Work ability and exposure to work demands among workers with neck pain

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If you want people to do a good job, give them a good job to do — an enriched job.

Frederick Herzberg (1984)

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ABSTRACT

Neck pain is one of the most common musculoskeletal disorders, which causes sickness absence and early retirement. Manual labor, awkward postures and repetitive work are commonly reported as causes for work-related neck disorders. Both neck pain and heavy physical work have been linked to lower levels of work ability. The overall aim of this thesis was to gain knowledge of how work demands can influence the work ability and sickness absence of workers with neck and upper extremity disorders, and also investigate a method that measures work demands. One cross-sectional study, two longitudinal studies and one experimental study were included in this thesis. Papers I-III uses material from Statistics Sweden (SCB) “Work environment” and “Work related disorders” surveys. Sickness absence data from the Longitudinal integration database for health insurance and labor market studies (LISA) database were also used in these studies. The relationship between exposure to work demands (high or low) or work place interventions (yes or no) were compared to work ability or sickness absence. Paper IV investigated the inter-rater reliability of the summary scores and individual items of a method to measure work demands, the Quick Exposure Check (QEC), by comparing two simultaneous assessments of 51 work tasks. The results showed that a lower level of physically demanding work and having high control over ones work can result in lower levels of sickness absence and promote excellent work ability for workers with neck pain, especially among older workers (Papers I, II). In Paper III it was found that work place interventions that improves neck pain were associated with fewer number of sickness absence days. Paper IV found that the QEC has good reliability in total scores but a few of the individual items showed low reliability. The results from this thesis can be used in different work settings, to promote work ability and prevent sickness absence by employers and occupational healthcare professionals. **Keywords**: work ability, prevention, neck pain, sickness absence, musculoskeletal disorders, exposure, work demands

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SAMMANFATTNING PÅ SVENSKA

Nacksmärta är ett vanligt muskuloskeletalt besvär, som kan leda till sjukfrånvaro och förtidspension. Manuellt arbete, obekväma arbetsställningar och repetitivt arbete anses som orsaker till arbetsrelaterade nackproblem. Både nacksmärta och tungt fysiskt arbete har kopplats till lägre arbetsförmåga. Det övergripande syftet med denna avhandling var att få kunskap om hur arbetskraven kan påverka arbetsförmågan och sjukfrånvaron för arbetstagare med besvär från nacke och övre extremiteter, samt undersöka en metod som mäter arbetskrav. En tvärsnittsstudie, två longitudinella studier och en experimentell studie ingick i denna avhandling. Delarbete I-III använder material från SCB:s undersökningar: "Arbetsmiljön" och "Arbetsorsakade besvär". Sjukfrånvaro från den Longitudinella integrations-databasen för sjukförsäkrings- och arbetsmarknadsstudier (LISA) användes också i dessa studier. Exponering för arbetskrav (hög eller låg) eller arbetsplats-interventioner (ja eller nej) jämfördes med nivå av arbetsförmåga eller sjukfrånvarodagar. Delarbete IV undersökte reliabiliteten av det totala resultatet och resultatet från enskilda delar i en metod för att mäta arbetskrav, Quick Exposure Check (QEC), genom att jämföra två samtidiga bedömningar av 51 arbetsuppgifter. Resultaten visade att en lägre nivå av fysiskt krävande arbete och hög kontroll över arbetet kan minska sjukfrånvaron och främja utmärkt arbetsförmåga för arbetare med nacksmärta, särskilt bland äldre arbetstagare (Delarbete I, II). I delarbete III fann man att arbetsplats-interventioner som förbättrar nacksmärta var förknippade med lägre sjukfrånvaro. Delarbete IV fann att QEC har god tillförlitlighet i totala poäng men några av de enskilda delarna visade låg reliabilitet. Resultaten från denna avhandling kan användas av arbetsgivare och företagshälsovård i olika arbetssituationer i arbetet med att främja arbetsförmåga och förebygga sjukfrånvaro

LIST OF PAPERS

This thesis is based on the following studies, referred to in the text by their Roman numerals.

I. Oliv S, Noor A, Gustafsson E, Hagberg M. A Lower Level of Physically Demanding Work Is Associated with Excellent Work Ability in Men and Women with Neck Pain in Different Age Groups. *Safety and Health at Work. 2017;8(4):356-63.*

II. Oliv S, Gustafsson E, Baloch AN, Hagberg M, Sanden H. Important work demands for reducing sickness absence among workers with neck pain: a prospective cohort study. *Submitted.*

III. Oliv S, Gustafsson E, Baloch AN, Hagberg M, Sanden H. Workplace Interventions can Reduce Sickness Absence for Persons with Work-related Neck and Upper Extremity Disorders: A One-year Prospective Cohort Study. *J Occup Environ Med. 2019.*

IV. Oliv S, Gustafsson E, Baloch AN, Hagberg M, Sandén H. The Quick Exposure Check (QEC) - Inter-rater reliability in total score and individual items. *Appl Ergon. 2019;76:32-7.*

CONTENT

ABBREVIATIONS

WAI	Work Ability Index
WAS	Work Ability Score
QEC	Quick Exposure Check
UE	Upper Extremity
OHS	Occupational Health and Safety
SCB	Statistics Sweden
LISA	Longitudinal integration database for health insurance and labor market studies

1 INTRODUCTION

1.1 WORK ABILITY

Work ability is a complex and multidimensional concept, which can be viewed from different perspectives. A single view or definition may not be useful to describe the diversity of this concept [1]. In a review of the conceptualization of definitions of work ability 115 different definitions were found [2]. In this review, three main dimensions of work ability could be identified: individual, organizational and societal.

The *individual* level includes all dimensions related to the worker's condition, which must be understood not only medically (as the presence or absence of illness/disability) but including all personal resources, facilitators and barriers that characterize the worker in regard to the work, including skills, behavior, values, etc.

The *organizational* level considers the organizational and institutional factors that contribute to shaping or structuring work ability, including attributes related to relationships between different stakeholders (worker, clinicians, employer, colleagues, family and friends, compensation board case managers, etc.) and different mesosystems in which interpersonal relations occur (compensation boards, workplace, union, healthcare services).

At the *societal* level, work ability is conceptualized as a social phenomenon influenced or even generated by broader historical, cultural, legislative, financial, social, demographic and political macrostructures and dynamics, such as unemployment rates, sick leave policies and compensation levels, work legislation, healthcare access and coverage, population aging, historical union battles and value systems [2].

From an insurance perspective, the purpose of describing an individual's work ability is to clarify the legal rights to sickness, or other, benefits. In Sweden sickness benefits can be claimed if the individuals work ability is reduced (by at least 25 %) [3]. Historically this have been defined in relation to the individual as "The frail and others, who, having an insufficient work ability, are incapable of earning their living" (Swedish Academy 1901).

Nordenfelt [4] argues that both internal factors (ability) and external factors (opportunity) influence work ability. Ability refers to the individual capacities and opportunity refers to factors in the environment. The practical possibility to work means having both the ability and opportunity to work. Furthermore the same author defines work ability as the ability to fulfil the tasks and reach the goals of the actual job, by a person with the competence, qualifications, and health required [4]. Another suggested definition of and a framework for assessing work ability is made by Tengland [5]. This definition addresses assessing work ability with the purpose of legislating for the regulation of sickness insurance. In this definition work ability is something within the individual and work environment as the platform for work-related actions. This means that work ability cannot be specified without relating it to a task and a work environment. The definition separates two situations within the work ability definition, one for a specific job and one for work in general. The first definition, specific work ability, is the ability one has in relation to a specific job. The second, general work ability, refers to basic abilities most people have to perform some kind of job after a shorter introduction [5].

In Finland in the 1980s there were a discussion of an increasing trend towards work disability and a shortening of work careers due to a variety of reasons, not only medical in nature [1]. Researchers recognized the need for a new, positive approach, as represented by work ability as opposite to work disability. Work ability was defined as a balance between personal resources and work. Personal resources includes health related resources, competence and values and motivation. This balance may change continuously and be different in different phases of working life. The basic scientific question that was recognized was how long workers and employees are able to work and to what extent being able to work depends on the work content and job demands. Using the stress-strain concept, a multidisciplinary study group developed and validated a series of question which led to the development of the work ability index (WAI) [1, 6].

Work ability is also affected of life outside the immediate workplace. Other factors, such as family, other societal environments, infrastructure, services and regulations also have an impact on work ability. Work ability can be promoted by many factors other than health-related ones. Ilmarinen illustrates work ability as a multifaceted concept, graphically represented by a ′Work ability house′ with four floors [7]. The first floor consists of physical, mental and social abilities. The second floor contains the individual′s skills and competence. On the third floor there is motivational factors, while on the fourth floor there is work and work related environmental exposures to physical, psycho-social and organizational factors. The Work ability house is surrounded by factors outside work including family, close community and occupational health and safety factors, etc (Figure 1) [7, 8].

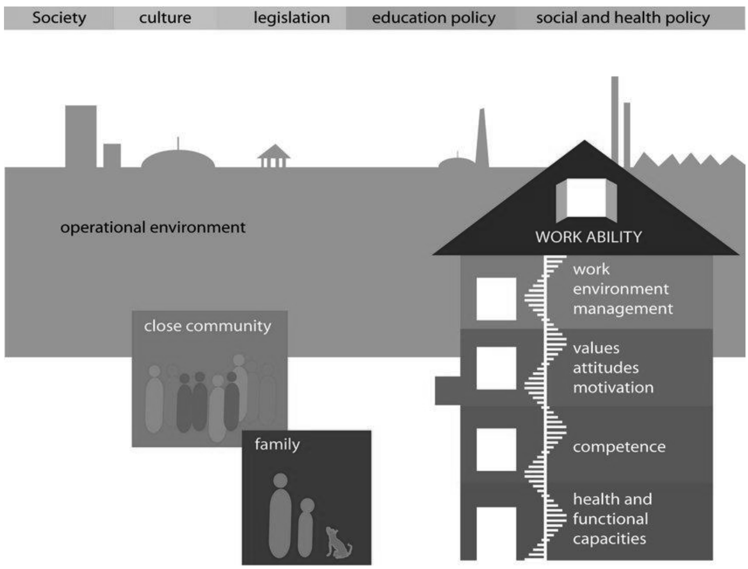

Figure 1. The house of work ability (J Ilmarinen, Finnish Institute of Occupational Health 2010)

There are several other similar concepts related to or interchangeable with work ability. Work capacity has been used synonymously [9, 10] and also capacity to work [11] work limitations [12], activity capacity [13] and work functioning [14]. These concepts are usually described in a context of using a certain measure, usually a self report instrument, observation protocol or a test procedure. Reasons for using these tools to measure work ability include the desire to find early signs of work ability loss, assess ability to return to work after sickness absence, the impact of disability on work, right to sickness benefits and the economic impact of health-related work disability.

Work ability can also be viewed as a continuum as suggested by Lindberg [15]. In this model, work ability is affected by both destructive and supportive factors along a sloping line. Somewhere along this line is the position where an individuals work ability is so reduced that she/he will resort to sickness absence.

Another concept with close relation to work ability is the model of human occupation (MOHO). This model was developed in the 1980s by Kielhofner [16]. These are one of the leading theories in occupational therapy practice worldwide. MOHO seeks to explain how occupation is motivated, patterned, and performed. By offering explanations of such diverse phenomena, MOHO offers a broad and integrative view of human occupation. Within MOHO, humans are conceptualized as being made up of three interrelated components: volition, habituation, and performance capacity. MOHO also emphasizes that to understand human occupation, we must understand the physical and social environments in which it takes place [16].

