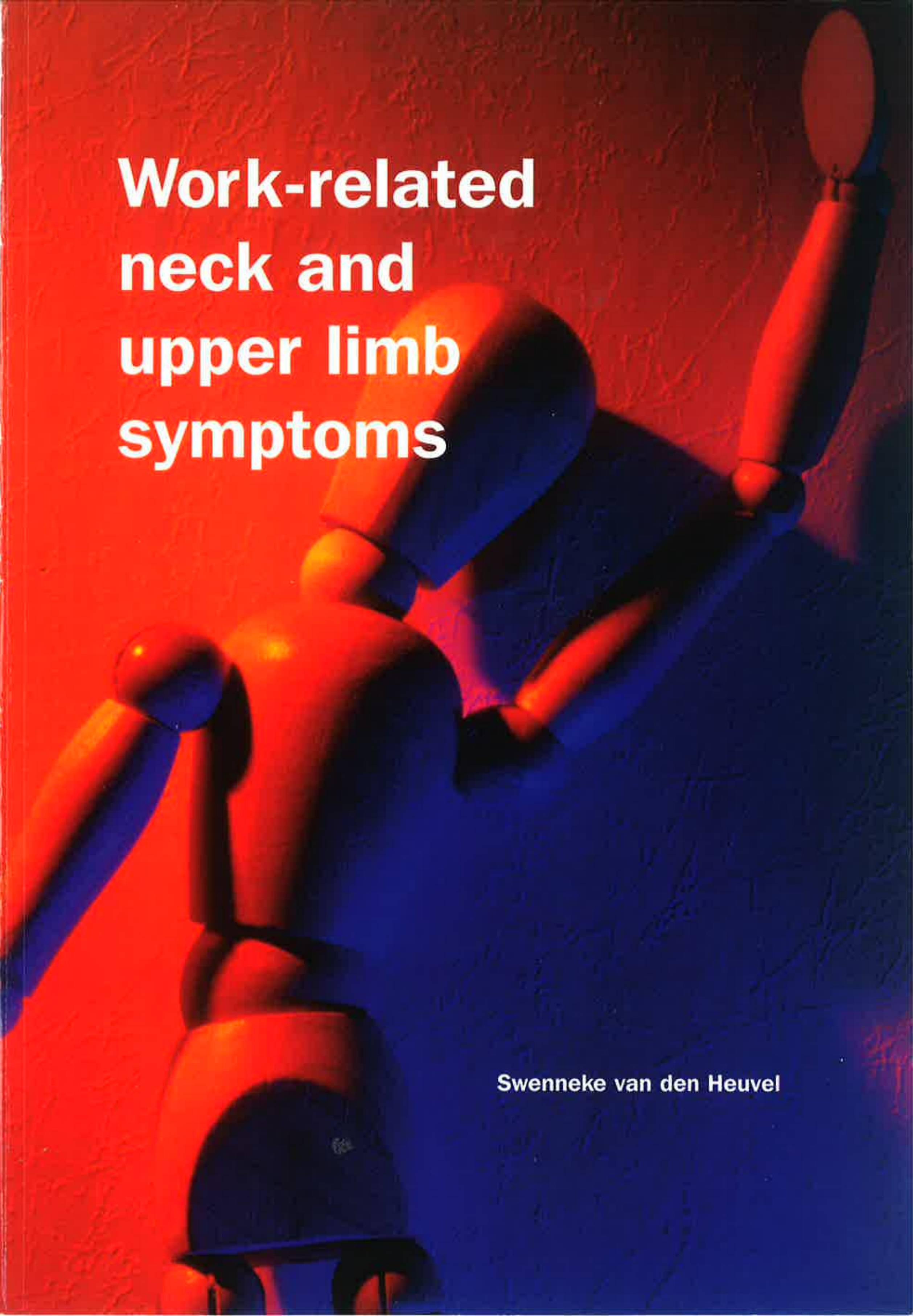
Work-related neck and upper limb symptoms



Swenneke van den Heuvel

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1 Introduction

1.1 Definition of neck and upper limb symptoms

This thesis is about neck and upper limb symptoms. They are often mentioned together or formulated in one word, usually an abbreviation of the different components. The most common formulations are CTDs (Cumulative Trauma Disorders), MSDs (Musculoskeletal disorders), WRULDs (work-related upper limb disorders), WRUEDs (work-related upper extremity disorders), and RSI (Repetitive Strain Injuries). At first sight it might be unclear what the symptoms of neck, shoulder, arm, elbow, hand or wrist have in common. The reason why these symptoms or disorders have been grouped together, is that their origin is often supposed to be (partly) work-related and the approach to prevent these symptoms is supposed to be similar, irrespective of their specificity.

In the Netherlands RSI has been the expression mostly used. However, there are objections to this term. The I for Injury suggests trauma and accidents, whereas these origins are excluded in most definitions. Moreover, not only repetitive strain, but also static load could lead to this type of symptoms. The Expert Centre for Work-Related Musculoskeletal Disorders (in Dutch: Kenniscentrum AKB) proposed a new name for this type of symptoms: CANS, Complaints of the Arm, Neck and/or Shoulder. CANS refers to a complex of symptoms, complaints or disorders of the arm, neck or shoulder, not originating from an acute trauma or systemic disease. CANS is not considered a diagnosis, but it is a label meant to facilitate the communication of medical professionals and researchers (www.kenniscentrumakb.nl).

Although it might be useful for general practice to use one label indicating these different symptoms, in this thesis the label neck and upper limb symptoms will be used. To use the term disorders would not be appropriate, as most research on this subject deals with self-reported pain, and not with diagnosed disorders, resulting from clinical examination. The drawbacks of the expression RSI have already been mentioned. With the plain label of "neck and upper limb symptoms" it is clear that a compilation of symptoms is meant, without suggesting beforehand a common aetiology, course or treatment.

1.2 Prevalence

Estimates of the prevalence of neck and upper limb symptoms are not always comparable due to the use of different definitions. Most surveys refer to the working population. This is not considered a deficiency as most adults are in the active workforce and occupationally unexposed groups represent a diverse and unrepresentative fraction of the population. In the Netherlands, a survey showed that in 2002 28% of the working population reported neck/shoulder or elbow/wrist/hand symptoms in the previous 12 months. These symptoms were at least partly caused by work, according to the self-report of the participants[1]. Data from the European Foundation for the Improvement of Living and Working Conditions, based on fifteen European countries, showed that 25% of the workers reported work-related neck/shoulder pain, and 15% reported work-related arm pain[2].

These symptoms could lead to serious disability, as is shown by data of the Dutch Workers Insurance Authority. This institute registers information on all workers' disability benefits. The number of new cases of chronic disability for work due to neck and upper limb symptoms increased every year from 1998 till 2001. In 2001, over 6000 new cases were registered, which represented 0.1% of the working population and 6% of the total number of new disability benefits. After 2001 incident disability for work due to neck and upper limb symptoms has decreased[3]. However, for the greater part this decrease could be attributed to a general decrease in all disability benefits, due to a change in the policy for granting benefits. Symptoms did not decrease, according to recent figures from a Dutch survey. In 2004, 28% of the working population reported neck/shoulder or elbow/wrist/hand symptoms, still the same percentage as in 2002 (results not published).

Neck and upper limb symptoms are not only health problems, they also are a financial burden to society. TNO examined the yearly costs of these symptoms[*]. The addition of costs due to decreased productivity, sick leave, chronic disability for work and medical costs led to a total of 2.1 billion euros.

1.3 Conceptual model

It is assumed that neck and upper limb symptoms have a multi-factorial origin. Possible risk factors are of a physical, psychosocial or personal origin, and, moreover, they could reinforce each other. Their influence could also be mediated by other factors, such as cultural or societal aspects. The importance of each factor, and hence its contribution to the risk of symptoms, varies among individuals and work environments[4]. In the figure below a model is presented illustrating the possible aetiology of neck and upper limb symptoms. Its purpose is to illustrate the diversity of causes and pathways. For some of these causes and pathways, former research has already produced evidence. Others are still hypothetical.

[*] Blatter BM, Houtman ILD, van den Bossche SNJ, Kraan KO, van den Heuvel SG. Gezondheids-schade en kosten als gevolg van RSI en psychosociale belasting in Nederland. Results will be published in 2006.

Due to the high prevalence of neck and upper limb symptoms in the working population, it is evident that risk factors will be searched for at the workplace. Exposure at work is divided into physical and psychosocial factors. Similar factors could also occur during leisure time, but the focus in this thesis is on the situation at work.

Initially, most research on neck and upper limb symptoms focused on work-related physical exposure (path a). Although the pathophysiological pathway is not yet clear, it is assumed that physical factors, such as postures, movements and exertions of force could cause damage to muscles and tendon tissue and a poor blood circulation. Not only strong muscle contractions could cause damage and pain, low intensity muscle activation can cause damage as well, if the activation takes place over an extended period. Moreover, excessive mechanical exposure could cause peripheral nerve malfunction[5].

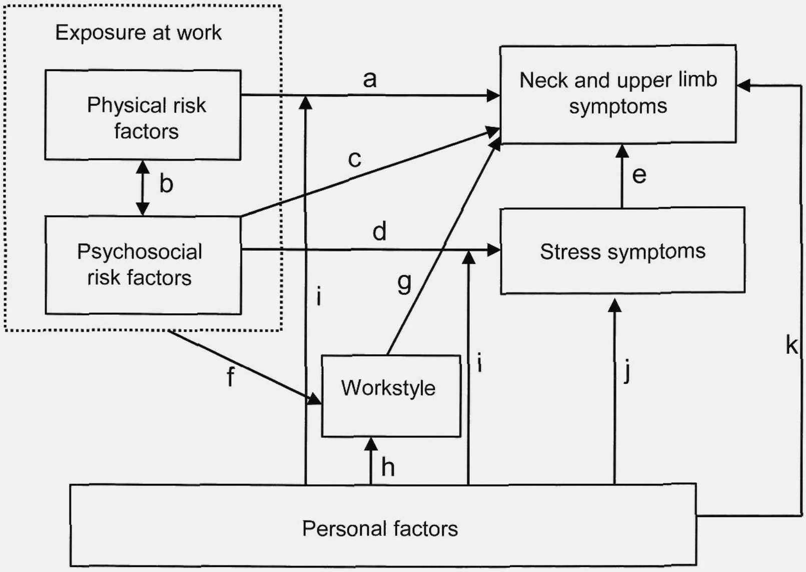

Figure 1.1

In epidemiological studies several physical risk factors for neck and upper limb symptoms have already been identified. Repetitiveness, especially in combination with forceful exertions, is generally acknowledged as an important risk factor[4,6,7]. However, this type of physical exposure mainly concerns industrial workers. In office workers neck and upper limb symptoms are common as well[2]. Since office work is dominated increasingly by computer work[8], and potential harmful effects of computer work receive a lot of attention, several longitudinal studies have been carried out concerning office workers[9,10,11,12,13,14,15,16]. Results from these studies show that mouse usage longer than 10-20 hours per week might be a risk factor for hand/arm symptoms, but not for neck/shoulder symptoms. Insufficient evidence is available for an effect of long duration of keyboard usage and total computer usage. High quality studies on working postures among computer users are still scarce. Summarizing the literature, it appears that posture is an independent risk factor of modest magnitude for neck and upper limb symptoms. The most consistent finding is that locating the keyboard at or below the height of the elbow and resting the arms on the desk surface or chair armrests is associated with reduced risk of neck/shoulder symptoms[17]. Evidence with respect to hand/arm symptoms is inconclusive.

