population. The other Nordic countries are similar to Sweden in many aspects. Therefore, the study population can be considered as a general population representative for at least the Nordic countries and maybe also to the rest of Europe.

Response rate

Probably all available caregivers in the area participated in the baseline study. The response rate of the participants in the baseline study has earlier been estimated at 69% (160, 166). Eighty-three percent responded to the follow-up questionnaire. There were no differences in response rates found between cases and referents, blue and white collar workers, and subjects with and without pain/pain-related disability. The proportions of males and subjects < 45 years were higher in the group of non-respondents compared to the respondents.

Exposures

The exposures used in the thesis were based on the potential risk or health factors for neck/shoulder and low back pain that were known at the time of study-start. New research indicates that other variables also should have been included. This is a limitation shared with other longitudinal studies.

In the MUSIC-Norrtälje baseline study, a considerable effort was made to achieve high-quality exposure assessments. Nearly all work-related exposures were, after a long period of testing, considered sufficiently valid and reliable to be used in epidemiological studies, except for repetitive work (87, 105, 119, 141, 163). Nevertheless in Paper II and Paper III, non-differential misclassification of exposure could have occurred, perhaps diluting the risk and chance estimates in the COX regression analyses. Probably, non-differential misclassification could also have occurred in paper IV. The subjects might have had problems to classify the ergonomic interventions received during the follow-up due to interpretation and memory problems. If the four different ergonomic intervention groups were equally incorrect in reporting exposure, non-differential misclassification might have occurred.

Concerning *differential misclassification*, one disadvantage of using self-ratings compared to observational measures could be that those with complaints might systematically overestimate the levels of exposure (125). For this reason, a longitudinal design was used in the studies on the risk and prognostic factors (Paper II and Paper III) in order to avoid measuring work-related exposures at the same time as measuring the outcome. In Paper IV, differential misclassification could theoretically have occurred, because both the exposure (ergonomic intervention) and outcome (pain intensity and pain-related disability) were measured at the follow-up. If there were more subjects that had forgotten whether they had received an ergonomic intervention in the group that had recovered, compared those still in pain, the effect of ergonomic interventions could have been underestimated, since these recovered subjects were then wrongly ascribed to the reference category.

Definitions of neck/shoulder pain

Despite an impressive number of studies on neck/shoulder pain, there is still considerable uncertainty about the etiology of these problems (131). Most of the clinical assessment methods and radiological examination methods used are still insufficient regarding sensitivity and specificity (106). Using specific neck/shoulder diagnoses in order define “cases” seems therefore to be difficult. As pain is an individual sensation, according to the definitions proposed by the IASP (102), maybe the use of self-rated pain intensity scores is a better way to differentiate the pain-free individuals from individuals with neck/shoulder pain (129). For many diseases, the cases seen by medical care providers are an unrepresentative group of all cases in the community, as merely those with severe complaints seek medical care (14). However, using care-seeking as a method to identify “cases” in a population-based study has a strong socio-economic importance (30). In this thesis, two definitions of neck/shoulder pain were used: 1) self-rated pain/disability with predefined cut-off points, and 2) seeking medical care.

Self-rated pain/disability

The definition of self-rated neck/shoulder pain was based on a combination of pain intensity and pain-related disability. A similar approach to define the presence/absence of musculoskeletal disorders has been proposed by others (18, 97, 122). The chosen limit for a subject to be considered to have neck/shoulder pain or low back pain was a pain intensity score ≥ 3 and/or a disability score ≥ 1. These cut-off points were based on the distribution in the entire cohort of 2329 subjects. In both the baseline study and the follow-up study, about a third of the subjects had a pain intensity score of ≥ 3 and/or a pain-related disability score of ≥ 1. These distributions correspond to the 1-year prevalence of neck/shoulder pain found in earlier studies (31, 120). It was also considered that these levels of pain intensity and pain-related disability had a clinical relevance. Moreover, the chosen cut-off scores were at a level where it was still possible for the subjects to be able to work.