1.1.1 WAI AND WAS

The Work Ability Index (WAI) was constructed in Finland during the 1980s, as a method to measure work ability in an occupational setting [6, 17]. The aim when creating this index was to answer the question: "How good is the worker at present, in the near future, and how able is he or she to do his or her work with respect to work demands, health and mental resources?"[6]. It combines the individual's subjective assessment of his/her own ability to handle physical and mental work demands with information on diseases and consequent functional limitations. The index is sensitive to changes in work conditions, health status and physical fitness and it has been validated in different settings [18-20]. The WAI has shown to predict sickness absence in that workers who report a lower level of work ability are at higher risk for future sickness absence [21, 22]. There has been some criticism of the WAI. One is that it contains several questions that measures work ability more or less directly (diagnosis and sick leave) [22]. It has been suggested that the WAI does not capture the latest aspects of work ability and that the score is to heavily influenced by the individuals diagnosis [23, 24]. However, it has been found that individuals with chronic diseases can report excellent work ability [25]. WAI has also been criticized for its theoretical grounds, as it consists of a combination of self-reported work ability, diagnoses, symptoms and sick leave, which do not seem to form a single dimension of work ability as originally intended [19, 26]. Therefore simpler measures to monitor work ability have been called for [22, 27].

The first question in the WAI has been used in epidemiological studies to investigate work ability. The question is: “Assume that your work ability at its best has a value of 10 points. How many points would you give your current work ability?”. This question, also called the “work ability score” (WAS), has been compared to the total WAI and has shown a strong association and an equally good predictive value with regard to sick leave, health, age, job content and reported pain [22, 27]. Single items of WAI have also been examined as predictors of disability pensions and long-term sickness absence. The single item examined most often is WAS, which is a self-assessment of present overall level of work ability compared with lifetime best. In recent studies WAS predicted register-based disability pension among ageing Finnish municipal workers [28] and register-based long-term sickness absence among a national Swedish sample [29]. It also predicted self-reported long-term sick leave among female Swedish human service workers [22]. In the study by Roelen et al. [21] both the WAI and WAS predicted self-reported disability pensions among male Dutch construction workers.

1.2 WORKERS WITH NECK AND UPPER EXTREMITY DISORDERS

The prevalence of neck pain is high among workers in industrial countries [30, 31] and it has been shown that having neck pain is one risk factor for developing long term sick leave [32]. Musculoskeletal disorders are one of the main causes of sick leave and disability pensions, leading to high costs for both the individual and society [31, 33-35]. Regardless of the cause, these disorders can lead to reduced work ability, reduced productivity, work disability and early retirement [36-39]. It has been shown that workers with a high level of physical work demands have a higher risk of work-related disability compared with workers in less physically demanding jobs [8, 40]. Manual handling, awkward postures and repetitive work are commonly reported as causes for work-related neck disorders. Psychosocial factors such as high job demands, low support from supervisors and co-workers and low job control have also been reported as important contributors to musculoskeletal problems [41-45]. Recent studies have shown that workers with pain report lower work ability and also lower work performance and productivity [46, 47] compared with workers without pain.

In general, neck pain is more prevalent in women than men and the peak prevalence is at 45 years, compared to low back pain which peaks at 80 years [48]. Prevalence estimates differs across studies, a review found that the annual prevalence of neck pain in workers ranged from 27-48 % [49]. Among workers, 11–14% report activity limitation due to neck pain as measured with compensation claims, but it has been suggested that this is a significant underestimation [50]. In Sweden approximately 23 % of workers report neck pain during the last three months. Of those reporting neck pain 63 % were women [51]. It has been shown that having neck pain is one risk factor for developing long-term sick leave [32].

1.3 MEASUREMENTS OF WORK DEMANDS

Physical work demands

Workers with high physical work demands are well documented to be at elevated risk for impaired work ability [52, 53], musculoskeletal disorders (MSD) [54], cardiovascular disease [55] , all-cause mortality [56], long term sickness absence and early retirement from the labour market [57]. Specifically, prolonged standing, highly repetitive work, heavy lifting, working with the hands lifted to shoulder height or higher, and working with the back twisted or bent forward are physical exposures, that have been shown to predict impaired work ability, musculoskeletal disorders and enhance long term sickness absence [10, 41, 53]. Therefore, workers in job groups exposed to these physical factors at work are at particular need for health promoting initiatives for preserving or improving their work ability [53].

Risk assessments are an important tool to investigate risk factors at work and are meant to be used to prioritize changes at the work place. It is stated, both in Swedish and European safety and health legislation, that regular assessments should be carried out to prevent exposure to a potentially harmful work environment [58, 59].

Common methods for assessing risk factors for MSDs at the workplace are self-report, observational methods, and direct measurement [60]. One of the most used methods to identify risk factors for MSDs at work and evaluating the effect of ergonomic changes are observational methods [61]. There are several protocols for observation assessments available, some are more general to fit in a variety of setting and some more specialized [61]. It has been suggested that the physical exposures at work should be assessed in three dimensions; intensity, frequency and duration [62, 63]. These protocols typically include posture and intensity (force) and fewer include frequency and duration and some include vibration exposure.

In a recent review [64] it was found that some items (including time working with the hands above shoulder level and exposure to whole-body vibrations) showed good validity but other items (including trunk position and hand-held vibrating tools) showed a lower level of validity.

Many of the available tools are limited in their scope of application and do not sufficiently include the risk factors [65] Therefore, the use of several different assessment tools may be needed to assess the major risk factors in a job [66]. Due to differences in methods and diversity in user needs, the selection of an appropriate tool can be challenging. The selection of a method should be based on the objectives of its use, the type of work to be assessed, the individual(s) who will use the method and the resources available for collecting and analyzing data [61]. No single tool appears to have a clear advantage over any other. When trying to select the most appropriate method in a specific setting, users should thoroughly define their needs and how the information will affect decision-making. In addition to choosing an appropriate method, the sampling strategy is essential if the results are to be generalized beyond the observed sample [61].

Previous research has shown that some workers with pain rate their exposure higher or worse than those without pain, although their measured exposure was similar or lower [67, 68]. In epidemiologic studies, self-reports are the most common method to measure work demands. Most of these questions measure the presence or absence of an exposure or provide only crude or limited quantification of the intensity, duration, or frequency of these physical workload exposures. Generally, they permit relative ranking of exposure rather than absolute quantification [64].

The correctness of self-reported task durations is, at the best, moderate at the individual level, and this may present a significant problem when using self-reports in task-based assessment of individual job exposures. However, average self-reports at the group level appear reasonably correct and may thus be a viable method in studies addressing, for instance, the relative occurrence of tasks in a production system. A decision is needed to be made for when to apply or avoid self-reports to measure task durations, depending on study purpose and occupational setting [69].
In Sweden some of the methods that are used include the Rapid Entire Body Assessment (REBA) [70], Key Indicator Method (KIM) [65], the Risk management Assessment tool for Manual handling Proactively (RAMP) [66] and the Quick Exposure Check (QEC) [71].

QEC is a general observational method that was designed to assess exposure to work-related musculoskeletal risk factors affecting the back, shoulder/arm, wrist/hand, and the neck [71]. The method involves both the observer and the worker in the scoring of the work task. The QEC method was designed specifically to meet the requirements of both safety representatives practitioners and researchers. QEC estimates exposure levels for body postures, repetition of movement, force/load and task duration for different body regions, with a hypothesized score table for their interactions[71]. The original English version of QEC has been shown to be largely reliable and applicable to a wide range of jobs. The tool has been translated into several languages and are used both in practice and research in a variety of setting including industry, nursing, dentistry and taxi driving [72-78].

Psychosocial work demands

Strong evidence has been found for that high job demands, low job control, low co-worker support, low supervisor support, low procedural justice, low relational justice and a high effort–reward imbalance predict the incidence of stress related disorders [79].

Self-reported questionnaires, usually containing questions regarding presence of risk factors in the work environment, are widely used since they are inexpensive and easy to analyze. An intrinsic limitation of self-reported questionnaires is that they provide subjective measures, representing the occupational stress perceptions of individual workers. Objective assessments are based on observational approaches, including archival data (e.g. sickness absence, performance measures, accidents), and biological measures (adrenaline, cortisol, etc). However, these methods are much more expensive to administer [80].

Two of the most commonly used self-report questionnaires are the Effort-Reward Imbalance questionnaire (ERI) [81] and the Job Content Questionnaire (JCQ) [82]. The ERI measures effort-reward relations as determinants of well-being. It contains three unidimensional scales: effort (quantitative/qualitative load, overall increase and physical load); reward (financial, esteem, career, security, etc.) and over commitment (need for approval, competitiveness and latent hostility, impatience and disproportionate irritability and inability to withdraw from work obligations). The JCQ measures the content of respondents' work tasks using high-demand/low-control/low-support model of job strain development. There are also several widely used adaptations of the JCQ including the Swedish Demand-Control Questionnaire (DCQ) [83].

1.4 SICKNESS ABSENCE

Sickness absence is a complex phenomenon with it being a function of a disease or injury and its effect on work capacity, as well as the insurance rules that apply in a country. The rates of sickness absence vary but are generally high in the Nordic countries [84]. In Sweden, the number of cases of sickness absence has increased since 2010 with a slight decrease in 2016-17 [85] and the duration of sickness absence periods are increasing [86]. Very few studies of sickness absence have investigated whether the national context plays a role in the results [87]. Various risk factors for sickness absence, apart from disease, have been explored and identified, including old age, being a woman, low socioeconomic status, poor self-rated health and previous history of sickness absence [88, 89]. Factors at work, such as non-strenuous work and recuperation, have both been linked to lower levels of sickness absence and higher work ability [51, 90, 91].

There is limited scientific evidence for an effect of physically stressful work, and moderate scientific evidence for low psychological control over the work situation. Also there are limited scientific evidence for a correlation in time between unemployment and sickness absence, but insufficient scientific evidence for the causes of the association [88].

When measuring sickness absence registries are sometimes used. These can be found with employers and private or public insurance holders. In some studies self reported measures are also used, mainly because of the difficulty in obtaining registered data. Self-reported sickness absence has been shown to have a good correlation with recorded sickness absence [92, 93].

Not all workers who are sick or have some impairment are on sickness absence. To explain the decision of going on sickness absence Johansson developed the "illness flexibility model" [94]. This is an explanatory model of sickness absence including several factors affecting and explaining the actions taken in this process. It emphasises the choice people have to make between sickness absence and going to work when they feel ill. Ill health is the starting point for the model. The model assumes that life situations involve different possibilities to embrace ill health by giving different opportunities of remaining at work or being absent. Sickness absence can have other causes than ill health, both ''legitimate'' and ''illegitimate''. Further, the alternative action, attendance, may theoretically be considered as sickness attendance. However, most absence-inducing situations will be due to ill health. Loss of function affect workability but work ability is determined also by conditions at work. While some people may always have to work fully if they attend work others may be able to choose among work tasks, adjust work pace or work fewer hours. Adjustment latitude is a central concept in this model. It describes the opportunities people have to reduce or in other ways alter their work effort when e.g. feeling ill. The likelihood of retaining the ability to work should be greater where there is high adjustment latitude compared to where there is low. Work ability is thus seen as both individually and contextually determined. Attendance requirements describe the negative consequences of absence for e.g. the individual, work-mates or a third party. These requirements may originate both at and outside work. When one is absent, work tasks might accumulate, work-mates might get more to do, or activities are cancelled [94].

In Sweden, sickness absence insurance covers all inhabitants of working age. Sickness benefit amounted to approximately 80% of lost income up to a certain level. Sickness benefit can be granted to those who have reduced work capacity due to disease or injury. There is no economic reimbursement for the first day. The first 7 days in a sick-leave spell are self-certified. After that, a medical certificate is required. Sick pay is covered by the employer for the first 14 days of a sick-leave spell. Thereafter, sick-leave benefit is granted from the Swedish Social Insurance Agency.

To receive benefits, work ability needs to have decreased by at least 25% for the individual to be covered; it is possible to receive sickness benefits covering 25%, 50%, 75%, or 100% of work ability. The insurance is in principal limited to 365 days, with exception of certain diseases and conditions. There is no difference in insurance between if the disorder are work-related and non-work-related (1976:380, Occupational Injury Insurance). There is schedule for work ability assessments which should be made in different points during sickness absence. Different assessments of the work ability are made depending on how long the individual has been off work. During the first 90 days, work ability is assessed in relation to the individual's present work. After 90 days up to 180 days, work ability is assessed in relation to other available work tasks with the same employer. The individual can remain on sickness benefits it if the employer cannot adapt the work or relocate the individual within the workplace. After 180 days work ability is assessed in relation to any regular work on the labour market. If it is determined that there is work, that is regularly occurring in the labour market, that the individual is capable of performing, the person is passed on to the Unemployment Agency. After 365 days, sickness benefits will no longer be granted except for cases of severe illness. If a person's work ability is assessed as decreased for life, a disability pension may be granted.