Another type of work-related risk factors can be found in psychosocial work characteristics. In earlier studies, these factors were considered as potential confounders in the relation between physical exposure and symptoms[18]. The lack of attention to psychosocial factors may be, partly, attributed to difficulties in precisely conceptualizing and measuring the mechanisms by which these factors influence work and health outcomes[19]. Nowadays, psychosocial factors are also studied as independent risk factors.

In a systematic review Bongers et al. summarized the results of studies that explored the association of psychosocial factors and neck and upper limb symptoms[20]. It was concluded that there was no strong evidence for this relationship, due to the absence of prospective studies. Recently, more prospective studies have been published[21,22,23,24,25,26,27,28,29]. These studies had in common that they all identified psychosocial work characteristics as risk factors for neck and upper limb symptoms. However, psychosocial factors were defined in many ways, which complicates an attempt to draw conclusions from the findings. Most studies examined the concepts of job demands, control and social support or a combination of these concepts. In the studies that used neck or shoulder symptoms or both as an outcome measure, job demands was identified as a statistically significant risk factor in two studies, control in two studies and social support in one study. One study identified the combination of high demands and low control as a risk factor for neck pain. Job demands and control were not identified as risk factors for elbow/wrist/hand symptoms, whereas lack of social support was identified as a risk factor in two studies.

There are several possible pathways through which psychosocial factors could lead to neck and upper limb symptoms. It has been suggested that the effect of physical exposure may be modified by psychosocial factors[30]. In a cross-sectional study it was found that psychosocial factors were more important when physical exposure was high than when physical exposure was low[31]. It is also possible that adverse psychosocial work characteristics could lead to an increased exposure to physical factors (path b). For example, high job demands could lead to longer working hours, fewer rest breaks, but also to changes in posture, movement or exerted forces. However, this pathway has not been examined extensively. In a recent review, it was concluded that the interaction between physical and psychosocial risk factors may be complex and longitudinal studies are desperately needed[30].

The relation between psychosocial factors and neck and upper limb symptoms does not need to be mediated by physical exposure (path c). It is generally accepted that musculoskeletal pain can be experienced in the absence of evident physiological change or tissue damage and that such pain is modulated primarily by cognitive processes[4]. For example, when job demands are high symptoms may be reported that may have gone unnoticed in a less demanding work environment. Moreover, recent longitudinal studies examining psychosocial factors found independent effects of these factors, after adjustment for physical exposure[21,22,23,24,25,26,27,28]. However, the specificity of these pathways is still unknown.

A little more is known about the pathway of psychosocial factors to neck and upper limb symptoms via stress. It is well known that exposure to psychosocial factors could lead to stress (path d). Probably the most widely known model of psychosocial factors and stress at work is Karasek's demand-control(-support) model[32]. According to this model, the combination of high job demands and low control could lead to stress. A low level of social support will enhance the adverse effects of this combination. A recent systematic review concerning the influence of the psychosocial factors derived from this model concluded that 16 of the 19 high-quality studies (84%) provided support for lagged causal effects of psychosocial factors on self-report measures for health and/or well-being, usually seen as indicators of psychological distress. However, only modest support was found for the hypothesis that especially the combination of high demands and low control results in stress[33].

Another well-known stress-model with respect to the relation between psychosocial factors and stress-related outcomes (path d) is Siegrist's Effort-Reward Imbalance (ERI) model[34,35]. The assumption of the ERI-model is that an imbalance between high efforts and low rewards leads to adverse health effects, including stress. In a recent review concerning this model, it was concluded that in most studies a high-effort-low-reward situation was associated with poor psychological well being (i.e. 18 out of 21 studies)[36].

The relation between stress and neck and upper limb symptoms (path e) has been examined extensively before. In the aforementioned review of Bongers et al., it was already concluded that high-perceived job stress was consistently associated with all upper extremity problems[20]. More recent studies have confirmed this finding[21,23,27].

Although there is sufficient evidence for the relation between stress and neck and upper limb symptoms, the pathways are still unclear. Various models have been developed to offer frameworks for possible pathways, but their empirical support is still rather primitive[19]. In the literature many ways have been suggested in which stress might contribute to the onset of musculoskeletal symptoms. Palmer named the following possible pathways[37]: Stress may alter the way in which work is conducted in such a way that it increases the mechanical load. Also stress may reset the tone in muscles causing them to become fatigued more readily. Or stress may extend the duration of muscle tension and reduce the rest period. Stress may also intensify the perception of pain, influence people's opinion on the labeling and attribution of pain or undermine the mechanisms used to cope with pain. Finally, stress may modify the physical and behavioral responses to pain. Seen from a more pathophysiological perspective, stress may, apart from an increased muscle activity, impair circulation and the supply of oxygen to tissues as a result of hyperventilation. Moreover, prolonged stress may degrade tissue quality and the ability of tissues to recover due to hormonal processes[5].

Next to work-related risk factors, it has been suggested that personality traits could contribute to the onset of neck and upper limb symptoms: some studies found an association between type A behavior and neck/shoulder symptoms[6]. One recent study found that subjects with work-related upper limb disorders had more neurotic perfectionist traits[38]. However, the pathway through which personality could lead to neck and upper limb symptoms is still unclear and little research has been done on the subject.

Possibly, work-related risk factors and personality traits reinforce each other (path i). Siegrist's effort-reward imbalance model combines psychosocial work characteristics and personality aspects[34,35]. Apart from the theory mentioned above that a combination of high effort and low reward could lead to adverse health effects, Siegrist incorporated the concept "overcommitment" in the model. Overcommitment is a personality trait that could reinforce the unfavorable effect of effort-reward imbalance. Furthermore, overcommitment might have an independent effect. The concept overcommitment specifies those cognitive, emotional and motivational components within the global concept of Type A behavior that are important in coping with work demands.

Studies on the effect of the effort-reward imbalance model and the concept of overcommitment usually focus on stress-related disorders such as cardiovascular diseases[36,39,40,41]. Little research has been done on the effect of overcommitment on musculoskeletal symptoms. However, the effects on less specific psychosomatic symptoms have been studied before. A recent review concluded that most studies (i.e. 6 out of 7 studies) reported a positive relation between overcommitment and psychosomatic health outcomes[36]. One cross-sectional study[42] used musculoskeletal symptoms as an outcome measure and found a higher prevalence of neck pain in subjects with a high score on overcommitment and in subjects with an unfavorable effort/reward-imbalance, but shoulder pain and pain in the upper extremities were associated with neither overcommitment nor ERI.

It is unknown how a personality trait, such as overcommitment, could lead to symptoms. Overcommitted workers may expose themselves more often to high demands at work, or they may exaggerate their efforts beyond what is formally needed[43]. This could result in unhealthy behavior at work. To define this aspect, Feuerstein constructed the concept of "workstyle". Workstyle indicates the individual responses to high work demands. It is not conceptualized as a personality factor, but rather as a learned and reinforced strategy for completing, responding to, or coping with increased job demands that may affect musculoskeletal health[18]. A high-risk workstyle implies: taking shorter or fewer breaks or even skip breaks, working through pain, anticipating the possible negative reactions of colleagues, and making high demands on one's own performances at work. Exposure at work and personality traits could induce a high-risk workstyle (path f and h, respectively), while this workstyle could lead to neck and upper limb symptoms (path g).

Empirical evidence of the workstyle concept is still scarce, as little research has been done on this subject. Preliminary analyses, before the concept was defined explicitly, have shown support for the hypothesis that a high-risk workstyle could have an adverse effect on musculoskeletal symptoms[18]. In one study an association between workstyle and pain severity was found in a population of symptomatic female office workers[44]. The results of a recent study have shown that workstyle predicted upper extremity symptoms and functional limitations at 3 months[45]. No studies have been published on the determinants of a high-risk workstyle.

Apart from overcommitment there are several personal factors that could have indirect effects on the occurrence, recurrence or persistence of neck and upper limb symptoms. These factors determine the susceptibility of workers to symptoms. Among these factors are diverse characteristics such as gender, age, lifestyle, parenthood and household activities. They could have a moderating effect on the relation between exposure at work and symptoms (path i). One obvious example is physical capacity. It could be assumed that workers with high physical capacity are less susceptible. Physical capacity is largely congenital, but could be increased through physical activity in leisure time, for example sporting activities.

There is no consensus on whether physical activity could have an effect on musculoskeletal symptoms. In their review Hildebrandt et al. found associations between physical activity in leisure time and musculoskeletal symptoms, although the results of the studies were somewhat inconsistent[46]. Ariëns et al. concluded in their review that there was inconclusive evidence for a relationship between sports and exercise and neck pain[47], although hardly any high quality studies were found. In a more recent study among forestry workers, it was concluded that physical exercise had more protective than impairing effects on shoulders[48]. Also several intervention studies concluded

that physical activity had a positive effect on neck or shoulder symptoms[49,50,51], although in a study concerning an individual counseling intervention at the workplace no significant effect regarding neck and upper limb symptoms was found[52].
Apart from work demands, personal factors, such as personality traits, personal circumstances or the combination of demands from work and demands from private life, could cause stress (path j). Since stress symptoms could have a direct effect, as indicated before, these personal factors could have an indirect effect on neck and upper limb symptoms (path j-d). Finally, personal factors could have a direct effect on neck and upper limb symptoms (path k). As mentioned before, physical and psychosocial factors, similar to those in the workplace, could occur during leisure time as well. Furthermore, the individual's physical build or posture, susceptibility, character or lifestyle in combination with personal circumstances in leisure time, could lead to neck and upper limb symptoms. However, this thesis is focused mainly on work-related risk factors. Therefore, the pathways j and k will not be discussed further.