One disadvantage of using self-ratings is that pain-thresholds are different for each individual. There are also several methodological/statistical problems with the use of Visual Analogue Scales (129). Moreover, "subjective" ratings seldom correspond with "objective" measures. Winters et al. compared "clinical" recovery with "self-rated" recovery (169). One-hundred-and-one patients with a new episode of shoulder complaints were studied during a 26-week period at five points in time. Besides a clinical examination of the ROM in the shoulder-joints, the subjects were asked to fill in a 6-item questionnaire concerning shoulder pain, and were also asked to indicate if they were "cured" or "not cured". The results showed that a fast decrease of the pain and the ROM scores occurred within the first weeks, and that after 6 weeks hardly any further changes were seen. After 12 weeks, 25% of the patients still had clinical shoulder signs, but these were not perceived as very disabling. In addition, the ratings of the ROM and pain intensity at the end of the study did not correspond to whether the subject felt recovered or not. There was a very narrow margin between those that rated themselves as "cured" and those that rated themselves as "not cured", concerning these scores. The authors concluded that self-perceived recovery depended mainly on the initial levels of pain intensity and not on the clinical picture at the end of the study. This indicates that the *change* in pain intensity levels between baseline and the end of the study seems to be of importance in determining whether a patient considers themselves recovered or not, and not just the *level* of pain intensity at the end of the study-period.

Seeking Medical care

Using seeking medical care as an operationalization of neck/shoulder pain has the advantage that is it a feasible method to identify incident cases in a general population and it may restrict the selection of study subjects to the more severe cases (14, 104). A disadvantage of this outcome measure is that, conceptually, seeking medical care is a "behavior" and not a "disease". The biological tissue damage is not automatically greater in individuals that seek medical care than in those that do not seek medical care. Care-seeking behavior is influenced by many individual factors such as individual tolerance to pain, coping, and the economical feasibility of seeking care, and also by societal factors such as the availability of and the geographic distance to the relevant medical service (14, 30).

Interestingly, the two definitions of neck/shoulder pain used in this thesis were comparable, at least with respect to the severity of neck/shoulder pain. There were no differences in pain intensity or pain-related disability between the two definitions. Note that these results are not in contradiction to studies that showed that high pain intensity and pain-related disability scores are strong predictors for health care utilization (30, 104). The study group in these studies was selected based on the presence of pain, excluding the care-seekers that seek for other reasons than pain. Moreover, the incidence and recovery proportions did not differ between the two definitions used in this thesis. This could imply that in future studies in the field of public health, the use of these self-rated pain/disability scores, using these cut-off points, may be a useful and uncomplicated method of identifying subjects with moderate/severe neck/shoulder pain. It is possible that the use of repeated measurements and a combination of the two definitions of neck/shoulder pain (self-rated pain/disability and seeking medical care) could increase the precision one step further. This possibility remains to be investigated.

6.8 FUTURE STUDIES

This thesis has identified several areas in which more research is warranted.

There is a need for:

- more studies on the determinants for sickness absence
- better exposure assessment methods that can quantify work-related exposures
- better diagnostic methods
- reviews to establish the degree of evidence for work-related risk factors for neck/shoulder pain
- more high-quality studies on work-related exposures influencing the onset and prognosis of neck/shoulder pain
- more effective ergonomic interventions
- more in-depth studies of my belly button

7 CONCLUSIONS

- For individuals with consistent and concurrent neck/shoulder and low back pain, sickness absence was more common than for individuals with solely consistent low back pain or solely consistent neck/shoulder pain.

- During a four to six year period, 18 % of the men and 29 % of the women sought medical care due to a new episode of neck/shoulder pain. Among subjects with self-rated neck/shoulder pain, 44 % of the men and 33 % of the women had recovered at the end of the study.

- For men, manual handling $\geq$ 50 N $\geq$ 60 $^{min}/_{day}$ and night work/shift work were identified as risk factors for the onset of neck/shoulder pain. The risk increased with the number of simultaneous exposures. For women, no biomechanical, psychosocial or organizational work-related risk factors were found.

- For both men and women exposed to sitting $\geq$ 75% of the working time, the recovery from neck/shoulder pain was enhanced. The recovery was hampered for those exposed to at least two of the following three biomechanical exposures: manual handling $\geq$ 50 N $\geq$ 60 $^{min}/_{day}$, work with hands above shoulder level $\geq$ 30 $^{min}/_{day}$, or work with vibrating tools $\geq$ 60 $^{min}/_{day}$.

- For men and women with neck/shoulder or low back pain, ergonomic interventions were ineffective concerning the reduction in pain and pain-related disability.

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