1.5 GENDER AND AGE ASPECTS

Both gender and age have been shown to affect the prevalence of neck pain, level of work ability and sickness absence. It has been reported that women have higher prevalence of neck pain compared with men, which is partly explained by differences in work exposure between men and women [95-98]. Neck pain has also been reported as being more prevalent among older workers [96].

In Sweden it has been reported that 23 % workers report neck pain and among these 63 % are women. In general women report more musculoskeletal and mental disorders, seek care more often and have more sickness absence than men [85]. However, very little is known on long-term disability explored from a gender perspective. It has been showed that women on long-term sickness absence were slightly more likely to transition to permanent disability than men. Broader literature on disability indicates that women face a higher prevalence and incidence of work-related musculoskeletal disorders, a higher incidence of work disability, and a slightly longer duration of work disability [99].

Several authors have suggested explanations for gender differences in health and Punnett and Herbert synthesized possible reasons for gender discrepancies in the risk of work-related musculoskeletal disorders [100]. These could also help in understanding gender differences in occupational disability and return to work (RTW) patterns. First, men and women are not exposed to the same physical and psychosocial stressors at work. Even within an occupation or with the same job title, residual confounders can remain important, as physical tasks and psychosocial characteristics (e.g. decision latitude, social support) often differ by gender. Secondly, assuming exposure is properly measured, its effect may vary by gender due to physiological, genetic, psychological and social differences. The authors also mention some extrinsic factors: double exposure at work and at home as a risk for injury and a source of delay for recovery; different evaluation of symptoms; different propensity to report injury to the employer or seek medical care [100].

In Sweden several reports have been conducted to address gender differences in both health and work exposure [101-103]. Some of the conclusions from these report are: There is a significant segregation of the labour market which mean that men and women are found in different trades and occupations, with small changes during the last 30 years. Of all women working in Sweden, 72%

are in occupations dominated by women, and 68% of men are in male-dominated occupations. Many women are working in health care, education, social services, and administration, while men are more often occupied in sales, computer programming, transport, manufacturing, construction, and repair work.

It is stated that the existing gender pattern of the male norm in society is also found in working life. This segregation of the labour market, with different work tasks and work environments for men and women can be one explanation for the difference in work-related health. Several independent steps have been presented to try to explain inequalities in work-related health. Most important is the previously described segregated labour, but even when women and men have the same occupation, they may perform different work tasks, possibly related to attitudes of the employer and gender roles within the occupation. This could lead to that men can create more real variation in their work in a higher degree than women in the same occupation, due to gendered work tasks in working life. This is supported by findings of gendered organization in job rotation among employees, resulting in more varied works for men [101-103].

Several studies have found that the return to work after rehabilitation is higher for men than for women (104). A review of studies addressing factors that influence return to work after vocational rehabilitation found that men and women cope with pain differently, receive different types of rehabilitation interventions, and are treated differently by rehabilitation staff. It has long been indicated that pain has different consequences for men and women with regard to daily living, leading some to claim that a more complex pattern of factors influence women's experience of chronic pain and how women relate to work and other important domains of life. Several studies have indicated that high total strain due to the combination of employment and parenthood may cause role conflicts and lower women's chances of returning to work. Conversely, women's multiple roles may also promote health and well-being and counteract prolonged work absence. In addition, the subjective experiences of barriers that hinder return to work are connected to the result of the rehabilitation. Thus, the differences men and women face in societal expectations and behaviour norms might affect their own perception of barriers for participation in work, and thereby create different premises for the rehabilitation processes and successful return to work [104].

Many Western countries face an ageing workforce, which places demands on the workplace to accommodate problems associated with ageing, such as decreased muscle strength and decreased physical fitness [105-107]. Studies have shown that there is an association between older age and self-reported lower work ability; also, the association between physical work demands and work ability is stronger in workers closer to retirement then in younger workers [8, 108].

Ageing workforces pose a challenge for employers and workers' compensation boards as older workers experience poorer return-to-work outcomes following work-related injury, such as lower likelihoods of RTW , greater likelihoods of disability recurrences, and greater time-loss duration [109]. Work-related musculoskeletal disorders are the main cause of disability among occupationally active adults, and older workers typically experience a higher prevalence of musculoskeletal complaints than younger workers [110].

Tuomi and colleagues found that work ability in older workers was poorer among those doing physical work than among those doing mental work, for both women and men [6]. Although the authors did not highlight gender differences, elsewhere it has been reported that women have significantly lower scores on the Work Ability Index than men [8]. It was also found that good quality of work and the enjoyment of staying at work also predicted active and meaningful retirement [111].

2 AIM

The overall aim of this thesis was to gain knowledge of how work demands can influence the work ability and sickness absence of workers with neck and upper extremity disorders and also investigate a method that measures work demands. The specific aims of the individual studies (Paper I-IV) were:

- To investigate which physical and psychosocial exposures and combinations of these exposures were associated with excellent work ability, defined as self-reported work ability score of 10, among men and women with neck pain, and to investigate age and gender differences in this association. (Paper I)

- To investigate what exposure to work demands, physical and psychosocial, is associated with lower levels of sickness absence among workers with neck pain in different groups, by age, gender, length of sickness absence and work ability score. (Paper II)

- To investigate whether workplace interventions are effective in reducing sickness absence in persons with work-related neck and upper extremity disorders in different groups, according to age, sex, sickness-absence period and work ability score. Also, to investigate if disorder improvement after intervention reduces sickness absence and whether there is a difference between men and women with work-related neck and upper extremity (UE) disorders, regarding cause, interventions, work ability and sickness absence. (Paper III)

- To investigate the inter-rater reliability of the summary scores and individual items of the QEC, and to analyse various aspects of any disagreements found between assessors. (Paper IV)

3 MATERIAL AND METHODS

This thesis are based on four studies (Papers I-IV). Papers I-III are cohort studies exploring the effect of exposure to work demands on work ability and sickness absence among workers with neck pain. Paper IV is an experimental study measuring agreement and disagreement between two assessors using the Swedish translated QEC. An overview of the papers are found in Table 1.

Table 1. Summary of the design and methods of Papers 1-IV

	Paper I	**Paper II**	**Paper III**	**Paper IV**
Design	Cross-sectional cohort study	Longitudinal cohort study	Longitudinal cohort study	Reliability study
Data collection	Telephone interview and questionnaire	Telephone interview, questionnaire and registries	Telephone interview, questionnaire and registries	Field measures
Study sample	Workers with neck pain	Workers with neck pain	Workers with neck pain	Ergonomists from OHS
N	3212	4567	1750	7+1
Outcome	Excellent work ability	Registered sickness absence	Registered or self-reported sickness absence	Levels of agreement or disagreement

OHS=Occupational Health and Safety

3.1 STUDY DESIGNS

Papers I-III uses survey and registry data from Statistics Sweden. Statistics Sweden conducts the Labor Force survey each month on a randomized sample of the Swedish population age 15-74 years. The sample is drawn to represent the total population with regards to: sex, region, citizenship and occupation. The survey is conducted by telephone and describe current occupational aspects to provide a picture of the current labor market.

As a compliment to the Labor Force survey the Work Environment survey and the Work Related Disorders surveys are added every two years. The Work Environment surveys carried out during the last quarter and The Work Related Disorders during the first quarter and are based on the sample of the Labor Force survey. Most of those who participate in the Work Environment survey will be included in Work Related Disorders survey in the following year. These surveys are aimed at persons registered in Sweden between the ages of 16 and 64 and all participants have some form of employment.

3.1.1 THE WORK ENVIRONMENT SURVEY

The Work Environment Survey are used in Papers I-III. Since 1989, Statistics Sweden has conducted the Work Environment Survey every two years on behalf of the Swedish Work Environment Authority. The purpose of the surveys is to describe the work environment of the employed population aged 16 to 64. The report highlights how the employed population experienced their work environment and any disorders caused by it. The survey questions strive to provide an objective description of work environment conditions such as heavy lifting, noise, cold and work in a twisted position, or sitting for more than two hours straight. Other questions measure the work environment experience, for example, if you have too much work to do, have monotonous work assignments, or if you are overall satisfied with your job. Some questions ask about physical disorders such as pain or mental disorders like sleeping difficulties.

The Work Environment Survey is conducted each year based on a sample of about 10 000-16 000 persons of the employed Swedish population aged 16-64. A number of questions about the work environment are asked in Statistics

Sweden's regular Labour Force Survey, which is conducted as telephone interviews. Those who participate in the telephone interview subsequently answer a questionnaire. The sample is sufficiently large to enable descriptions for different categories: occupation, economic activity, socio-economic group, sex and age. A very extensive statistical material can be created by combining several surveys, which enables breaking down and reporting the labour market in many different subgroups. In spite of the relatively large number of respondents, some study domains are small and therefore give uncertain results for individual years if broken down, for example, by sex and occupation or sex and industry. Reporting data by sex is very important since women and men are employed in different parts of the labour market and thus have different work environments.

The questionnaire consists of detailed questions about work environment conditions, both physical and psychosocial, and attempts to provide an objective description of the work environment. The development and the validation of the method used in these surveys is described [112, 113], and has also been developed further by Statistics Sweden. In the development of the questionnaire an extensive description of different work environments were made by conducting technical measurements, literature reviews, expert interviews and observations. When the work environments were described, questionnaires were sent out to workers and the results were compared. The conclusion drawn were that survey questions regarding work can give relatively dependable answers regarding the actual work environment. In 2001 an analysis of drop-out from the survey made in 1999 was made. It was found that the drop-outs were larger among men, young workers, workers with low education, low income and workers who were born outside Sweden. There were also a larger drop-out among workers with part time and temporary employment and also among self-employed workers [114]. The total drop-out is reported as 20 % in the Labour Force survey (telephone), a further 20 % from the Labour Force survey to the Work Environment Survey (telephone) and another 30 % who did not answer the Work Environment Survey questionnaire (postal). The inclusion and drop-out in Paper I can be seen in Figure 2.