In conclusion, the literature offers sufficient evidence that work-related physical exposure is a risk factor for neck and upper limb symptoms in industrial workers. However, results concerning office workers are often inconsistent. Psychosocial factors seem to be important as well. How these factors could lead to symptoms, and how they interact with physical factors remains unclear. It has been often suggested that behavioral aspects, such as workstyle and physical activity in leisure time, are of importance in the aetiology of neck and upper limb symptoms. However, studies concerning these factors are still scarce. Also, there is little evidence that personality traits could have an effect on neck and upper limb symptoms, due to a lack of studies on this subject.

1.4 Aim of the study

In the model ten pathways (a to k) relating to the aetiology of neck and upper limb symptoms were mentioned. It is beyond the scope of this thesis to examine them all thoroughly. Some belong to the area of other research disciplines. For other pathways the available sources supply insufficient data. The focus of this thesis is on the aetiology of symptoms in the working population. Therefore, the aim of this study is restricted to the following nine questions, eight concerning the aetiology of symptoms and one concerning the effectiveness of an intervention (the letters between brackets indicate the pathway in the model):

- What is the influence of physical exposure at work on neck and upper limb symptoms (a)?
- What are the main effects of psychosocial work characteristics on neck and upper limb symptoms (c)?
- To what extent can the relationship between psychosocial work characteristics and neck and upper limb symptoms be explained by work-related physical exposure (b,a)?
- To what extent is the relationship between psychosocial work characteristics and neck and upper limb symptoms mediated by stress symptoms (d,e)?
- What is the influence of overcommitment on neck and upper limb symptoms (i,k)?
- To what extent is the relation between work-related exposure and neck and upper limb symptoms mediated by a high-risk workstyle (f,g,)?
- To what extent is the relation between overcommitment and neck and upper limb symptoms mediated by a high-risk workstyle (h,g)?
- What is the effect of physical activity in leisure time on neck and upper limb symptoms and sickness absence due to these symptoms (i,k)?
- What is the effect of software programs stimulating a healthy workstyle (regular breaks and exercises) on neck and upper limb symptoms (g)?

1.5 Outline of the thesis

Chapter 2 and 3 both present the results of analyses examining work-related risk factors for neck and upper limb symptoms. For these analyses data were used from a prospective cohort study in a working population in the Netherlands, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH). Chapter 2 describes the results concerning physical risk factors and chapter 3 the results concerning psychosocial risk factors, based on the Demands-Control Model. Chapter 4 is also about work-related psychosocial factors but the analyses were performed with data from a prospective cohort study in a working population in Denmark, called the Project on Research and Intervention in Monotonous Work (PRIM). This population consisted of workers with repetitive tasks. Psychosocial factors were examined that were based on the Effort-Reward Imbalance Model. In this model psychosocial and personal factors were combined. Chapter 5 describes the results of analyses with the concept of workstyle, a mainly behavioral concept that may act as a mediator in the relation between work demands and personality traits. For these analyses data from a large survey at a European company were used. Chapter 6 describes the results of analyses concerning the effect of physical activity in leisure time, for which the data from SMASH were used. In these analyses not only the effect on neck and upper limb symptoms was studied, but also the effect on sickness absence due to these symptoms. Chapter 7 describes the results of a randomized controlled trial examining the effects of a software program stimulating a healthy workstyle (i.e. regular breaks and exercises). Chapter 8 contains the general discussion and this thesis concludes with a summary in both English and Dutch.

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Do work-related physical factors predict neck and upper limb symptoms in office workers

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2 Do work-related physical factors predict neck and upper limb symptoms in office workers

The objective of this study was to examine the influence of physical exposure at work on neck and upper limb symptoms in office workers. Data were used from a prospective cohort study with a follow-up period of 3 years. Independent variables were observed and self-reported physical exposure at work. Outcome measures were neck/shoulder symptoms and elbow/wrist/hand symptoms. Data were analyzed with the generalized estimating equation (GEE) method, with adjustment for age, gender, psychosocial work characteristics and the outcome at baseline. Neck rotation was associated with neck/shoulder symptoms in the analyses with observed data (OR: 1.57; CI: 0.99-2.50) as well as those with self-reported data (OR: 1.43; CI: 1.02-2.01). Neck extension was also statistically significantly associated with neck/shoulder symptoms (OR: 2.42; CI: 1.22-4.80), but only self-reported data were available. Neck flexion, self-reported wrist pronation, self-reported arm elevation, and self-reported duration of computer work, were not associated with symptoms. An indication was found for an adverse effect of long working days on neck/shoulder symptoms, and for self-reported wrist flexion and full-time work or longer compared to part-time work on elbow/wrist/hand symptoms. It was concluded that only a limited number of work-related physical factors were related to neck and upper limb symptoms in office workers. Only neck rotation and self-reported neck extension were identified as risk factors for neck/shoulder symptoms. No risk factors for elbow/wrist/hand symptoms were identified.

2.1 Introduction

Neck and upper limb symptoms are common in the working population. In the Netherlands, a recent survey showed that 28% of the working population had had neck/shoulder or elbow/wrist/hand symptoms in the previous 12 months[1]. Data from the European Foundation for the Improvement of Living and Working Conditions, based on fifteen European countries, showed that 25% reported that their work causes neck/shoulder pain, and 15% reported that their work causes arm pain. The phrasing of this question contained no time-perspective. In a subpopulation of office workers these percentages were 20% and 9%, respectively[2]. Reported symptoms would probably be higher if the condition that work had caused the symptoms would be omitted from the question. In a longitudinal study among computer users the prevalence at baseline of neck and hand/wrist symptoms lasting more than 7 days within the last year was 45% and 26%, respectively[3]. The percentage of workers with neck pain was comparable with the results of another recent study among office employees working with VDUs, in which 44% reported neck pain for more than 7 days at the baseline measurement[4]. A study among technical assistants found a lower percentage of elbow, forearm and hand pain. However, this percentage was restricted to symptoms of the right side of the body: at baseline, 12% of the participants reported that they had been troubled quite a lot, much or very much by pain or discomfort in the right elbow, forearm, or wrist-hand during the past 12 months.

Although it is not clear to what extent these symptoms are work-related, the high prevalence among workers compels preventive actions at the workplace. Accordingly, knowledge concerning the significance of risk factors is needed. Although there is a growing interest in psychosocial and personal risk factors for neck and upper limb symptoms, it is beyond doubt that work-related physical risk factors will remain an important issue in the investigation of the aetiology of neck and upper limb symptoms. Firstly, the identification of relevant physical risk factors offers probably more opportunities for prevention than other factors. Secondly, it is relevant to know more about the interaction effects between personal and psychosocial factors and physical exposure at work.

Already several physical risk factors for neck and upper limb symptoms were studied. Repetitiveness, especially in combination with forceful exertions, is generally acknowledged as an important risk factor[5,6,7]. However, this mainly concerns industrial workers. Until recently, high-quality studies concerning office workers have been scarce. Since office work is dominated by increasing computer work[8], and possibly harmful effects of computer work receive a lot of attention, several longitudinal studies were carried out concerning office workers[3,4,9,10,11,12]. These studies examined the hours per week of work time with the computer, often divided into keyboard and mouse use and/or examined working postures of office workers. However, results from these studies were often inconsistent and mostly based on self-reported data. Despite these recent studies, the knowledge of risk factors in office workers is still limited, and additional high quality studies are still needed to identify and verify work-related physical risk factors for neck and upper limb symptoms in office workers.

The present study has the advantage of a longitudinal design and observed physical exposure next to self-reported data. The objective of this study is to determine the influence of physical exposure at work on neck and upper limb symptoms in an office population.

2.2 Methods

2.2.1 Study population

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a prospective cohort study with a follow-up period of three years, was initiated among a working population in The Netherlands. The main purpose of this study was to determine risk factors for musculoskeletal disorders, with a focus on low back, neck and shoulder symptoms. The 34 participating companies were asked to select workers who had been employed in their current job for at least one year and who were working 24 hours per week or more. At baseline, 1,789 (87%) of the 2,064 workers invited to participate in SMASH filled in a questionnaire. After exclusion of workers who did not meet the selection criteria mentioned above and who did not have another paid job for a substantial amount of time, 1,742 were eligible for participation. Based on video-observations and worksite inspection, job titles were assigned according to the International Standard Classification of Occupations (ISCO 1988). For the present study, a selection was made of 398 office workers, based on job title. The following job titles were selected (between brackets the ISCO-code): computing professionals (213), administrative associate professionals (343), and office clerks (41).

2.2.2 Physical risk factors

Data on physical exposure at work were obtained using questionnaires as well as video observations. The questions were derived from the standardized Dutch Musculoskeletal Questionnaire[13] and were part of all yearly questionnaires. Workers were asked if they were occupied 'never', 'occasionally', 'often' or 'very often' with computer tasks. Flexion and rotation of the wrists as well as neck flexion and neck extension were assessed by asking whether they, yes or no, carried out these activities for a prolonged period of time. Data on working hours were only assessed at baseline.

At baseline physical exposure was assessed using video observations according to a group based measurement strategy. Of each worker four video-recordings were made of 10-14 minutes during one day. All workers were classified into groups with similar tasks and a similar physical load, based on on-site inspection. The video-recordings of one fourth of the workers in each group were observed according to a standard protocol. All individuals within a group were assigned the mean values of the exposure variables, based on the individuals observed in that group.

From the video observations, data were obtained of neck flexion, neck rotation and arm elevation. Wrist postures were not assessed as no reliable measurement of these postures could be extracted from the video observations. Duration of computer work and neck extension were not registered. Neck flexion was divided into 20 degrees or more, and 45 degrees or more. Neck rotation was defined as a rotation of 45 degrees or more, and both flexion and rotation were expressed as the percentage of time subjects were working in this posture. Arm elevation was divided into elevation of 30 to 60 degrees, elevation of 60 to 90 degrees and elevation for more than 90 degrees. However, postures of arm elevation for more than 60 degrees hardly occurred among office workers. Therefore, only arm elevation of 30 to 60 degrees was included in the analyses. Arm elevation was also expressed as the percentage of time subjects were working in this posture.

2.2.3 Psychosocial risk factors

Data on psychosocial work characteristics were assessed with a Dutch version of the Job Content Questionnaire (JCQ)[14], which measures all dimensions of the widely used Demand-Control-Support model[15]. These questions were included in all yearly measurements. Various items were combined to form dimensions of job demands, decision authority and social support of colleagues. The precise calculation of these dimensions, based on data from SMASH, has been described by de Jonge et al.[16]

2.2.4 Outcome measure

Data on symptoms were collected with an adapted version of the Nordic Questionnaire[17]. Workers were asked to rate the occurrence of pain in neck, shoulders, elbows, wrists or hands in the previous 12 months on a four-point scale (never, sometimes, regular, prolonged). Workers were identified as cases if they reported regular or prolonged pain in these regions during the previous 12 months. Combined outcome measures were made for neck/shoulder symptoms and elbow/wrist/hand symptoms.