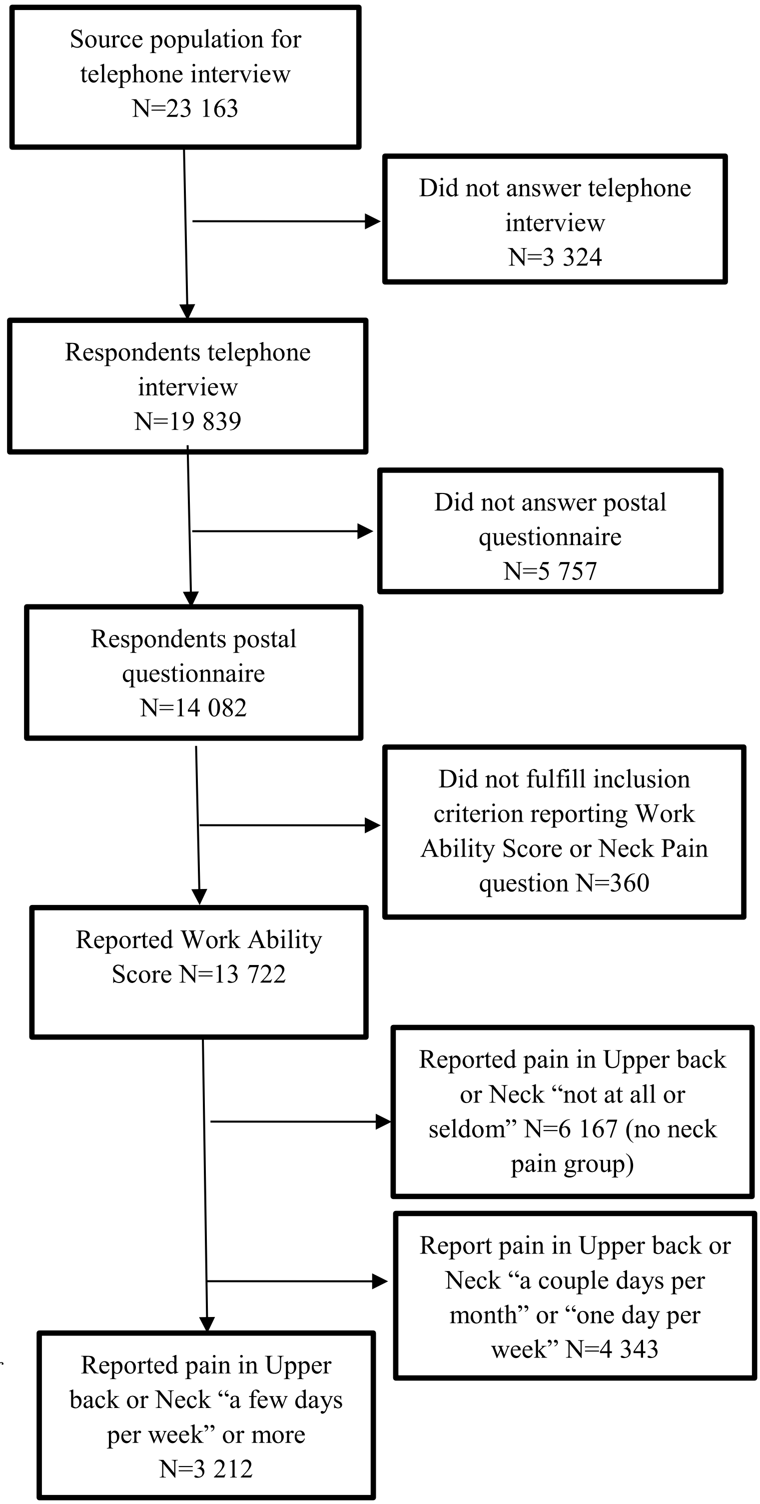

Figure 2. Flowchart of inclusion and drop-out in Paper I

3.1.2 THE WORK RELATED DISORDERS SURVEY

The Work Related Disorders Survey is used in in Paper III. The purpose of the Survey on Work-related disorders is to describe disorders that people relate to their work, the parts of the body affected by the disorders, and what it is about their work that could have caused the disorders. The survey begins with two questions:*1. During the last 12 months, have you at any time experienced any physical, i.e. bodily, disorder as a result of your work that has made it difficult for you to work at your job or carry out everyday housework? Consider disorders as resulting from an accident at work, conditions at work or an accident on the way to or from work. 2. During the last 12 months, have you at any time experienced any type of disorder other than a physical disorder as a result of your work that has made it difficult for you to work at your job or to carry out everyday housework? Consider disorders as resulting from stress at work, the content of your work, poor relations with your superiors or fellow employees, threats or violence, etc.* Individuals who answered YES to one or both of these questions are then asked additional questions about the disorders they have experienced. Questions asking when the disorder started and whether an occupational injury report had been submitted make it possible to compare the findings with the statistics on occupational injuries from the Swedish Occupational Injury Information System (ISA) maintained by the Swedish Work Environment Authority. ISA measures the *incidence of new occupational injuries* during a calendar year, whereas the Survey on Work-related disorders measures the *prevalence of both new and older cases of work-related disorders*. The Survey on Work-related disorders is carried out as a supplementary survey to the Labour Force Survey (LFS).

3.1.3 THE LISA DATABASE

The Longitudinal Integration Database for health Insurance and Labor Market Studies (LISA) contains demographic information such as employment, education, family, sickness absence, disability pension and so forth. The database is administered by Statistics Sweden and include administrative data from several sources. The purpose of the database is to use registry data on factors in life in relation to labor market, work and health. It is constructed to provide easy and flexible access to data primarily for research. LISA contains data on all Swedish residents older than 15 (16 before 2010) years since 1990. For Papers II and III the LISA database was used to retrieve data on sickness absence.

3.1.4 PAPER I

This was a cross-sectional study using material obtained from the National Work Environment survey conducted by Statistics Sweden (SCB) from 2007 and 2009. The Work Environment survey is part of the larger Swedish Labour Force survey. The Swedish Labour Force survey is conducted by a telephone-based interview with a representative sample of the general Swedish population between 16 and 74 years old. Those who answered the survey and were between 16 and 64 years, employed and not on long-term sick or maternity leave were asked 25 extra questions with regard to their work environment. They also received an additional questionnaire sent by mail. A total of 19,839 individuals from the Labour Force survey answered the telephone interview (86 % of the source population), and were sent the Work Environment survey questionnaire. Of these 14,082 answered the questionnaire (72 % response rate).The study sample for the present study was selected by including those reporting pain in the “upper back or neck” (neck pain) after work at least two days per week during the last 3 months (Figure 1). Those who reported no pain in “upper back or neck” (no neck pain) were used as a reference group.

3.1.5 PAPER II

This was a follow-up study using data sourced from the Swedish Work Environment survey from 2009, 2011 and 2013, and from the Longitudinal integration database for health insurance and labour market studies (LISA) database from 2010, 2012 and 2014. All Swedish residents are included in the LISA database. Individuals in these databases were linked using the Swedish personal number in Statistics Sweden’s (SCB) Microdata Online Access (MONA) system. The Work Environment survey is an addition to the annual Swedish Labour Force survey.

The Work Environment survey is part of the larger Swedish Labour Force survey. The Swedish Labour Force survey is conducted by a telephone-based interview with a representative sample of the general Swedish population between 16 and 74 years old. Those who answered the survey and were between 16 and 64 years of age, employed and not on long-term sick or maternity leave, were asked 25 extra questions with regard to their work environment. They also received an additional questionnaire sent by mail. 18786 persons answered the questionnaire (approximately 70 % response rate).

3.1.6 PAPER III

This was a follow-up study using material from Sweden's Work-related disorders survey from 2010, 2012 and 2014; from its Work Environment survey from 2009, 2011 and 2013; and from the 'Longitudinal integration database for health insurance and labour market studies' (LISA) database from 2011 and 2013. All Swedish residents are included in the LISA database. Individuals in these databases were linked using the Swedish personal number in Statistics Sweden's (SCB) Microdata Online Access (MONA) system. Both the Work-related disorders and the Work Environment surveys are additions to the annual Swedish Labour Force Survey. The Work-related disorders survey is conducted by telephone interview, with questions about work-related accidents and disorders. For inclusion in this study, the following question was used: 'Now we would like to know about disorders caused by circumstances other than accidents at work. These might be workload, doing a job that is physically demanding or monotonous, or exposure to chemicals, noise, stress or, say, bullying. Have you at any time during the past 12 months suffered from disorders caused by circumstances of this kind at work?' Also used was a question about where the disorders were located: 'During the past 12-month period, because of work, have you had problems with your neck, shoulder or arm?' If a worker answered yes to these two questions, the worker was included in this study.

The population eligible for the Labour Force Survey were all persons aged 15–74 years and registered in Sweden. After the questions in the Labour Force survey were completed, all individuals aged 16–64 years, employed and not on long-term sickness absence, were invited to answer questions either from the Work-related disorders survey or the Work Environment survey, depending on when the Labour Force survey was conducted. The Work Environment survey is conducted every two years during the last quarter of the year, and the Work-related disorders survey is conducted during the first quarter of the following year. Approximately 70% of those who participate in the Work Environment survey are also included in the Work-related disorders survey.

The Work-related disorders survey was used as the main source of data for this project, as it includes questions on work-related disorders, causes of the disorders, interventions and self-reported sickness absence. The only question from the Work Environment survey that was used was the question on work ability, the Work Ability Score (WAS).

In the years 2010, 2012 and 2014 a total of 39,717 workers aged 16–64 years were asked whether they had had any work-related disorders during the last 12 months. Of these, 11,287 (28%) replied that they had had a work-related disorder (physical or other types) during the last 12 months. On the question about work-related neck and UE during the last 12 months 1750 replied that they have or had had work-related neck or UE disorders during the last 12 months, and these respondents were included in this study.

3.1.7 PAPER IV

This was an inter-rater reliability study. Invitations were sent out to OHS ergonomists in western Sweden, and eight agreed to participate. One dropped out due to a change in work situation, leaving four women and three men aged between 38 and 60, all with at least seven years' experience of making ergonomic risk evaluations. Before the exposure assessments were carried out, the participants took part in a training session to learn the QEC method. The training session was conducted by an experienced ergonomist who had previously been trained to use the English version of the QEC by one of the original developers. The training session lasted 6 hours and included general information on risk assessments, background on the development and use of the QEC method, and training by assessment of three different work tasks from video recordings: repacking of boxes with automotive parts, hanging of hospital clothes in a hospital laundry, and packaging of small parts on an assembly line. The assessments were then adjusted by the course leader and were followed by a discussion about the assessments.

3.2 DATA COLLECTION

3.2.1 OUTCOME VARIABLES

The outcome variables varied between the different papers. In Paper I the outcome variable was the self-reported work ability. Work ability was measured with the work ability score question (WAS):

"Assume that your work ability at its best has a value of 10 points. How many points would you give your current work ability?".

In the Work Environment Survey the WAS has a possible score of 1-10 as a 0 would mean that the individual cannot work. This question was asked during the telephone interview conducted by Statistics Sweden. Studies [22, 27] have shown that the work ability score question has good validity and reliability when compared with the total WAI. In this study the work ability score was categorized in three levels: 1-7 (poor/moderate), 8-9 (good) and 10 (excellent). In the statistical analysis, excellent work ability was compared with poor/moderate work ability.

In Papers II and III, the outcome measure was sickness absence. I both papers sickness absence was obtained from the LISA database. The measure used was total net days (2 days on 50% sick leave measured as one net day) >14 days during the year following participation in the Work-related disorders survey (N-Days). The registered sickness-absence is for all causes. The LISA database contains demographic information such as employment, education, family, sickness absence, disability pension and so forth. In Sweden, sickness benefits are granted to those who have impaired work capacity due to disease or injury. There is no financial reimbursement for the first qualifying day. The initial 7 days of a sick-leave period are self-certified; after that, a medical certificate is required. Sickness benefits are covered by the employer for the first 14 days of a sick-leave spell. Thereafter, sickness benefits are granted by the Swedish Social Insurance Agency.

Paper III also uses self-reported sickness absence as an outcome. Self-reported sickness absence was measured in the Work-related disorders survey. The question used to measure sickness absence was: 'Have you during the last 12 months received sick-leave benefits (or similar), full- or part-time, as a result of these disorders?' If the individual stated that they had received sick-leave benefits, another question was asked: 'How long in total during the last 12 months did the sickness absence or sick-leave benefits last as a result of these disorders?' The alternatives given for this question were: 1–3 days, 4 days to 1 week, 8 days to 2 weeks, 2–4 weeks, 4 weeks to 2 months, 2–3 months, 3–6 months, 6 months to 1 year, the whole year or more. For this study, a median of each of these was used to calculate the total number of self-reported sickness absence days (S-Days).

3.2.2 EXPLANATORY VARIABLES

In papers I and II the explanatory variables used came from the Work Environment survey. These variables were self-reported from a questionnaire. The variables used were: In the Work Environment survey questionnaire, participants were asked to answer whether their jobs involved physical exposure, using a six-category scale: "no, not at all", "some (approximately 1/10 of the time)", "roughly ¼ of the time", "half of the time", "roughly ¾ of the time" and "nearly all the time". In this study those who reported exposure "half of the time" or more were classified as having *high exposure* and those who reported exposure less than half of the time or no exposure were classified as having *low exposure*. This exposure level has previously been used in a similar study [115]. The questions used in this study were the regular questions used in the SCB survey and were not formulated specifically for this study.

The questions regarding physical exposures were: *"Vibrations that make your whole body shake and vibrate"; "Vibrations from hand-held machines or tools"; "Does it happen at work that you bend or turn in the same way many times per hour for several hours in 1 day?"; "Do you have to lift at least 15 kg several times a day?"; "Do you sometimes work bending forward without supporting yourself with your hands and arms?"; "Do you sometimes work in a twisted posture?"; "Do you sometimes work with hands raised to the level of your shoulders or higher?"; " Does your work require you to perform only repetitive work movements at least twice every minute?"; "Do you sometimes work in a sitting position?"*

The variables for psychosocial exposure were: demand, control and support. These variables were created by SCB by indexing the answers for several questions into *high* or *low*. The index for demand was calculated based on following four questions. "Is your work, *half of the time* or more, so stressful that you do not have time to talk or even think of anything other than work";

"Does your work require your undivided attention and concentration *nearly all of the time*"; "Do you, *every week or more often,* have so much work to do that you have to skip lunch, work late, or take work home with you?"; "Do you *agree completely* or *agree to a certain extent* that you have far too much to do at work?". Replying at most one of the questions with the answer alternative given in *italic* text categorized a worker as having *low demands* and two or more of the answer alternative given in *italic* text categorized a worker as having *high demands*.