2.2.5 Analysis

The effects of physical exposure at work were examined with the generalized estimating equation (GEE) method[18], using the Proc Genmod procedure in the statistical package SAS (version 9.1.2). A time lag of one measurement (= 1 year) was built into the model to relate the independent variables (physical exposure) at one point in time to the dependent variable (symptoms) in the following year, as assessed in the next measurement. The dependent variables were studied separately: neck/shoulder symptoms and elbow/wrist/hand symptoms. The independent variables were derived from the self-reported and observed data on physical exposure. Since data from the video observations were only available for baseline, we had to use baseline values as the independent variables in the analyses with observed exposure.
The continuous variables of the observed data were divided into tertiles, indicating low, medium and high values of exposure. Univariate analyses were carried out first. Then, to examine if the effect of physical exposure changed after time, the interaction terms of the exposure variables and time were

included in the models. Finally, multivariate analyses were carried out, with the covariates age, gender, the value of the outcome measure at the time of exposure measurement and the psychosocial work characteristics job demands, social support of co-workers and decision authority. From earlier analyses with the same data, the confounding effects of these psychosocial work characteristics were already known[19]. It was examined if physical activity in leisure time had a confounding effect, but the inclusion of this variable in the model did not influence the results.

2.3 Results

2.3.1 Prevalence of symptoms

Table 2.1 shows the prevalence of neck and upper limb symptoms. Symptoms were reported more often at baseline than during the follow-up period. Neck/shoulder symptoms were reported more often than elbow/wrist/hand symptoms.

Table 2.1 The 12-month prevalence of neck/shoulder symptoms and elbow/wrist/hand symptoms among office workers (n=398)

	baseline		**follow-up 1**		**follow-up 2**		**follow-up 3**	
	%	(n)	%	(n)	%	(n)	%	(n)
Neck/shoulder symptoms	38	(153)	28	(102)	26	(92)	23	(82)
Elbow/wrist/hand symptoms	16	(62)	12	(43)	13	(47)	10	(35)

2.3.2 Effects of physical exposure at work on neck/shoulder symptoms

Table 2.2 shows the effects of physical exposure at work on neck/shoulder symptoms. Self-reported neck extension was identified as a statistically significant risk factor. Observed neck flexion was not associated with symptoms. The association between neck rotation and neck/shoulder symptoms was statistically significant with the self-reported variable. An even higher risk estimate was found in the analyses with observed neck rotation, although the association was only borderline statistically significant. The results also showed an effect of long working days. However, in the multivariate analyses this association was not statistically significant. Analyses of the interaction with time showed that the association between self-reported neck extension and neck/shoulder symptoms increased after time.

Table 2.2: Results of the GEE-analyses concerning the risk at neck/shoulder symptoms of physical exposure in office workers (n=398); self-reported exposure is presented in italic small print

		%[1]	(n)[1]	crude OR	(CI)	adj. OR[2]	(CI)
neck flexion >= 20° (% of time)							
	low (0-33%)	21	(82)	1.00		1.00	
	medium (33-38%)	44	(175)	1.01	(0.60-1.71)	0.92	(0.58-1.46)
	high (38-73%)	35	(139)	1.20	(0.70-2.05)	1.06	(0.65-1.72)
neck flexion >= 45° (% of time)							
	low (0-3%)	19	(74)	1.00		1.00	
	medium (3-4%)	43	(172)	1.05	(0.62-1.79)	0.95	(0.59-1.52)
	high (4-24%)	38	(150)	1.21	(0.70-2.08)	1.10	(0.67-1.80)
neck flexion	*no*	*25*	*(99)*	*1.00*		*1.00*	
(self-reported)	*yes*	*75*	*(299)*	*1.49*	*(1.09-2.02)*	*1.35*	*(0.92-1.99)*
neck extension	*no*	*96*	*(379)*	*1.00*		*1.00*	
(self-reported)	*yes*	*4*	*(16)*	*1.43*	*(0.78-2.61)*	*2.42*	*(1.22-4.80)*
neck rotation >= 45° (% of time)							
	low (2-13%)	46	(142)	1.00		1.00	
	medium (14%)	43	(172)	1.37	(0.87-2.16)	1.06	(0.70-1.60)
	high (14-45%)	21	(82)	2.60	(1.54-4.40)	1.57	(0.99-2.50)
neck rotation	*no*	*50*	*(198)*	*1.00*		*1.00*	
(self-reported)	*yes*	*50*	*(200)*	*1.69*	*(1.29-2.21)*	*1.43*	*(1.02-2.01)*
arm elevation 30°- 60° (% of time)							
	low (9-32%)	37	(146)	1.00		1.00	
	medium (32-35%)	14	(55)	0.56	(0.29-1.07)	0.76	(0.42-1.38)
	high (36-65%)	49	(195)	0.70	(0.46-1.06)	0.81	(0.55-1.19)
computer work (self-reported)							
	seldom/never to now and then	*19*	*(74)*	*1.00*		*1.00*	
	rather often	*43*	*(170)*	*1.14*	*(0.84-1.54)*	*1.23*	*(0.81-1.85)*
	very often	*39*	*(154)*	*1.03*	*(0.70-1.52)*	*0.94*	*(0.60-1.48)*
working week	*< 40 hours*	*14*	*(54)*	*1.00*		*1.00*	
(self-reported)	*40 hours*	*73*	*(286)*	*0.68*	*(0.39-1.18)*	*0.89*	*(0.54-1.45)*
	> 40 hours	*13*	*(53)*	*0.97*	*(0.48-1.95)*	*1.04*	*(0.55-1.97)*
long working days	*< 8½ h per day*	*90*	*(343)*	*1.00*		*1.00*	
(self-reported)	*≥ 8½ h per day*	*10*	*(40)*	*1.81*	*(1.01-3.27)*	*1.57*	*(0.91-2.70)*

1 percentages and number of workers at baseline
2 Adjusted for the value of the outcome measure at the time of exposure, age, gender and psychosocial work characteristics

2.3.3 Effects of physical exposure at work on elbow/wrist/hand symptoms

Tabel 2.3 shows the effects of physical exposure at work on elbow/wrist/hand symptoms. The univariate analyses resulted in a statistically significant association between wrist flexion and elbow/wrist/hand symptoms. This association was no longer statistically significant in the multivariate analyses. A self-reported full-time working week (= 40 hours) and a working week longer than 40 hours seems to be unfavorable compared to part-time work. However, the associations were not statistically significant.

Table 2.3: Results of the GEE-analyses concerning the risk at elbow/wrist/hand symptoms of physical exposure in office workers (n=398); self-reported exposure is presented in italic small print

		%[1]	(n)[1]	crude OR	(CI)	adj. OR[2]	(CI)
wrist flexion	*no*	*67*	*(265)*	*1.00*		*1.00*	
	yes	*33*	*(132)*	*1.53*	*(1.01-2.33)*	*1.45*	*(0.92-2.30)*
wrist pronation	*no*	*84*	*(332)*	*1.00*		*1.00*	
	yes	*16*	*(64)*	*1.14*	*(0.64-2.04)*	*1.27*	*(0.69-2.34)*
arm elevation 30°- 60° (% of time)							
	low (9-32%)	37	(146)	1.00		1.00	
	medium (32-35%)	14	(55)	0.33	(0.15-0.73)	0.52	(0.25-1.11)
	high (36-65%)	49	(195)	0.57	(0.34-0.96)	0.82	(0.51-1.31)
computer work seldom/never to now and then		*19*	*(74)*	*1.00*		*1.00*	
(self-reported)	*rather often*	*43*	*(170)*	*1.22*	*(0.68-2.18)*	*1.29*	*(0.63-2.66)*
	very often	*39*	*(154)*	*1.42*	*(0.77-2.60)*	*1.42*	*(0.70-2.86)*
working week	*< 40 hours*	*14*	*(54)*	*1.00*		*1.00*	
(self-reported)	*40 hours*	*73*	*(286)*	*0.89*	*(0.44-1.79)*	*1.67*	*(0.90-3.11)*
	> 40 hours	*13*	*(53)*	*1.00*	*(0.41-2.41)*	*1.45*	*(0.62-3.37)*
long working days	*< 8½ h per day*	*90*	*(343)*	*1.00*		*1.00*	
(self-reported)	*≥ 8½ h per day*	*10*	*(40)*	*1.22*	*(0.71-2.11)*	*1.04*	*(0.45-2.41)*

1 percentages and number of workers at baseline

2 Adjusted for the value of the outcome measure at the time of exposure, age, gender and psychosocial work characteristics

2.4 Discussion

2.4.1 Summary of findings

Neck rotation was associated with neck/shoulder symptoms, although the association was only borderline statistically significant in the multivariate analyses with data from the observed exposure. Furthermore, the analyses with self-reported data resulted in statistically significant associations between neck extension and neck/shoulder symptoms. Observed neck flexion was not associated with symptoms. An indication was found of an adverse effect of long working days. However, the association was not statistically significant in the multivariate analyses. None of the variables concerning physical exposure at work were statistically significantly associated with elbow/wrist/hand symptoms, although an indication for an adverse effect was found of wrist flexion and of full-time work or longer compared to part-time work.

2.4.2 Comparison with previous findings

The effect of observed physical exposure on musculoskeletal symptoms and sickness absence due to these symptoms has been examined before with the same data. Hoogendoorn and colleagues studied the effect on low back pain[20], whereas Ariëns and colleagues studied the effect on neck pain[21]. The present study might seem rather similar to the study of Ariëns. However, there are important differences. While Ariëns studied only neck symptoms, neck symptoms were combined with shoulder symptoms in the present study. Secondly, Ariëns used the total population of workers with many different job titles, whereas in the present study only office workers were included. Thirdly, the categories of physical exposure were different. In the present study the variables were categorized into tertiles, whereas Ariëns constructed three categories out of smaller categories on the base of similarity of effect estimation. These differences led to different results. Ariëns found no statistically significant associations with observed neck flexion and neck rotations either, although a trend for an association between neck flexion and neck symptoms was found. This trend was not found in the present study among office workers. The trend for an association between neck rotation and neck/shoulder symptoms, as found in the present study, was not found in the study of Ariëns.

In the present study no statistically significant effect of frequent computer work was found. Although this association was suggested in earlier studies[22], most recent longitudinal studies found no association between long duration of computer work and neck/shoulder symptoms [3,4,9,10]. Only one study[12] found an association between keyboard use for more than 15 hours and mouse use for more than 20 hours per week and new right shoulder symptoms. There are only few high quality studies on the relation between duration of computer work and elbow/wrist/hand symptoms. The results of studies that examined the effect of the duration of mouse use were fairly consistent and showed an unfavorable effect on elbow/wrist/hand symptoms of mouse use for at least half of the working time[3], and of mouse use as a continuous variable[11]. Moreover, an association was found between mouse use for more than 20 hours per week and carpal tunnel syndrome[23], and between mouse use for more than 30 hours per week and forearm pain[24]. Results on total computer time or keyboard use were less consistent: a weak association was found between the hours of keying per week and hand/arm symptoms[9]; a stronger association was found between computer work for more than 75% of the time and wrist/hand symptoms[3] and between keyboard time as a continuous variable and wrist/hand symptoms[11]; no associations were found between total computer time and elbow symptoms[10]. Since the results in the present study only refer to total computer time, it can be concluded that results from the present study do not contradict the existing evidence on the relation between computer work and neck and upper limb symptoms.

Ariëns et al. reported in their review that there is inconclusive evidence for a relation of neck flexion and neck rotation with neck pain. The inconclusiveness was caused by the low quality of the included studies[25]. A more recent prospective study observed different postural risk factors in computer workers, including head tilt angle and head rotation angle, but the analyses did not produce statistically significant results for these variables[9]. In the present study neck rotation was identified as a risk factor for neck/shoulder symptoms, while neck flexion was associated with neck/shoulder symptoms in the analyses with self-reported data only.

Arm elevation was not identified as a risk factor in the present study. In former studies some evidence for a relation between arm elevation and neck and shoulder symptoms was found[26,27]. However, these studies did not concern office workers. Moreover, these studies had much more contrast in exposure.

In the present study, there were no observed data on wrist postures. There are few comparable studies on wrist posture and its relation with elbow/wrist/hand symptoms. The already mentioned prospective study that observed different postural risk factors in computer workers, found no risk factors of several wrist positions in relation to the mouse[9].

Another aspect of physical factors is the duration of the physical exposure, expressed in hours per week and hours per day. There are few studies on the effect of the duration of working day or working week on musculoskeletal symptoms. An intervention study in care institutions showed that the shortening of working days from ≥ 7 hours to 6 hours might considerably reduce the prevalence of neck/shoulder symptoms[28]. The results of the present study showed a comparable effect, as subjects who worked for more than 8½ hours per day had higher risk estimates for neck/shoulder symptoms. However, the association was not statistically significant.

2.4.3 Observed versus self-reported data

The results of analyses with observed and with self-reported data on physical exposure diverged. Several reasons could be given for these diverging results. Firstly, the analyses were not fully comparable as no data on observed physical exposure were available at follow-up. In the analyses with observed data, the relation of physical exposure at baseline and the outcome variables at all measurements was studied, irrespective of changes in exposure. The advantage of the analyses with self-reported data, is that changes in exposure were taken into account. Therefore, the odds ratios do not only account for the between-subjects relationship, but also for the within-subjects relationship. In other words, the odds ratios do not only represent the risks of subjects with higher scores on the exposure variables compared to subjects in the reference group, but also the risk of an increase in score over time within subjects[29].

Secondly, the use of self-reported data has drawbacks compared to observed data. One important disadvantage of analyses using self-reported data is the risk of an overestimation of the risks. Subjects with symptoms are probably more aware of possible disadvantageous postures or actions at work than subjects free of symptoms. The reason could be that they feel pain exerting these actions or remaining in these postures, or because they attribute their symptoms to more or less known risk factors. This might lead to differential misclassification. Although in the design of the present study the assessment of exposure was not at the same measurement as the assessment of symptoms, this problem might still occur, as subjects with symptoms had often also symptoms at the previous measurement, when the exposure was assessed. Summarizing, the analyses with observed and self-reported data both have their pros and cons and are not entirely comparable. Therefore, each result should be judged on its own merit.

2.4.4 Methodological considerations

The population in this study consisted of subjects with and without symptoms, with adjustment for their symptoms at exposure measurement. Therefore, the effects studied reflect not only the onset of symptoms, but also the persistence or disappearance of symptoms. The design of this study is not suitable to determine how long the exposure should be lasting, in terms of months or years, to cause an effect.

A group-based measurement strategy was used to asses data on physical exposure. The choice for this strategy opposed to an individual-based strategy is dependent on the estimation of variance in exposure between and within workers[30]. In general, individual-based strategies generate precise, though biased, estimates and group-based strategies generate less precise but essentially unbiased estimates[31]. Furthermore, the choice for a group-based strategy is usually based on reasons of efficiency. To prevent misclassification in a group-based measurement it is important to minimize the within-group variance and maximize the between-group variance[31,32]. Grouping on the base of job-title is usually too crude. To minimize misclassification in the present study, groups were composed on the base of the estimation of the comparability of jobs during onsite inspections. As a consequence, it is not possible to measure individual differences within work groups. Furthermore, misclassification of exposure for individual workers still may have occurred due to differences between individuals within a group.

A common problem in occupational cohort studies is the healthy worker effect[33,34]. Also in this study this effect could have biased the results. According to table 2.1 subjects reported considerably more symptoms at baseline than at follow-up. This could suggest that workers with starting symptoms have left their job and were lost to follow-up, which would lead to an underestimation of the risk. However, subjects who reported symptoms at baseline did not drop out more often than subjects without symptoms. Moreover, there were hardly any differences between subjects who dropped out and subjects who did not on physical exposure at baseline. Therefore, it can be concluded that bias due to a healthy worker effect will be limited.

2.4.5 Conclusions

Neck rotation was identified as a risk factor for neck/shoulder symptoms. Neck extension was also statistically significantly associated with neck/shoulder symptoms, but only self-reported data were available. An indication was found of an adverse effect of long working days. None of the factors of physical exposure, examined in the present study, were statistically significantly associated with elbow/wrist/hand symptoms, although an indication of an adverse effect was found of wrist flexion and of full-time work or longer compared to part-time work. In line with previous studies, it can be concluded that there is only a slight effect of posture on neck and upper limb symptoms in office workers.

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Psychosocial work characteristics in relation to neck and upper limb symptoms

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3 Psychosocial work characteristics in relation to neck and upper limb symptoms

The aim of this study was to investigate the relationship between psychosocial work characteristics and neck and upper limb symptoms and to examine to what extent this relationship could be explained by other risk factors. Data were used from a prospective cohort study in a working population, with a follow-up period of 3 years. The 3-year cumulative incidence rates of neck or upper limb symptoms, neck/shoulder symptoms and elbow/wrist/hand symptoms were 32%, 24% and 15%, respectively. After adjustment for potential confounders high job demands was identified as a risk factor for neck/shoulder symptoms (RR: 2.1; CI: 1.2-3.6) and elbow/wrist/hand symptoms (RR: 1.9; CI: 1.0-3.7), and low social support of co-workers was identified as a risk factor for elbow/wrist/hand symptoms (RR: 2.2; CI: 1.0-4.9). Partly, but not exclusively, these relationships were intermediated by an increased exposure to physical risk factors and increased stress symptoms. Personal characteristics did not considerably influence the main effects of the identified risk factors.

3.1 Introduction

It is known that neck and upper limb symptoms have a multifactorial aetiology. Several physical risk factors have been identified, with repetitive movements[1,2,3] and prolonged computer work[4] as the most prominent until now. Also, neck and upper limb symptoms were associated with personal characteristics, such as coping style[5], type A personality[6] and introversion[7]. Another type of risk can be found in the psychosocial work characteristics. In a review dealing with studies published before 2000, it was concluded that there still was no strong evidence for this relationship[8], due to the absence of prospective studies. Recently more prospective studies have been published[1,3,9,10,11,12,13,14]. These studies varied in symptoms and psychosocial factors studied, but had in common that they identified psychosocial work characteristics as risk factors for neck or upper limb symptoms.

The precise mechanisms through which psychosocial work characteristics lead to symptoms have not yet been fully uncovered. The simple model presented in figure 3.1, which is based on the model introduced by Bongers et al.[15], illustrates possible associations.

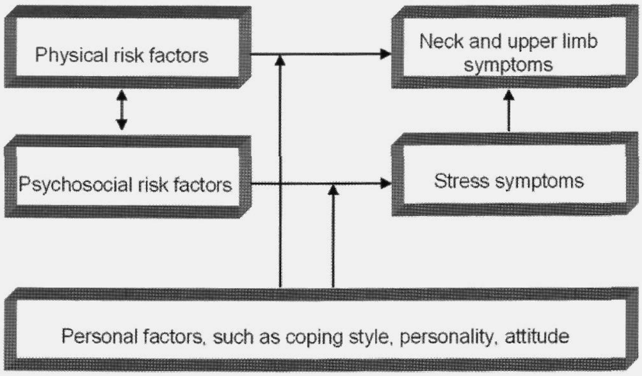

Figure 3.1 Possible associations between psychosocial and physical risk factors, personal factors and neck and upper limb symptoms

According to this model psychosocial work characteristics could have an adverse effect on neck and upper limb symptoms via several pathways. Physical risk factors and stress symptoms both could play an intermediate role, as psychosocial work characteristics could cause an unfavorable change in the physical exposure as well as an increase in stress symptoms. Personal characteristics could influence the process as well. In this model it is assumed they play a confounding role.

The aim of this study was to investigate the relationship between psychosocial work characteristics and neck, shoulder, elbow, hand and wrist symptoms, according to the mechanisms, mentioned in the model. Within the limitations of this study it was not possible to test the complete model. However, some of the associations could be elucidated. Therefore, the first objective was to study the main effects of psychosocial work characteristics on neck and upper limb symptoms. The second objective was to examine to what extent this relationship might be explained by work-related physical risk factors, stress symptoms and personal characteristics.

3.2 Methods

3.2.1 Study population

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH) was initiated among a working population in the Netherlands. SMASH was a prospective cohort study with a follow-up period of 3 years. The main purpose of SMASH was to determine risk factors for musculoskeletal disorders, with a focus on low back, neck and shoulder disorders. The 34 participating companies were asked to select workers who had been employed in their current job for at least 1 year and who were working 24 hours per week or more. The population included blue-collar workers, white-collar workers, and workers in caring professions. For the analysis described here, workers were excluded if they had another paid job for a substantial amount of time (n=18), received work disability payment for neck or shoulder pain (n=3) and had regular or prolonged pain in neck, shoulders, elbows, wrists or hands in the previous 12 months (n=710). Of this subcohort of 1029 workers, complete follow-up data were available for 787 workers.

3.2.2 Outcome measure

The outcome measure was the 3-year cumulative incidence of neck and upper limb symptoms. Data on these symptoms were collected with one question of an adapted version of the Nordic Questionnaire[16]: "Have you at any time during the last 12 months had trouble (ache, pain, discomfort) in: ....", after which various musculoskeletal regions were listed. Workers could fill out "never", "sometimes", "regular" or "prolonged" to rate the occurrence of their symptoms. They were identified as cases if they filled out the categories "regular" or "prolonged" for symptoms of elbow, wrist or hand, or for symptoms of neck or shoulder.