The index for control was calculated by using the following four questions. "Is it possible for you to set your own work tempo *half of the time* or *less*"; *"*Is it, *mostly not* or *never*, possible for you to decide on your own when various tasks are to be done?", *"*Are you*, mostly not* or *never,* involved in planning your own work?"; *"Do you agree completely* or *agree to a certain extent* that you have too little influence?". Replying at most two of the question with the answer alternatives given in *italic* text categorized a worker having *high control* and replying at least three of the question with the answer alternatives given in *italic* text categorized a worker having *low control*.

The support index was calculated using the following two questions: "*Can you receive support and encouragement from your superiors when your work becomes troublesome?*"; "*Can you receive support and encouragement from your fellow workers when your work becomes troublesome?".* Worker answering having support and encouragement from both superiors and fellow workers *"mostly"* or *"always"* were considered workers with high *support* and workers answering having support and encouragement from either superiors or fellow workers *"mostly not"* or *"never"* were considered workers with *low support*.

In paper II the variables came from the Work Related Disorders survey. These questions were asked during a telephone interview. Workplace interventions were measured by the question: *'Were any of the following measures taken to alleviate the disorders, to stop them from getting worse or returning?'*. If the individual stated that interventions had taken place, the following question was asked: *'What interventions have been done in the workplace where your disorders developed?'* Several alternatives were used for this study*: in the physical work environment, in the work organization, in the work methods, education for the workers, use of personal protection or aides, individual support, and other*. Respondents could choose one or more answers. If the respondent answered that interventions had been made the following question was asked: *"Have your disorder improved as a result of the intervention? (yes/no)"*.

3.3 QUANTITATIVE ANALYSIS

3.3.1 PAPER I

For all analyses in this study, SAS version 9.3 (SAS Institute, Cary, NC, USA) was used. Descriptive data on the neck pain and no neck pain group were derived through frequency analyses. Spearman's rank correlation was calculated between all relevant exposure categories to check for collinearity. All analyses were stratified by age group and gender. The exposure category *high exposure* was used as reference category for physical exposures as it was hypothesized that *high exposure* would have a negative effect on work ability. The work ability score, 10 (excellent) versus 1-7 (poor), was used as the outcome variable. Bivariable logistic regression was used to investigate the relationship between the outcome, work ability score 10, and an explanatory variable, physical or psychosocial work exposure. Prevalence ratios were calculated based on the result of the bivariable logistic regression [116]. An association was considered significant when the Prevalence Ratio (PR) and the corresponding 95% Confidence Intervals (CI) were above 1. By a reversed significant association, we mean to have a PR and corresponding CI below 1.

To investigate whether there was a different level of association if workers are exposed to several exposures as opposed to one, a second set of bivariable logistic regression was performed. Combinations of physical and psychosocial exposures were made according to author's (SO, EG, MH) ergonomic experience to reflect exposure combinations seen in different occupations. Workers reporting *low exposure* to these combinations were compared to workers reporting *high exposure* to these combinations.

3.3.2 PAPER II

For all analyses in this study, SAS version 9.3 (SAS Institute, Cary, NC, USA) was used. Descriptive data on the neck pain and no neck pain groups were derived through frequency analyses. Wilcoxon Sum Rank Test was performed to estimate the association between high or low exposure to physical and psychosocial work demands and sickness absence as measured by n-days [117]. A difference between high and low work demands was considered significant when $P < 0.05$. The analyses were stratified for gender, age group and WAS. Quantile regression is a semi-parametric statistical method that investigates the difference between high and low work demands and several percentiles of sickness absence [118]. A quantile regression analysis was used to estimate the association between high or low exposure to different work demands and sickness absence (n-days) in the 90th, 95th and 99th percentiles. Coefficients from quantile regression are interpreted similarly to coefficients of ordinary linear regression, except that a quantile regression coefficient indicates the change in the value at the given percentile, not the mean, of the outcome variable.

3.3.3 PAPER III

Wilcoxon Rank Sum Test was performed to estimate the association between workplace intervention and sickness absence, both S-Days and N-Days, and between improvement after intervention and sickness absence, both S-Days and N-Days. The analyses were stratified for sex, age group and WAS.

A quantile regression analysis was used to estimate the association between receiving a workplace intervention, improvement after intervention and sickness absence (N-Days) in the 90th to 99th percentiles. This analysis was also performed with an adjustment for sex. Coefficients from Quantile regression are interpreted similarly to coefficients of ordinary linear regression except that a quantile regression coefficient indicates the change in the value at the given percentile, not the mean, of the outcome variable. Quantile regression is a semi-parametric statistical method that investigates the association of workplace intervention and several percentiles of sickness absence [118].

For all analyses in this study, SAS version 9.3 (SAS Institute, Cary, NC, USA) was used. Descriptive data on the neck and UE disorders group and on the no neck or UE disorders group were derived through frequency analyses.

3.3.4 PAPER IV

Several statistical methods were used to investigate the inter-rater reliability of the Swedish QEC. To measure exact agreement, percentage agreements (PA) were used for all the items of the QEC, calculated as the number of assessments in agreement divided by the total number of assessments. The level of agreement between two assessors was measured with the weighted kappa (κ_w) [119] for both the individual items and the total scores, calculated using version 9.4 of the SAS software package. Levels of agreement were categorised as poor (<0), slight (0.01–0.20), fair (0.21–0.40), moderate (0.41–0.60), substantial (0.61–0.80), and almost perfect (0.81–0.99) [120]. For two items, wrist position and visual demands, simple kappa was used as these items only have two categories.

Intra-class correlation coefficients (ICC) were calculated for the inter-rater agreement of the total scores, in order to make comparisons possible with other similar studies that have used this statistic [71, 74, 77]. Version 23 of the IBM SPSS software package was used for this calculation. A rank-based method that allows for separate analyses of the systematic and individual components of an observed disagreement between assessors was also used [121].

Systematic disagreement was calculated using relative position (RP) and relative concentration (RC). RP estimates the extent to which the distribution of scores from one assessor is systematically concentrated towards higher or lower score categories than the other assessor, while RC estimates the extent to which the distribution of scores from one assessor is more or less concentrated on the scale than that of the other assessor. Random disagreement was calculated using relative rank variance (RV), which is a measure of the variation that cannot be explained by a systematic disagreement between the assessors.

The method measures the difference between the probabilities Prob (X<Y) – Prob (Y<X). A positive RP indicates that Y has systematically higher categories than X. RC measures the Systematic change of how the assessment are concentrated on categories of the scale. It is the difference between

probabilities $P(X<Y<X) - P(Y<X<Y)$. Positive RC indicates Y is more concentrated than X. The smaller the RV, the less variation there is between the assessors' scores [121]. Values for RP and RC can range from -1 to +1 and RV from 0 to 1. Values close to 0 can be interpreted as a negligible level of disagreement [121]. A free Excel software program was used to calculate the measures of systematic and random disagreement and the 95% confidence intervals [122].

The standard error of measurement (SEM) were calculated using the formula: $\text{SEM}=\text{SD}\times\sqrt{(1-r)}$. The minimal detectible change (MDC) was calculated using the SEM according to the following formulae: $\text{MDC}=1.96\times\sqrt{2}\times\text{SEM}$. The $\sqrt{2}$ is used to account for the underlying uncertainty when using two assessors. The value 1.96 is the z score associated with the 95% confidence level, and r is the coefficient of the inter-rater reliability, which was estimated by ICC [123]. MDC% was calculated as (MDC/mean) x 100% [123].

3.4 ETHICS

In the surveys performed by Statistics Sweden (used in Papers I-III) informed consent was given when answering the telephone interviews and when answering the postal questionnaires. In Paper IV signed consent was given by all participating workers. They received written and verbal information regarding the study, including contact information if they wished to withdraw. All studies in this thesis were conducted following the ethical standard of the 1964 Declaration of Helsinki.

The papers included in this thesis received ethical approval from the regional ethics board Gothenburg, Sweden (Dnr:221-15 and 114-08).

4 RESULTS

4.1 PAPER I

Of the total 14,082 persons who answered the Work Environment survey questionnaire a total of 3,212 reported neck pain (23%). The mean age in the study sample was 44 years. There was a larger proportion of females (65%) than males (35 %) among workers reporting neck pain. In the female group 43 % reported neck pain and in the male group 25 % reported neck pain. The most common occupational group among women was service, care and shop sales workers for both those who reported neck pain (30%) and those who reported no neck pain (27 %). Among men, craft and related, trade workers, miners and construction workers (24%) were the most common occupation group for those that reported neck pain and among those who reported no neck pain the most common occupation was technicians, associated professionals and nurses (22 %).

The most frequently reported physical work demand for men with neck pain was "frequent trunk rotations" and for men reporting no neck pain was "seated work". For women the most frequent physical exposure was "seated work" for both those reporting neck pain and those reporting no neck pain. The most frequent psychosocial exposure was reporting "high work demands" for both men and women with and without reported neck pain.

There was an association found between self-reported l*ow exposure* to most physical work demands and self-reported excellent work ability for both men and women reporting neck pain in the 50-64 years age group except for seated work.

The strongest associations for self-reported excellent work ability and work demand exposure among men and women with neck pain were found in the 50-54 years age group. For men the strongest association was self-reported *low exposure* to "hand held vibration tools" (prevalence ratio (PR) 1.77 (95 % confidence interval (CI) 1.26-2.89). For women, the strongest association (with excellent work ability) was self-reported *low exposure* to "working with hands in shoulder level or higher" (PR 1.41(95 % CI 1.09-1.99). There were no significant associations found in the youngest age group, 16-29 years, with any of the measured physical exposures and excellent work ability for neither men nor women reporting neck pain. Physical exposure was the most common factor to be associated with excellent work ability for workers reporting neck pain, especially in the highest age group. The associations were mainly found in the 50-64 years age group and the associations were generally stronger among men than women. The only exposure found with excellent work ability in the no neck pain group but not in the neck pain group was *low exposure to* “whole body vibrations”.

“Seated work” was the only physical exposure showing a reversed association between self-reported *low exposure* and excellent work ability for workers reporting neck pain. This association was found for both men and women in the age group 50-64 years and 30-49 years.

Regarding psychosocial exposure an association was seen for both men and women reporting neck pain in the 30-49 years group between self-reported “high support” and self-reported excellent work ability, but this was not seen in any of the other age groups. Self-reported “low demands” was reverse associated with excellent work ability among men and women in the 50-64 years group. In the 16-29 years age group an association was found, among women, between self-reported “low demands” and excellent work ability, this was not found in any other group.

In the analysis performed by combining different exposures, associations were found for self-reported *low exposure* to all combinations which included physical exposures. The combination including *low exposure* to seated work showed a reversed association for both men and women reporting neck pain, especially in the 50-64 years age group.

When introducing exposure to “low demands” with the physical exposure combinations the association with excellent work ability did not increase. The combination containing *low exposure to* “seated work” and the combination only containing psychosocial exposures showed a reversed association with excellent work ability for both men and women reporting neck pain in the 50-64 years age group.

4.2 PAPER II

There was a difference in sick days found between the groups reporting low or high exposure to several physical work demands. The groups reporting low exposure to: lifting ≥15 kg, twisted work posture, leaning forward without support and frequent trunk rotations had fewer n-days (net sickness absence days >14 days two days on 50% sick leave were counted as one n-day). Among men, a difference was found for low exposure compared to high exposure, to whole-body vibrations and working with hands above shoulder level. For women, reporting high control was associated with fewer sickness absence days compared to having low control. A difference was found among the group who reported high exposure compared to the group reporting low exposure to seated work and for having high control over one's work and fewer n-days. The analysis divided on age groups found differences mainly in the middle and older age groups, except for having high control, where differences were found for both the youngest and oldest age groups.

The quantile regression analysis showed a difference in lower number of n-days on the 90th percentile for those workers who reported low exposure to lifting ≥15 kg (14 compared to 28 n-days), twisted work posture (15 compared 26 n-days), leaning forward without support (14 compared to 34 n-days) and frequent trunk rotations (12 compared to 24 n-days). There was a lower number of n-days on the 90th percentile for those workers reporting high exposure to seated work (13 compared to 27 n-days) and for high control (13 compared to 24 n-days).

On the 95th percentile there was a lower number of sickness absence days among workers reporting low exposure to lifting ≥15 kg (50 compared to 89 n-days), twisted work posture (54 compared 73 n-days), whole-body vibrations (71 compared to 130 n-days), leaning forward without support (51 compared to 94 n-days) and frequent trunk rotations (42 compared to 84 n-days). There was a lower number of n-days on the 90th percentile for those workers reporting high exposure to seated work (45 compared to 86 n-days) and for high control (40 compared to 83 n-days).

On the 90th percentile there was a lower number of sickness absence days among workers reporting low exposure to frequent trunk rotations (199 compared to 297 n-days).

4.3 PAPER III

There were a total of 11287 persons who reported that they have or had had work-related disorders during the last 12 months. Of these 1750 reported neck or upper extremity (UE) disorders. In this group there was a larger proportion who reported ‘poor’ or ‘moderate’ work ability compared to the group with work-related disorders but not a work-related neck or UE disorder .

The most commonly reported causes of the work-related neck or UE disorder were, for women, work stress (38%), and among men, heavy manual work (27%).

A total of 622 persons (35%) reported that they had received workplace interventions, 37% of the women and 31% of the men. The most common intervention was in the physical work environment for both men and women, with 66% of the women who received an intervention reporting that the disorder improved as a result of the intervention, and 69% of the men reporting improvement.

Among those who reported interventions, the largest proportion were found in the age group 30–49 years; 38% of those in that age group reported that they had received interventions. Among those who reported a work ability score and reported that they had received interventions, the highest proportion was among those who reported excellent work ability (42%).

The mean number of self-reported median sickness absence days during the last 12 months (S-Days) was 65 days for female workers and 49 days for male workers. The mean number of registred net days >14 days (N-Days) during the following year was 17 for female workers and 9 for male workers. Among the workers who reported work ability score (WAS), the highest number of sickness absence days, both S-Days (self-reported) and N-Days (registered net days), was found in the group reporting poor work ability (WAS 1–5). The median number of N-Days for the workers reporting neck or UE disorders was 0, for the 75th percentile was 0, for the 90th percentile was 26.5 days and for the 95th percentile was 89.25 days.

There were no statistical difference in either S-Days or N-Days between those who reported receiving a workplace intervention and those who did not. There was a statistical difference found between the groups who reported improvement of work-related neck or UE disorders after workplace intervention both in S-Days and N-Days and those who did not report improvement after intervention. For S-Days, the difference was found in the total group, and for N-Days, in the total group, among female workers and among those reporting good work ability (WAS 8–9).

The quantile regression analysis showed a statistically significantly lower number of sickness absence N-Days for those workers who reported improvement after intervention on the 91st, 92nd and 95th percentiles. The differences in number of N-Days were for the 91st percentile 54 days (15 to 69 days, P = 0.012), for the 92nd percentile 54 days (17 to 71 days, P = 0.019) and for the 95th percentile 101 days (39 to 140 days, P = 0.018). When adjusted for sex, the patterns were as above. There were also a significant difference in the sickness absence days between men and women in the 91st and 92nd percentiles (P = 0.042 and P = 0.017, respectively).

4.4 PAPER IV

The ICC analysis for the total scores showed agreements of between 0.83 (shoulder/arm) and 0.95 (neck). PA was 63–100% (substantial to almost perfect) for the individual items and 71–88% for the total score. For the total scores, κ_W was between 0.61 (shoulder/arm) and 0.85 (neck), indicating substantial to almost perfect agreement. For the individual items scored by the assessors, κ_W was between -0.04 and 0.77, with the highest value seen for back motion and the lowest for wrist/hand position, indicating poor to substantial agreement. Agreement for the items scored by the workers varied from 0.88 to 1.

Back position showed a level of systematic disagreement, with an RP of -0.06 (95% CI: -0.17; 0.03) and RC of 0.10 (95% CI: -0.02; 0.22), but no statistically significant random disagreement (individual variability), with an RV of 0.02 (95% CI: 0.00; 0.07). All other assessments of individual items except shoulder/arm motion, wrist/hand position, and wrist/hand movement showed similar non-significant results. Shoulder/arm motion assessments showed an RP of 0.24 (95% CI: 0.12; 0.36), wrist/hand position assessments showed an RP of -0.16 (95% CI: -0.27; -0.04) and the wrist/hand movement assessments showed an RC of -0.13 (95% CI: -0.24; -0.02). The statistical analysis showed no statistically significant random disagreement between assessors as measured with the relative rank variance (RV) for any of the items.

For the total scores there was a statistically significant level of disagreement for the shoulder/arm item, with an RP of 0.13 (95% CI: 0.02; 0.23), and no statistically significant random disagreement.

5 DISCUSSION

The overall aim of this thesis was to gain knowledge of how work demands can influence the work ability and sickness absence of workers with neck and upper extremity disorders.

5.1 THESIS FINDINGS

5.1.1 WORK DEMANDS ASSOCIATED WITH EXCELLENT WORK ABILITY

This study shows an association between self-reported excellent work ability and self-reported *low exposure* to most measured physical and psychosocial work demands with the strongest associations in the 55-64 years age group. This is in agreement with previous studies which have shown that older workers are more affected by physical work demands compared with younger workers [8]. Furthermore some studies have shown that older workers who rate their work ability lower in relation to their work demands also have a higher risk of being on sick leave in the future [124].

The physical factors which showed the strongest association with excellent work ability for men with neck pain were: self-reported *low exposure* to “hand held vibrating tools”, “lifting ≥15 kg” and “leaning forward without support”. For women, they were self-reported *low exposure* to working with the “hands at shoulder level or higher”, “leaning forward without support” and “lifting ≥15 kg”. These work demands have been reported as risk factors for developing work related neck pain [44, 96, 125].

The analysis made using combination exposures did not greatly increase associations compared to the single exposure analysis. When creating the classifications for the single exposure categories all workers reporting low exposure to one work demand were compared to those reporting high exposure to the same work demands. This means that in both groups there are workers both reporting high and low exposures to other work demands. It was not possible to include only workers reporting high or low exposure to only one work demand and no other work demands.

Self-reported *low exposure* to “seated work” showed a reversed association with excellent work ability in the middle and older age categories. This can be interpreted as meaning that seated work is generally less physically demanding, which could be a positive factor for having excellent work ability with increasing age for workers with neck pain. It has been reported that standing, walking, lifting and other physically demanding exposures put stress on the cardiovascular and musculoskeletal systems which generally become weaker with age [106]. This could be one explanation as to why work ability and physical exposure are associated with age. Prolonged seating has recently been suggested as a risk factor for several health factors [126]. Most of the studies in this review have measured tv-time or total time spend sitting and not specifically seated work. However, from these results it cannot be recommended to encourage workers to spend most of their time sitting.

In this study women had a lower prevalence of exposure to most physical work demands compared with men. Women had a higher prevalence of exposure to low control and men had a higher prevalence of high demands and low support. These results, somewhat, support previous findings in a study [127] which showed a significant association between neck and shoulder symptoms and physical exposure for men and neck and shoulder symptoms and psychosocial exposure for women. In a Norwegian longitudinal study [128] it was found that older workers, women and those who reported musculoskeletal symptoms reported higher degree of disability. The same study also found that several physical work factors were associated with disability. Both these studies suggest that interventions aimed to increase the work ability in workers with neck pain might need to adopt a different approach for men and women.

In this study, 44 % of included workers reported excellent work ability despite having neck pain. Others who have investigated the relationship between pain and work ability have found much lower work ability scores. This may be explained by the study population and how pain was reported. In another study individuals with pain were actively invited to participate, which could mean that the severity of symptoms was higher in that study population [129]. In one review of factors for staying at work despite chronic pain, [130] it was found that both individual factors and factors at the workplace were important determinants. Qualitative studies have shown that the ability to make adjustments in the workplace were one factor which seems important for staying at work despite having pain [131].

5.1.2 EFFECTS OF WORK DEMANDS ON SICKNESS ABSENCE

The main findings in this study suggest that low or high exposure to certain work demands, such as low exposure to lifting >15 kg, twisted/bent work postures, high exposure to seated work and high control, can result in lower sickness absence for workers with neck pain. A difference, by reporting high or low exposure, in sickness absence was found among those who reported low exposure to several physical work demands and those who reported high control of their work and high exposure to seated work. These differences were mainly found in the middle and older age groups.

In this study we used the WAS as a health measure. The group who reported excellent work ability (WAS 10) and also reported low exposure to physical work demands (leaning forward without support and frequent twisting) had n-days compared to those who reported high exposure. The excellent work ability group also had fewer sickness absence days if reporting high exposure to seated work. The only finding in the group with poor work ability (WAS 1–5) was that those who reported high control over their work had fewer sickness absence days than those reporting low control. These findings are somewhat supported by a Finnish study [132], where it was also found that workers reporting lower levels of work ability have higher numbers of sickness absence days regardless of age, sex or occupation. In this study, the measure of neck pain consisted of a question regarding whether the worker had had pain in the "upper back or neck" after work during the last three months, two days per week or more often. A study by Holtermann et al. [133] used a 0–9 scale to describe pain intensity, with 0 being no pain and 9 being the worst pain possible. In that study it was found that among workers with a pain intensity score ≥7, 23% had long-term sickness episodes compared with 15% among those who reported a score of 4 on pain intensity.

Reporting high or low exposure to the work demands measured in this study gave different results in the different age groups. In the youngest age group (16–24 years) we found a difference between reporting high control over one's work and a lower number of sickness absence days compared to those who reported low control. In the oldest age group (50–54 years) there were also a lower number of n-days among those reporting high control but also reporting high exposure to seated work and low exposure to frequent twisting and lifting

≥15 kg. Previous studies [132, 134] investigating sickness absence in different age groups also found the highest numbers of sickness absence among older workers, and furthermore that both musculoskeletal impairment and self-reported work ability and stressful work were determinants of future sickness absence. In this study we also found that low exposure to physical work demands is associated with lower numbers of sickness absence days in the middle-aged group.

The measured exposure to work demands showed a similar pattern for both women and men workers with a few exceptions. Among women, there was a difference in sickness absence days between reporting high or low control over one's work. Among men there were lower numbers of n-days among those reporting low exposure to whole-body vibration and working with hands at shoulder level or higher, but not among women. However, there were few women who reported high exposure to these work demands, which could affect the results. As found in previous studies, women workers had generally higher numbers of sickness absence days than men. This is in line with previous studies which have found higher risk of disability pensions among women workers [135].

The quantile regression analysis was used to investigate the effect of work demands on different lengths of sickness absence. The analysis showed that high or low exposure to the different work demands affect the level of sickness absence mainly on the 90th and 95th percentile but not on the 99th (except for exposure to frequent rotations). This can be interpreted to mean that exposure to work demands is linked to sickness absence for shorter but not long-term sickness absence. A previous study divided sickness absence into three time periods, early (≤14 days), medium–late (15–90 days) and late (≥90 days) for return to work, using the same data source on registered sickness absence as in this study [9]. If applied to this study, exposure to several work demands affects sickness absence for short (early) and medium long (medium–late) periods, but only one work demand (frequent rotations) affects longer (late) periods of sickness absence. This analysis also shows the difference in numbers of sickness absence days; for instance, the group that reported low exposure to heavy lifting had 39 fewer days compared to the high exposure on the 95th percentile. The group having high control over their work had 43 fewer days of sickness absence than the group with low control.