3.2.3 Psychosocial work characteristics

Data on psychosocial work characteristics were assessed at baseline with a Dutch version of the Job Content Questionnaire (JCQ)[17], which measures all dimensions of the widely used Demand-Control-Support model[18]. Various items were combined to form dimensions of job demands, skill discretion, decision authority and social support. The precise calculation of these dimensions, based on data from SMASH, has been described by de Jonge et al.[19].

Psychosocial work characteristics were also assessed at follow-up. However, the physical risk factors were only assessed at baseline. Therefore, in this study only data from baseline measurements were used. The JCQ variables of the different measurements were correlated between 0.38 and 0.64.

3.2.4 Physical risk factors

At baseline, data on physical load at work were obtained using questionnaires as well as video observations. The questions were derived from the standardized Dutch Musculoskeletal Questionnaire[20]. Flexion and rotation of the wrists was assessed using this questionnaire: workers were asked whether they carried out these activities for a long time in succession. Also, workers were asked how often they were occupied with computer work. They could choose between ‘never’, ‘occasionally’, ‘often’ or ‘very often’. Data on working hours were also assessed by questionnaire.

The percentage of working time spent in postures with rotation of the neck, lifting and sitting were assessed with video observations. Of each worker four video-recordings were made of 10-14 minutes during one day. All workers were classified into groups with similar tasks and a similar physical load, based on on-site inspection. The video-recordings of one fourth of the workers in each group were studied according to a standard protocol. All individuals within a group were assigned the mean values of the exposure variables, based on the individuals observed in that group.

3.2.5 Stress symptoms

The concept emotional exhaustion was used to identify stress symptoms. Emotional exhaustion was assessed at baseline using a seven-item sub-scale of the Dutch version of the Maslach Burnout Inventory[21]. Although stress symptoms were also assessed at follow-up, only baseline assessments were used in this study. Stress symptoms of the different measurements were correlated between 0.40 en 0.62.

3.2.6 Personal characteristics

Coping styles were assessed using the Utrecht Coping List[22], which was included in the baseline questionnaire. Three coping styles can be distinguished: active, avoidance and support seeking. For the analyses data on avoidance coping were used, as preliminary analyses showed that this coping style was associated with musculoskeletal symptoms.

Negative affectivity roughly corresponds to anxiety/neuroticism. Negative affectivity was assessed using the PANAS Scales[23]. As no baseline data on negative affectivity were available, the measurements at the second follow-up were used in these analyses. This was considered a sound procedure, since these characteristics can be seen as personality traits and should be stable in the course of time.

3.2.7 Analysis

The Cox regression procedure, with a constant risk-period for all subjects, was used to analyze the relationships between the various psychosocial work characteristics and the 3-year cumulative incidence of neck and upper limb symptoms. This technique is preferable to logistic regression in the case of high incidence rates in estimating the relative risk[24,25,26]. As a preliminary step the exposure variables were categorized, using small intervals. Categories showing similar effect estimates were regrouped into three categories, low, medium and high.

Firstly, analyses were performed to test the main effects of the various psychosocial work characteristics. Age, gender, physical risk factors and personal factors were included in the model, to adjust for their potential confounding effect. It was assumed that physical risk factors could play an

intermediate as well as a confounding role, in contrast to stress symptoms, of which only an intermediate role was expected. Therefore, the latter was not included in the model. As it is possible that reports on work characteristics are influenced by symptoms these analyses were repeated separately for the group of workers reporting never and reporting sometimes symptoms at baseline.
In addition to the analyses with the separate psychosocial work characteristics, analyses were performed with a combination of demands and control, according to the demand-control model of Karasek and Theorell[18]. High and low levels (divided by the median) were combined in four combinations: low strain jobs (low demands, high control), active jobs (high demands, high control), passive jobs (low demands, low control) and high strain jobs (high demands, low control). Control was defined as decision authority.
Secondly, analyses were performed to examine to what extent the relationship between psychosocial work characteristics and the outcome measures was influenced by physical risk factors, stress symptoms and personal characteristics. For this purpose multivariate analyses were performed with adjustment for age and gender, and either additional adjustment for physical risk factors, additional adjustment for stress symptoms or additional adjustment for personal factors.

3.3 Results

3.3.1 Incidence of neck and upper limb symptoms

In the population of workers who did not report symptoms at baseline and with complete data on follow-up measurements (n=787), the 3-year cumulative incidence was 24% (n=185) for neck/shoulder symptoms and 15% (n=118) for elbow/wrist/hand symptoms. As some employees reported both symptoms, the 3-year cumulative incidence of symptoms in one or more of the areas mentioned was 32% (n=251).

3.3.2 Main effects of psychosocial work characteristics

Table 3.1 shows the results of the univariate and multivarate analyses. High job demands was identified as a risk factor for both neck/shoulder symptoms and elbow/wrist/hand symptoms. Low co-worker support was identified as a risk factor for elbows/wrist/hand symptoms, but not for neck/shoulder symptoms. For all other psychosocial work characteristics the 95% confidence interval of the relative risk included 1.0.
Separate analyses with workers reporting sometimes complaints at baseline (results not shown) resulted in higher risk estimates for neck/shoulder symptoms than with workers reporting never complaints. This tendency could not be detected in the risk estimates for elbow/wrist/hand symptoms.

3.3.3 Influences on this relationship - neck/shoulder symptoms

Table 3.2 shows the results of the multivariate analyses for neck/shoulder symptoms with different types of adjustments. The adjustment for physical risk factors did not alter the results considerably. The adjustment for stress symptoms decreased the relative risk of high job demands by 12%, but it remained statistically significant. The adjustment for personal risk factors decreased the relative risk of poor social support from co-workers by 23%, but the relative risk was not statistically significant before the adjustment either.

3.3.4 Influences on this relationship - elbow/wrist/hand symptoms

Table 3.3 shows the results of the multivariate analyses for elbow/wrist/hand symptoms with different types of adjustments. Table 3.1 already showed that the relative risks changed after adjustment for potential confounders. Table 3.3 illustrates that the adjustment for physical risk factors accounted for most of these changes. Most changes were decreased, with the exception of the relative risk for poor social support from co-workers, which increased by 32% and became statistically significant. The adjustment for stress symptoms caused a decrease in the relative risk for high job demands by 18%, whereas the adjustment for personal risk factors caused a decrease in the relative risk for low decision authority (13%) and low social support from co-workers (16%).

Table 3.1: Relative risks of psychosocial work characteristics on the three-year cumulative incidence of neck/shoulder symptoms and elbow/wrist/hand symptoms

				neck/shoulder symptoms		elbow/wrist/hand symptoms	
		%	(n)	Crude RR (95% CI)	Adj. RR* (95% CI)	Crude RR (95% CI)	Adj. RR* (95% CI)
job demands	low (5-12)	47%	(369)	1.00	1.00	1.00	1.00
	medium (13-16)	47%	(365)	1.26 (0.93-1.72)	1.16 (0.82-1.64)	1.25 (0.85-1.83)	1.12 (0.74-1.70)
	high (17-20)	6%	(46)	***2.23 (1.36-3.66)***	***2.06 (1.19-3.55)***	***2.22 (1.20-4.10)***	***1.92 (1.00-3.71)***
skill discretion	high (17-20)	23%	(176)	1.00	1.00	1.00	1.00
	medium (12-16)	69%	(538)	1.23 (0.85-1.79)	1.17 (0.76-1.79)	0.99 (0.64-1.55)	0.85 (0.51-1.40)
	low (5-11)	8%	(66)	1.14 (0.62-2.09)	0.99 (0.48-2.05)	1.23 (0.62-2.44)	0.90 (0.41-1.98)
decision authority	high (10-12)	22%	(174)	1.00	1.00	1.00	1.00
	medium (7-9)	65%	(511)	1.21 (0.83-1.77)	1.13 (0.74-1.73)	1.01 (0.64-1.59)	0.81 (0.49-1.32)
	low (3-6)	13%	(98)	1.46 (0.89-2.41)	1.25 (0.70-2.22)	1.35 (0.74-2.45)	0.89 (0.45-1.74)
social support co-workers	high (14-16)	15%	(119)	1.00	1.00	1.00	1.00
	medium (11-13)	76%	(591)	1.02 (0.68-1.54)	1.04 (0.65-1.64)	1.06 (0.62-1.80)	1.43 (0.76-2.71)
	low (4-10)	9%	(68)	1.17 (0.64-2.12)	0.98 (0.51-1.92)	1.86 (0.94-3.68)	***2.23 (1.01-4.90)***
social support supervisor	high (13-16)	12%	(93)	1.00	1.00	1.00	1.00
	medium (11-12)	60%	(469)	0.96 (0.61-1.53)	1.01 (0.59-1.70)	0.71 (0.42-1.19)	0.76 (0.42-1.39)
	low (4-10)	28%	(217)	1.05 (0.64-1.73)	0.93 (0.53-1.64)	0.83 (0.47-1.47)	0.77 (0.41-1.46)
job strain	low	25%	(199)	1.00	1.00	1.00	1.00
	active	25%	(194)	1.23 (0.79-1.93)	1.10 (0.67-1.80)	1.34 (0.78-2.30)	1.44 (0.80-2.59)
	passive	22%	(171)	1.23 (0.78-1.95)	1.12 (0.67-1.86)	1.21 (0.69-2.15)	1.09 (0.59-2.03)
	high	28%	(216)	***1.79 (1.19-2.69)***	1.54 (0.97-2.44)	1.64 (0.99-2.74)	1.15 (0.64-2.07)

Abbreviations: RR, relative risk; CI, confidence interval

* Adjusted for age, gender, physical risk factors and personal risk factors

Table 3.2: Relative risks of psychosocial work characteristics on the three-year cumulative incidence of neck/shoulder symptoms after different types of adjustment

		%	(n)	**RR (95% CI) adjusted for age and gender**	**RR (95% CI) additional adjustment for physical risk factors[1]**	**RR (95% CI) additional adjustment for stress symptoms**	**RR (95% CI) additional adjustment for personal factors[2]**
job demands	low (5-12)	47%	(369)	1.00	1.00	1.00	1.00
	medium (13-16)	47%	(365)	1.27 (0.93-1.73)	1.21 (0.87-1.70)	1.22 (0.89-1.68)	1.22 (0.89-1.67)
	high (17-20)	6%	(46)	***2.22 (1.35-3.65)***	***2.14 (1.27-3.60)***	***1.96 (1.16-3.31)***	***2.14 (1.27-3.59)***
skill discretion	high (17-20)	23%	(176)	1.00	1.00	1.00	1.00
	medium (12-16)	69%	(538)	1.21 (0.84-1.76)	1.25 (0.82-1.90)	1.21 (0.83-1.76)	1.16 (0.79-1.69)
	low (5-11)	8%	(66)	1.08 (0.59-1.99)	1.01 (0.50-2.01)	1.06 (0.58-1.96)	1.09 (0.58-2.04)
decision authority	high (10-12)	22%	(174)	1.00	1.00	1.00	1.00
	medium (7-9)	65%	(511)	1.20 (0.82-1.76)	1.09 (0.73-1.64)	1.20 (0.82-1.76)	1.26 (0.85-1.87)
	low (3-6)	13%	(98)	1.41 (0.85-2.33)	1.34 (0.77-2.31)	1.38 (0.83-2.29)	1.39 (0.82-2.36)
social support co-workers	high (14-16)	15%	(119)	1.00	1.00	1.00	1.00
	medium (11-13)	76%	(591)	1.04 (0.69-1.58)	1.08 (0.68-1.71)	1.03 (0.68-1.56)	0.98 (0.65-1.49)
	low (4-10)	9%	(68)	1.18 (0.65-2.15)	1.25 (0.66-2.37)	1.11 (0.61-2.01)	0.91 (0.48-1.70)
social support supervisor	high (13-16)	12%	(93)	1.00	1.00	1.00	1.00
	medium (11-12)	60%	(469)	0.98 (0.62-1.55)	1.06 (0.63-1.80)	0.99 (0.62-1.57)	0.91 (0.57-1.44)
	low (4-10)	28%	(217)	1.07 (0.65-1.76)	1.06 (0.61-1.85)	1.01 (0.61-1.67)	0.92 (0.56-1.52)
job strain	low	25%	(199)	1.00	1.00	1.00	1.00
	active	25%	(194)	1.23 (0.78-1.92)	1.17 (0.73-1.90)	1.18 (0.74-1.86)	1.16 (0.74-1.84)
	passive	22%	(171)	1.21 (0.76-1.92)	1.11 (0.67-1.84)	1.23 (0.77-1.97)	1.24 (0.77-1.99)
	high	28%	(216)	***1.79 (1.19-2.69)***	***1.62 (1.03-2.53)***	***1.68 (1.10-2.56)***	***1.73 (1.14-2.63)***

Abbreviations: RR, relative risk; CI, confidence interval

1 Physical risk factors: flexion or rotation of the wrists, lifting, neck rotation, prolonged sitting, prolonged computer work and long working days.

2 Personal factors: negative affectivity and avoidance coping.

Table 3.3: Relative risks of psychosocial work characteristics on the three-year cumulative incidence of elbow/wrist/hand symptoms after different types of adjustment

		%	(n)	RR (95% CI) adjusted for age and gender	RR (95% CI) additional adjustment for physical risk factors[1]	RR (95% CI) additional adjustment for stress symptoms	RR (95% CI) additional adjustment for personal factors[2]
job demands	low (5-12)	47%	(369)	1.00	1.00	1.00	1.00
	medium (13-16)	47%	(365)	1.26 (0.86-1.85)	1.16 (0.77-1.76)	1.19 (0.80-1.77)	1.22 (0.82-1.80)
	high (17-20)	6%	(46)	***2.23 (1.21-4.12)***	1.87 (0.99-3.55)	1.83 (0.96-3.51)	***2.29 (1.21-4.32)***
skill discretion	high (17-20)	23%	(176)	1.00	1.00	1.00	1.00
	medium (12-16)	69%	(538)	0.97 (0.62-1.52)	0.89 (0.55-1.45)	0.97 (0.62-1.52)	0.95 (0.60-1.50)
	low (5-11)	8%	(66)	1.16 (0.58-2.32)	1.00 (0.47-2.11)	1.16 (0.58-2.32)	1.11 (0.54-2.28)
decision authority	high (10-12)	22%	(174)	1.00	1.00	1.00	1.00
	medium (7-9)	65%	(511)	1.01 (0.64-1.59)	0.91 (0.56-1.48)	1.01 (0.64-1.59)	0.92 (0.58-1.46)
	low (3-6)	13%	(98)	1.27 (0.70-2.32)	1.10 (0.57-2.11)	1.24 (0.68-2.27)	1.11 (0.60-2.07)
social support co-workers	high (14-16)	15%	(119)	1.00	1.00	1.00	1.00
	medium (11-13)	76%	(591)	1.08 (0.63-1.85)	1.29 (0.70-2.37)	1.07 (0.63-1.83)	1.13 (0.65-1.96)
	low (4-10)	9%	(68)	1.86 (0.94-3.68)	***2.46 (1.17-5.19)***	1.71 (0.86-3.40)	1.57 (0.76-3.23)
social support supervisor	high (13-16)	12%	(93)	1.00	1.00	1.00	1.00
	medium (11-12)	60%	(469)	0.70 (0.41-1.18)	0.74 (0.41-1.32)	0.71 (0.42-1.20)	0.69 (0.40-1.18)
	low (4-10)	28%	(217)	0.85 (0.48-1.50)	0.82 (0.44-1.52)	0.79 (0.45-1.41)	0.78 (0.43-1.40)
job strain	low	25%	(199)	1.00	1.00	1.00	1.00
	active	25%	(194)	1.36 (0.79-2.34)	1.40 (0.78-2.52)	1.28 (0.74-2.24)	1.36 (0.79-2.35)
	passive	22%	(171)	1.22 (0.69-2.17)	1.17 (0.63-2.16)	1.26 (0.70-2.25)	1.18 (0.66-2.10)
	high	28%	(216)	1.65 (0.99-2.75)	1.34 (0.75-2.38)	1.52 (0.89-2.59)	1.50 (0.89-2.53)

Abbreviations: RR, relative risk; CI, confidence interval

1 Physical risk factors: flexion or rotation of the wrists, lifting, neck rotation, prolonged sitting, prolonged computer work and long working days.

2 Personal factors: negative affectivity and avoidance coping.

3.4 Discussion

High job demands was identified as a risk factor for both neck/shoulder symptoms and elbow/wrist/hand symptoms. Low social support of co-workers was identified as a risk factor for elbow/wrist/hand symptoms, but not for neck/shoulder symptoms. To what extent these relationships might be explained by work-related physical risk factors, stress symptoms or personal characteristics will be discussed below.

The adjustment for physical risk factors resulted in a decrease in most relative risks for elbow/wrist/hand symptoms, especially of high job demands. This decrease could be explained by an increase in exposure to physical risk factors, caused by the high job demands. Nevertheless, the relative risk of high job demands was still rather high, after the adjustment for physical risk factors. The relative risk for neck/shoulder symptoms was hardly influenced by the adjustment for physical risk factors. Therefore, it can be concluded that the relation between high job demands and neck and upper limb symptoms is not only due to the increased exposure to physical risk factors.

Contrary to the effect on most relative risks, the adjustment for physical risk factors resulted in an increase in the relative risk of social support of co-workers. A possible explanation is that the effect of social support is different for employees with high and low exposure to physical risk factors. Then, the estimation of the effect of social support could be moderated if social support is distributed unevenly over the different exposures. Additional analyses show that the effect of social support of co-workers is indeed higher if the exposure to physical risk factors is high. However, no conclusive evidence could be found to support this possible explanation.

The adjustment for stress symptoms resulted in a decrease of the relative risk of high job demands. This could mean that stress symptoms played an intermediate role: psychosocial work characteristics lead to stress symptoms, after which stress symptoms lead to a physiological response that causes the musculoskeletal symptoms. Nevertheless, the relative risks of high job demands were still considerable after the inclusion of stress symptoms. Therefore, the role of high job demands in the aetiology of neck and upper limb symptoms is at least partly independent from the stress symptoms they might cause.

The adjustment for personal factors caused a decrease in the relative risk of social support of co-workers and a decrease in the relative risk for decision authority in the analyses with elbow/wrist/hand symptoms. Additional analyses showed that the inclusion of negative affectivity in the model influenced the relative risk of co-worker support, whereas the inclusion of avoidance coping in the model influenced the relative risk of decision authority.

The influence of personal factors in a model with psychosocial work characteristics and musculoskeletal symptoms is rather complicated. Negative affectivity has been called a general nuisance factor in health research, as it is associated with self-reported stressors as well as self-reported health complaints[27]. The inclusion of negative affectivity in the model will adjust for this effect. This could explain the decreases in the relative risks of social support co-workers and decision authority.

The change in relative risk of decision authority, due to the inclusion of avoidance coping might be caused by another mechanism. It is not inconceivable that the influence of a coping style is different and more important when workers have more job control. Conversely, the potential positive influence of more decision authority could be dependent on the worker's coping style. Previous studies have shown that personal characteristics, i.e. self-efficacy, determine whether more job control has a positive or negative effect on health outcomes[28,29]. This is supported by separate analyses (results not shown) for workers with high and low scores on avoidance coping. They showed that in workers with a high score on avoidance coping, little decision authority as well as much decision authority is unfavorable compared to the average situation. In workers with a low score on avoidance coping only the situation with little decision authority is unfavorable.

The analyses were carried out in a subpopulation of workers who did not report symptoms in the previous year at baseline. One reason to select this population was that the assessment of the exposure by the respondents at baseline could be biased by symptoms; workers with symptoms might perceive their job demands higher than workers without symptoms. As the workers with symptoms at baseline most likely will be the workers with symptoms at follow-up this might result in an overestimation of the relative risk. However, the most important reason for not including workers with symptoms at baseline was their different reactivity to exposure. Preliminary analyses showed that most risk factors did not affect the workers who already reported symptoms at baseline. Risk factors for the incidence of symptoms appear to be different than risk factors for the persistence or recurrence of symptoms.

A healthy worker effect could have biased the results. Firstly, the initial selection of subjects could lead to a relatively healthy study population, since these workers were not affected by adverse working conditions after at least one year of employment in their current job. Secondly, workers with starting complaints during the follow-up period might leave their job and will be lost to follow-up. Both effects would lead to an underestimation of the risk. A comparison with results of studies with newly employed workers could indicate the size of the first effect. However, high quality studies with newly employed workers are still scarce.

The second effect would be small if the percentage of subjects lost to follow-up is not too high and is unrelated to the studied outcomes. In this study almost 24% of the initial study population had missing data on symptoms during the follow-up period and were not included in the study. These respondents did not deviate from the study population at baseline on job demands, but reported more often low skill discretion, low decision authority and poor social support. This might have caused an underestimation of the risks.