This study has several strengths. It is prospective, it is based on a representative sample of the Swedish working population and it includes sickness absence from official registries. Some weaknesses of the study include the use of self-reporting by means of telephone interview and questionnaire. As there is no objective measure (except sickness absence), we cannot appraise the seriousness of the disorders or the exact level of exposure to the different work demands. No measurements of the intensity of the neck pain were made. This is a limitation in this study, as it is known that intensity of the neck pain is a predictor for long-term sick leave [133]. We also had no information about other confounders, including socio-demographic or individual factors such as self-efficacy, which also are known factors that influence sickness absence [136]. The registry measure of sickness absence from the LISA registry covers all causes of sickness absence, and in this study, we cannot distinguish between different causes. A methodological aspect of this study is that it took place in Sweden. Very few studies of sickness absence have investigated whether the national context plays a role in the results [87].

5.1.3 EFFECTS OF WORK PLACE INTERVENTION ON SICKNESS ABSENCE

The main findings in this study suggest that workplace intervention can reduce sickness absence for workers with neck or UE disorders, among certain groups, if the intervention improves the disorder. Significantly lower sickness absence was found among those who reported improvement of their symptoms after an intervention, and within this group, a significantly lower sickness absence was found among women and those who reported good work ability (WAS 8–9).

To reduce the burden of work-related sickness absence, for both workers and society, it is important to identify who is at risk and what factors can be targeted via interventions [137]. As has been shown previously and in this study, a measure of the individual's health, such as the WAS, could provide important information regarding for whom an intervention might be effective. As the lowest number of sickness absence days (both N-Days and S-Days) were found in the group who reported excellent work ability (WAS 10) and the highest in the group with poor work ability (WAS 1-5) this somewhat confirms that the measure of the work ability score can provide useful information on the risk of sickness absence among workers. As we wanted to investigate for who and when intervention might affect sickness absence we included this measure. If there would have been little difference in sickness absence between the WAS groups then this measure would not be useful in predicting sickness absence.

A recent study on intervention in an industry setting using a participatory approach found no effect on health outcomes [138]. The authors stated that one reason for this might be that the implemented action does not sufficiently reflect on the outcome. In the present study, it was shown that interventions did not significantly reduce sickness absence, unless the work-related disorder improved as a cause of the intervention. This affirms the statement that the intervention needs to sufficiently affect the health of the worker to be effective. This implies that follow-up of the workers is important to monitor the intervention for the desired effect.

In a recent review on prevention of new episodes of neck pain [139] it was found that exercise was more effective in preventing new episodes of neck pain than were ergonomic interventions. If, as the present study suggests, it is improvement of the disorder that is most important, then it could be true that interventions aimed at improving workplace ergonomics alone might not be powerful enough to reduce symptoms. As the concept of work ability can, in a simple form, be defined as a balance of demands at work and the individual's capacity to perform the work, a strategy that both strengthens the individual's capacity and also considers the demands at work would appear to be a better approach than one that only uses interventions aimed at either. The effects of work place interventions found in this study in the different subgroups were not conclusive. That only a few differences were found within the subgroups could be due to that there were few subjects in these groups, which results in low power.

Self-reported sickness absence has been shown to have a good correlation with recorded sickness absence [92, 93]. In this study, we used both self-reported (S-Days) and recorded (N-Days) sickness absence measures and found significant association between improvement of symptoms after intervention for both self-reported and recorded sickness absence days. This was despite the fact that the self-reported sickness absence measure only measured sickness absence due to work-related disorders, and the recorded measure used all-cause sickness absence of more than 14 days.

The measure of neck or UE disorder consisted only of a question regarding whether the worker had had work-related disorders in the neck or UE during the last 12 months that had made it difficult to perform work either at the workplace or in the home. No measurements of the intensity of the neck pain were made. This is a limitation in this study, as it is known that intensity of the neck pain is a predictor for long-term sick leave [133]. The study by Holtermann et al. used a 0–9 scale to describe pain intensity, with 0 being no pain and 9 being the worst pain possible. In that study it was found that among workers with a pain intensity score ≥7, 23% had long-term sickness episodes compared with 15% among those who reported a score of 4 on pain intensity. In this study we used the WAS as a health measure, which showed a similar result, in that individuals who reported a low WAS also had a higher mean number of sickness absence days, both S-Days and N-Days.

In this study group, which consisted of workers with work-related neck or UE disorder, 69% were women. Women also reported that work stress was the single most common cause of their work-related symptoms, with 38%. Men reported that heavy manual work was the most common cause of their neck or UE disorder. When looking at what type of intervention was performed, the most common for both men and women were physical interventions, about 35%. In this study we stratified the study population into age and WAS groups as it is know that both age and work ability are linked to sickness absence [21, 22, 140]. In the different WAS groups the highest proportion of interventions were found in the excellent (WAS 10) group. As a higher level of work ability are protective for sickness absence, the interventions in this group could have a lower chance of reducing sickness absence compared to the groups with lower work ability. Similar reasoning can be made with regards to the different age groups where interventions made in the youngest age group might not have the same effect as in the older age group with regards to the interventions effect on sickness absence. From the available data we cannot in detail describe the types of interventions that were made or the decision-making process for selecting a certain intervention. Previous studies have suggested that multidisciplinary approaches can be beneficial, especially if the workplace is involved [141-143].

Quantile regression analysis was used to not only investigate the effect of workplace interventions on the whole group but also to investigate when they were effective. The quantile analysis showed that the intervention had an effect on sickness absence when sickness absence was not short and not long. The analysis showed an effect of the intervention on sickness absence between 24 and 90 N-Days, but not for fewer or additional days. A previous study divided sickness absence into three time periods, early (≤14 days), medium–late (15–90 days) and late (≥90 days) for return to work, using the same data source on registered sickness absence as in this study [9]. This can be interpreted to mean that workplace interventions used in this study were effective in reducing medium long (medium–late) sickness absence but not short (early) or longer (late) periods of sickness absence.

Strengths, limitations and methodological considerations

This study has several strengths. It is prospective, it is based on a representative sample of the Swedish working population, and as we used both self-reported and sickness absence from official registries, nearly all episodes of sickness absence are included. Some weaknesses of the study include the use of self-reporting by means of telephone interview. As there is no objective measure (except sickness absence), we cannot appraise the seriousness of the disorders, whether interventions have been made or not, or whether the workers are exposed to work factors which are considered risk factors for neck and upper extremity disorders. Also there are some concerns with using administrative data as there is no information on reliability and no control variables are used [144]. In this study, we performed statistical analysis of several stratified sub groups. As this leads to multiple tests there is a possibility that the findings were due to chance. However all tests were based on the pre-planned hypothesis and no post-hoc test were made [145]. Another methodological aspect of this study, like all studies of sickness absence, is that it took place in a national context. Very few studies of sickness absence have investigated whether the national context plays a role in the results [87]. It should be stressed that the results of this study are found in the Swedish setting and might differ from other countries, as compensation for sickness absence varies between countries. The registry measure of sickness absence from the LISA registry covers all cause sickness absence, and in this study, we cannot distinguish between different causes. The use of the self-reported measure on work-related sickness absence make it possible, to some extent, to compare the self-reported sickness absence and the registered all-cause sickness absence. In future research, studies investigating how workplace intervention can be used to reduce neck and UE disorders are needed and also, how measures of work ability can be used in determining for who these interventions might be effective in preventing sickness absence.

5.1.4 RELIABILITY OF THE SWEDISH QEC

The aim of this study was to investigate the inter-rater reliability of the Swedish version of the QEC, using different statistical methods to measure levels of agreement and the disagreement between assessors. The total scores for each body part and the individual items were analysed for both agreement and disagreement separately.

The inter-rater reliability for the total scores was between 0.83 and 0.95 when measured with ICC and between 0.61 and 0.85 when measured with κ_w. For both measures, the lowest agreement was found for the shoulder/arm item and the highest for the neck item. This indicates that the Swedish version of QEC has fair to almost perfect inter-rater agreement on total scores. In the development of the original English version (phase 2, which is the current version), the agreement between two experts and seven ergonomists was found to range from 0.79 for the wrist/hand item and 0.98 for the neck item using Spearman's coefficient [146]. In the same study, the inter-rater reliability between six ergonomists ranged from 0.6 to 0.79 using Kendal's coefficient of concordance (KCC); the results were shown on different types of work and not on the individual items. These ranges of agreement seem similar to those in the current study, although we found the lowest score for shoulder/arm rather than wrist/hand as in the original version. These studies used slightly different approaches and statistical methods, but seem to follow a similar pattern.

Another investigation of inter-rater reliability in a translated version (Brazilian Portuguese) of the QEC found that the lowest level of agreement was for the neck item (0.62 ICC) and the highest for the wrist/hand item (0.82 ICC). It is difficult to interpret this difference, as several factors may have contributed, including the translation itself, and how the written and verbal instructions were given to the assessors. The QEC instructions state that the worst-case situation should be assessed; this can also be a cause of disagreement, as different assessors may interpret it differently. In addition, it should be remembered that a work task usually consists of several movements and postures, and it is not known at what exact moment during the observed work task the assessment is made for each item. The Rapid Entire Body Assessment (REBA) method [70], which is another method of measuring risk factors for musculoskeletal disorders, includes a list of statements to help select which position is actually being assessed. Adding a similar statement to the QEC in order to more clearly define which posture and movements are the basis for the assessment might increase the agreement between assessors.

A study on intra- and inter-rater reliability of risk assessments using κ_w, ICC, and KCC to measure agreement between assessors [25] found that when using these methods on the same data, κ_w gave the lowest score and KCC the highest; this needs to be taken into consideration when comparing studies using different statistical methods. Other studies investigating the reliability of the English and translated versions of the QEC have shown moderate to good levels of inter-rater reliability [71, 74, 77, 147]. Two of these studies [74, 147] compared assessments made using video recordings of work tasks, with the workers' assessments provided in written format, while the other two used live assessments like the current study.

The analysis of agreement on the individual items of the QEC (κ_w) showed poor to substantial inter-rater agreement on the items scored by the assessors and substantial to almost perfect agreement on the items scored by the workers. Although the wrist/hand showed poor agreement using κ_w, the PA was 80%. Assessor A only used the lowest score (neutral wrist) on one work task, whereas the ergonomists used this score on nine work tasks. This can be viewed as a difference in the interpretation of the definition of the score categories of the wrist/hand item, which are "almost straight" and "deviated or bent". This result indicates that either the question itself on the translated QEC needs revision or that the instructions for interpretation were not clear.

The measures of disagreement for the total scores showed a statistically significant level of disagreement for the shoulder/arm item, with assessor A systematically using a higher total score than the other assessors. The measure of systematic disagreement is an indicator of a difference in the interpretation of the assessment scoring. If we assume that the questions in the QEC method are properly formulated and unambiguous, these differences could be reduced by further training of the assessors. There were no other statistically significant disagreements on the other total score items measured with RC and RV.

The measures of disagreement for the individual items showed some systematic disagreement and no statistically significant random disagreement, with an RP between -0.16 and 0.24, RC between -0.13 and 0.11, and an RV between 0.00 and 0.03. For wrist/hand movement, the level of disagreement on the RC measure was -0.13, indicating a disagreement between the assessors. Assessor A systematically used a narrower scoring range on the item wrist/hand motion than the other assessors. There was a significant degree of disagreement between the assessors on shoulder/arm motion (RP 0.24), with assessor A systematically using higher scores than the other assessors and for wrist/hand position (RP -0.16); here, assessor A used systematically lower scores than the other assessors.

The analysis of random disagreement (RV) showed no statistically significant disagreements on any of the individual items or on the total scores. This indicates that the QEC method is robust and the items are relevant to the purpose of the assessment.

Other studies [71, 74, 77, 147] have compared the reliability of the summary scores of the QEC and not individual items, which makes direct comparisons with this study difficult. The total scores of the QEC are derived from several different items, which means that different scores for the individual items can give the same total score. In addition, the summary score contains both the items scored by the assessor and the items assessed by the worker, which in other studies have been provided in writing to the assessor.

This study includes the measures of Minimal detectible change (MDC). No previous study on the reliability of the QEC have used this measure. As the MDC is considered the minimal amount of change that is not due to chance variation of measurement [123] the MDC found in this study can be used in future studies using QEC, for example, to determine if an intervention have had an effect or if the changes in measures found can be attributed to variance of measures.

The ergonomists considered the Swedish QE to be easy to use and relevant for the purpose intended. In the comments from the ergonomists after the assessments, the biggest difficulty lay with deciding which work posture should be assessed, as all work tasks were dynamic. The QEC instructions state that the worst-case situation should be assessed, which can be interpreted differently by different assessors due to different experiences and expectations. Several of the ergonomists also commented that it was more difficult to assess work tasks which included fast position changes of the hands and arms. This is reflected in the results, where the second lowest κ_w and the lowest PA were for the shoulder/arm movement. Studies on both the QEC and other observational methods have shown that body positions are easier to assess than motion, and that the position of the trunk is easier to assess than the position of the hand [61].

This study used real cases and the work tasks were assessed live during a single visit, whereas other studies have used assessments from video recordings. The advantages of using live assessments are that the assessor can move to clearly see the different body parts being assessed, and that live assessments are closer to the way the assessments are used in practice [148]. One disadvantage of live assessments as compared to video recording is that with video the assessor can view the work task as many times as they like and also use slow motion and still frames to easier see fast movements and positions [149]. The use of real cases can also give a risk of bias. In this study, the ergonomists who nominated the work tasks to be assessed were familiar with the workplace and, for the most part, had previously observed the different tasks, whereas assessor A had no prior knowledge about the tasks. Thus, there was a difference between the assessors in the amount of knowledge about the work being assessed.

The work tasks assessed were mainly “light” to “moderately heavy”; no task was assessed with the highest category for the item on weight handled. Also no work task was performed in a seated position. This need to be taken into consideration as the type of work being assessed could influence the agreement between assessors.

Earlier discussions of the reliability and validity of observational methods have concluded that there is no perfect method [61, 150, 151] [152]. A systematic evaluation of observational methods found that most of the methods had moderate to good inter-rater reliability [61], similarly to the results in this study. Nevertheless, this study shows that the QEC can be further developed in order to improve the inter-rater reliability. We suggest that the first step should be evaluation and revision of the instructions given to the users, and the inclusion of additional practical examples; for example, in this study, three work tasks were used for the training session. A follow up some time after the initial training session might also be useful.

This study investigated the inter-rater reliability of the Swedish translated version of the QEC method. When the translation was made no proper cross-cultural adaptation or validation testing was made before distribution and training of ergonomist to use the method. This is a serious limitation as the validity and internal consistency of the Swedish version have not been established. Even though we can attest that we cannot discern any language issues that could lead to misunderstandings from the translation or that future cross-culture/cross-language comparison would find any inconsistences we do recommend further studies to investigate this and also caution users of the Swedish version that these aspects of the method have not been investigated.

5.2 METHODOLOGICAL CONSIDERATIONS

The four papers which this thesis are based on have different strengths and limitations. Paper I is a cross-sectional cohort study, papers II and III are prospective cohort studies and paper IV was an experimental study conducted in the field.

Papers I-III are based on large surveys conducted by Statistics Sweden. These surveys are conducted in the same manner every two years using the same method. This make it possible to combine several years to create a large sample size. In these studies we used stratified analysis based on age and gender (WAS for papers II and III) were performed since stratified analyses are easier to perform, comprehend, interpret and communicate than prevalence ratios in complex models. Even though there were a high number of participants in these studies the distribution in different exposure categories did not allow for further stratification. Stratification has been recommended as a method instead of adjusting as this can mask important differences in exposure [153].

Paper I was a cross-sectional study and this limits the possibility to draw conclusions about what affects the outcome, work ability score. It is not known, for instance, if the exposure to the work demands is a result of neck pain i.e. whether individuals with neck pain change their exposure to certain work demands. Both the work ability score and the work demand exposures were self-reported, therefore the study population's true exposure level is not known. In a review [64] it was found that some items (including time working with the hands above shoulder level and exposure to whole-body vibrations) showed good validity but other items (including trunk position and hand-held vibrating tools) showed a lower level of validity. The method for asking questions about exposure in this study has previously been validated, by Statistics Sweden [112, 113], and good validity has been demonstrated.

This main study group consisted of workers with pain in upper back and neck. Previous research has shown that some workers with pain rate their exposure higher or worse than those without pain, although their measured exposure was similar or lower [67, 68]. In the present study this may be a cause for misclassification, as exposure was divided into high and low exposure according to self-reports.

Paper II was a prospective cohort study using both self-reported and registered measures. This gives the study several strengths. It is prospective, it is based on a representative sample of the Swedish working population and it includes sickness absence from official registries. Some weaknesses of the study include the use of self-reporting by means of telephone interview and questionnaire. As there is no objective measure (except sickness absence), we cannot appraise the seriousness of the disorders or the exact level of exposure to the different work demands. No measurements of the intensity of the neck pain were made. This is a limitation in this study, as it is known that intensity of the neck pain is a predictor for long-term sick leave [133]. We also had no information about other confounders, including socio-demographic or individual factors such as self-efficacy, which also are known factors that influence sickness absence [136]. The registry measure of sickness absence from the LISA registry covers all causes of sickness absence, and in this study, we cannot distinguish between different causes. A methodological aspect of this study is that it took place in Sweden. Very few studies of sickness absence have investigated whether the national context plays a role in the results [87].

Paper III was a prospective cohort study using self reported and registered variables. This study has several strengths: it is prospective, it is based on a representative sample of the Swedish working population, and as we used both self-reported and sickness absence from official registries, nearly all episodes of sickness absence are included. Some weaknesses of the study include the use of self-reporting by means of telephone interview. As there is no objective measure (except sickness absence), we cannot appraise the seriousness of the disorders, whether interventions have been made or not, or whether the workers are exposed to work factors which are considered risk factors for neck and upper extremity disorders. Also there are some concerns with using administrative data as there is no information on reliability and no control variables are used [144]. Another methodological aspect of this study, like all studies of sickness absence, is that it took place in a national context. Very few studies of sickness absence have investigated whether the national context plays a role in the results [87]. It should be stressed that the results of this study are found in the Swedish setting and might differ from other countries, as compensation for sickness absence varies between countries. The registry measure of sickness absence from the LISA registry covers all cause sickness absence, and in this study, we cannot distinguish between different causes. The use of the self-reported measure on work-related sickness absence make it possible, to some extent, to compare the self-reported sickness absence and the registered all-cause sickness absence. The effects of work place interventions found in this study in the different subgroups were not conclusive. That only a few differences were found within the subgroups could be due to that there were few subjects in these groups, which results in low power. Having low power means that there is a high possibility of accepting the null hypothesis when the null hypothesis is false (type II error). This can be due to random errors within the sample, which is a larger risk if the sample size is small.

Paper IV was a reliability study using real cases and the work tasks were assessed live during a single visit, whereas other studies have used assessments from video recordings. The advantages of using live assessments are that the assessor can move to clearly see the different body parts being assessed, and that live assessments are closer to the way the assessments are used in practice [148]. One disadvantage of live assessments as compared to video recording is that with video the assessor can view the work task as many times as they like and also use slow motion and still frames to easier see fast movements and positions [149]. The use of real cases can also give a risk of bias. In this study, the ergonomists who nominated the work tasks to be assessed were familiar with the workplace and, for the most part, had previously observed the different tasks, whereas assessor A had no prior knowledge about the tasks. Thus, there was a difference between the assessors in the amount of knowledge about the work being assessed. Earlier discussions of the reliability and validity of observational methods have concluded that there is no perfect method [61, 150, 151] [152]. A systematic evaluation of observational methods found that most of the methods had moderate to good inter-rater reliability [61], similarly to the results in this study. This study investigated the inter-rater reliability of the Swedish translated version of the QEC method. When the translation was made no proper cross-cultural adaptation or validation testing was made before distribution and training of ergonomist to use the method. This is a serious limitation as the validity and internal consistency of the Swedish version have not been established.

5.3 ETHICAL CONSIDERATIONS

There are various ethical aspects in research. The recruitment of participants, the handling of informed consent, how measures are performed, and the possibility of withdrawal from the study are some areas to be taken into account [154].

There are basic principles of research ethics following the model of professional responsibility [155]. The principles include two positive duties: to conduct research and to evaluate the consequence of the research. Four negative duties: not to conduct research that violates informed consent; not to conduct research that converts public resources into private profit; not to conduct research that seriously jeopardizes environmental welfare; and not to conduct biased research. The personal dimensions of research ethics or the moral reasoning, along with dimensions reflecting professional aspects such as scientific integrity, need to be considered within the concept of research ethics.

A recent study investigated how three different categories (insurance official, physician and persons on sick leave) perceived an assessment of work ability. The results showed that the three respondent groups had slightly different perceptions of what a fair assessment means. Insurance officials considered the self-report part of the assessment made for a more participatory and hence more fair assessment, one of the physicians claimed that there were problems with self-reports, since they could lead to an overestimation of abilities. The people on sick leave, on the other hand, did not generally seem to consider their self-report as particularly important for their perception of fairness of the assessment [13].

5.4 CLINICAL IMPLICATIONS

This thesis have focused on the work ability of workers with neck pain and exposure to work demands and also on a method for measuring work demands. The finding that excellent work ability and that lower sickness absence are associated with certain work demands can be useful in a clinical setting. As there is a concern with regards to the high cost of sickens absence, both for society, organizations and the individual, this information can be useful in creating work environments which promotes work ability. The finding that interventions for workers with neck pain only are effective if the intervention improves the disorder is also important. As interventions can be costly, information if the intervention will be effective is useful.

The reliability of the Swedish QEC showed good reliability on the total scores which indicates that the instrument can be used and trusted in practice. However as the reliability of the individual items were low for some items care need to be taken and it is recommended that further training of those that will use this method is made. This can done in a clinical setting if there are several persons who work together and compare and discuss their results to try to reach heterogeneous results. As QEC is constructed to be sensitive to change, for example before and after an intervention, it might be possible to use this method to evaluate if an intervention is sufficient when trying to improve the work ability of workers with neck pain. However this has not been investigated and further research is needed.

6 CONCLUSION

General conclusions

Certain work demands can be important factors that have influence on excellent work ability and are associated with lower sickness absence among workers with neck and upper extremity disorders. In addition, interventions can have a positive effect on sickness absence if they reduce these disorders. A method for measuring work demands (QEC), translated to Swedish, showed moderate to very good inter-rater reliability.

Specific conclusions

A lower level of physically demanding work is an important element to maintain excellent work ability, especially for the older worker with neck pain. (Paper I)

Certain physical work demands and having high control over one's work can result in lower sickness absence, especially among middle-aged and older workers with neck pain. (Paper II)

Workplace intervention can reduce sickness absence for workers with neck or upper extremity disorders if the intervention improves the disorder. The interventions were most effective in reducing medium long sickness absence periods. (Paper III)

The Swedish translation of the Quick Exposure Check has moderate to very good inter-rater reliability with fair to slight levels of systematic disagreement. There was no statistically significant random disagreement. (Paper IV)

7 FUTURE PERSPECTIVES

This thesis contributes to the knowledge of factors associated with lower sickness absence and promotion of excellent work ability for workers with neck pain. However, there is much that is unknown in this area. In this thesis it was found that certain work demand are linked to excellent work ability and lower sickness absence but the role of interventions are not very clear. It was shown that interventions can lower sickness absence but only if the neck or UE disorder improved. Earlier research have also shown little evidence in how workplace interventions should be implemented to be effective. This thesis also found that the Swedish translated QEC to be generally reliable. As QEC and other similar methods categorize exposure to work demands, tools like this might be useful in promotive measures, not only in preventing musculoskeletal disorders, but also in preventing sickness absence and promoting excellent work ability. As it is shown that lower levels of certain work exposures can contribute to lower sickness absence and promote work ability, measures of these work demands might be useful. How this can be implemented is an area of research which need to be investigated.

Furthermore, research on promotional factors as opposed to risk factors should be prioritized as research have traditionally focused or risk factors but not so much on how to create healthy and promotive work. Another area which is important and merit further study is on healthy life-course work. As life expectancy increases and workers are expected to work later in life it is important to create work where both younger and older workers can maintain good health.

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