The influence of psychosocial work characteristics on musculoskeletal symptoms has been examined before with the same data. One study examined their influence on neck pain[30], and one on low back pain[31]. The present study differs from the study of Ariëns et al. on its outcome measure, which is more extensive. This is based on the assumption that the aetiology of these symptoms is comparable.

The results from other recent studies of the influence of psychosocial work characteristics on neck and upper limb symptoms are ambiguous. In two recent studies high job demands was identified as a risk factor for neck or shoulder symptoms[3,11], whereas four other studies did not[10,12,13,14]. Results regarding other psychosocial work characteristics, namely social support and control, were ambiguous as well. Three studies used a combined outcome measure of neck and shoulder symptoms[3,11,12], just like in the present study. Two of these studies found an effect of high job demands[3,11]. All these studies applied different models to test the relationship, but they all adjusted for physical risk factors and for some form of stress symptoms. It is not clear how to explain the diverging results of these studies.

In three recent longitudinal studies on elbow/wrist/hand symptoms, two identified low social support as a risk factor[1,9] and one did not identify any psychosocial work characteristics as risk factors[12]. In the present study the relative risk of low social support from co-workers was statistically significant, if adjusted for physical risk factors and not for stress symptoms and personal risk factors at the same time. All studies adjusted for physical risk factors, but apart from that different variables were included in the model. In the study that did not find an effect of social support, stress symptoms were included in the model. This might be an indication of the intermediate role of stress symptoms.

Summarizing, high job demands was identified as a risk factor for both neck/shoulder symptoms and elbow/wrist/hand symptoms and low social support of co-workers as a risk factor for elbow/wrist/hand symptoms, but not for neck/shoulder symptoms. These relationships were not only due to the increased exposure to physical risk factors. Partly, but not exclusively, these relationships were intermediated by an increased exposure to physical risk factors and increased stress symptoms. Personal characteristics did not considerably influence the main effects of the identified risk factors.

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Overcommitment and effort/reward imbalance in relation to neck and upper limb symptoms

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4 Overcommitment and effort/reward imbalance in relation to neck and upper limb symptoms

Several studies have shown that effort/reward imbalance (ERI) and overcommitment increase the risk at cardiovascular diseases. Less is known about the effects on musculoskeletal symptoms. The aim of this study was to examine ERI and overcommitment in relation to neck and upper extremity symptoms.

Data were used from a prospective cohort study of 3123 workers from industrial and service companies in Denmark, with a follow-up period of 3 years. Independent variables were effort and reward, a combination variable of effort and reward, and overcommitment. Outcome measures were neck/shoulder symptoms and elbow/wrist/hand symptoms. Random coefficient analysis was used to examine the relation between ERI and overcommitment at baseline and neck/shoulder symptoms and elbow/wrist/hand symptoms at all measurements. Men and women were analyzed separately.

The analyses showed that overcommitted workers and workers with low reward and high effort reported more symptoms. Symptoms of women with high overcommitment and elbow/wrist/hand symptoms of men with high effort increased more during follow-up than symptoms in the reference group. Neither for effort and reward, nor for ERI and overcommitment, interaction effects were found.

In conclusion, overcommitment and effort/reward imbalance, especially high effort, may have an unfavorable effect on neck and upper limb symptoms.

4.1 Introduction

Neck and upper limb symptoms have a multifactorial origin. Concerning work-related physical exposure, repetitiveness, especially in combination with forceful exertions, is generally acknowledged as an important risk factor[1,2,3]. Apart from physical factors, several recent prospective studies identified psychosocial work characteristics as risk factors for neck or upper limb symptoms[4-12]. Next to psychosocial work characteristics and physical factors it has been suggested that personality traits could contribute to the onset of neck and upper limb symptoms: some studies found an association between type A behavior and neck/shoulder symptoms[1]. One recent study found that subjects with work-related upper limb disorders had more neurotic perfectionist traits[13]. Nevertheless, little research has been done on the subject.

Siegrist's effort-reward imbalance model (ERI) combines psychosocial work characteristics and personality aspects[14,15]. The theory of this model is that a combination of high effort and low reward could lead to adverse health effects. Overcommitment could reinforce the unfavorable effect of effort-reward imbalance. Furthermore, overcommitment might have an independent effect. The concept "overcommitment" specifies those cognitive, emotional and motivational components within the global concept of Type A behavior that are important in coping with work demands. Overcommitted workers may expose themselves more often to high demands at work, or they may exaggerate their efforts beyond what is formally needed[16].

Often, research on the effects of ERI focuses on stress-related disorders such as cardiovascular diseases[17,18,19,20]. Conversely, research on psychosocial work characteristics in relation to neck and upper limb symptoms is usually restricted to Karasek's demand-control model or parts of this model[21] In view of the influence of psychosocial work characteristics identified in previous studies and the presence of a personality component in the ERI-model, it is interesting to examine the effects of ERI and overcommitment on neck and upper limb symptoms. Therefore, the objective of this study is to examine these relationships. Furthermore, it is examined whether the effects of ERI on symptoms are stronger in overcommitted subjects. As former studies have shown that the components of the ERI-model could have different effects on men and women [19,22], all analyses will be stratified for gender.

4.2 Methods

4.2.1 Study Population

Data were used from a prospective cohort study in a working population in Denmark, called the Project on Research and Intervention in Monotonous Work (PRIM). The baseline measurement of the study started in 1994, followed by three follow-up measurements in 1996/97, 1998 and 1999. The study population comprised 3123 workers from 19 different companies. The selection of the companies was aimed at obtaining a variety of repetitive work tasks, and resulted in a variety of industries. Included were 4 food processing companies, 3 textile plants, 7 other manufacturing and 5 service companies[23]. Three quarters of the workers had mainly repetitive job tasks, while a quarter had more varied jobs and served as a reference group. These groups did not differ on educational level or salary.

4.2.2 Effort-Reward Imbalance

Data on effort and reward were assessed at baseline. As the original items of Siegrist's effort-reward questionnaire were not available in this study, proxy measures were constructed. The original effort scale contains items about time pressure, pressure to work overtime, responsibility and interruptions/ disturbances, and asks if subjects feel distressed about it. The first three items were replaced by three items derived from the concept of job demands of Karasek's Job Content Questionnaire (working very fast, very intensively and time to do everything)[24], and an extra item on work speed. There was no replacement for the items on interruptions/disturbances and responsibility. It is recommended to include an item on physical load to the scale in those occupational groups where prevalence of physical workload is part of the typical task profile[16]. Therefore, a question about physical activity was added to the scale: “which degree of physical activity is needed in your present job?” The scale constructed with these five questions had a Cronbach’s alpha of 0.49. High scores reflected high work demands and high work speed.

The original reward scale contains a mix of different concepts. Subjects were asked if they feel distressed about an unfair treatment, promotion prospects, undesirable change, job redundancies, job security, work prospects, respect from colleagues, (in)adequate support, respect and prestige, skills and salary. They were replaced by a scale of 4 items on job insecurity (worried about lose your job, seconded to another job, redundancy, trouble finding new job), 4 items of Karasek's concept of social support (help from colleagues and superior, colleagues and superior listen) and 7 items on job satisfaction (wages, work prospects, people you work with, physical working conditions, the way your department is run, the way your abilities are used, interest and skill involved and job as a whole). The Cronbach’s alpha of this scale was 0.75. High scores reflected low insecurity, low support and low job satisfaction.

Next to the two continuous variables effort and reward, a new variable was constructed, based on the combination of scores on effort and reward. This variable contained four categories: no high effort and no low reward, high effort (but no low reward), low reward (but no high effort) and both high effort and low reward. Scores in the upper tertile of the effort scale and the reward scale were classified as high effort and low reward, respectively.

4.2.3 Overcommitment

Overcommitment was assessed at baseline with the standard questionnaire on this item[14,15]. Although all 29 items of the scale were included in the questionnaire, for this study a short version of the scale was used, as previous research showed that the explanatory power was confined largely to this smaller set of six items[16,25]. The scores were dichotomized (applicable or not applicable). The added scores on these items resulted in an overcommitment score ranging from 0 to 6. As only 9% of the subjects scored 3 or higher the categories 3, 4, 5 and 6 were combined.

4.2.4 Work-related physical factors

Physical exposure at work was assessed with video observations. Firstly, all companies were visited by ergonomists who classified tasks as either repetitive or reference tasks. Secondly, in every company, groups were composed consisting of workers with the same level of physical exposure, resulting in 103 task groups. In each group one to seven workers were videotaped from three camera angles for at least 10 working cycles for a minimum period of 10-15 minutes. More details on this method were described in previous publications[9,23].

The physical exposure variables were highly correlated. To avoid collinearity only one variable was used in the analyses to adjust for physical exposure. In the analyses with neck/shoulder symptoms as the outcome repetitive shoulder movements was used and in the analyses with elbow/wrist/hand symptoms repetitive hand movements was used. Three levels of exposure were distinguished: 0 for the reference group, 1 for low repetitiveness (1-15 shoulder movements/minute or 1-12 elbow/wrist/hand movements/minute) and 2 for high repetitiveness (>15 shoulder movements/minute or >12 elbow/wrist/hand movements/minute).

4.2.5 Outcome measure

For this analysis, data on symptoms were assessed by questionnaires at baseline and during the follow-up measurements. Subjects were asked to rate on a scale ranging from 0 (no symptoms at all) to 9 (pain as bad as could be) the level of the worst pain, the level of the average pain, the level of impairment due to pain, and the severity of pain in the last seven days. Following former analyses with PRIM data, these scores were added for each body part separately, resulting in a symptom score with a possible range of 0-36. A distinction was made between neck/shoulder symptoms and elbow/wrist/hand symptoms. A total score for neck/shoulder symptoms was calculated by adding the symptom scores of the body parts neck, right and left shoulder. This resulted in a score with a possible range of 0-108. A total score for elbow/hand/wrist symptoms was calculated by adding the symptom scores of the body parts right and left elbow, and right and left wrist/hand, resulting in a score with a possible range of 0-144.

4.2.6 Analyses

The relations between overcommitment and neck/shoulder symptoms and elbow/wrist/hand symptoms, respectively, were analyzed with random coefficient analysis with a random intercept, using the Proc Mixed procedure in the statistical package SAS (version 9.1.2). This technique is suitable for longitudinal analyses, as observations over time are correlated within subjects. By allowing the intercept to vary randomly among persons, these correlations were taken into account[26].

Three types of analyses were carried out separately for men and women and with neck/shoulder symptoms and elbow/wrist/hand symptoms as the outcome variables. Firstly, a model was tested that included the separate continuous effort and reward variables as well as the interaction term effort*reward. Secondly, separate univariate analyses were performed with overcommitment and the categorized ERI-variable as the independent variables, respectively. Then, the coefficients produced by these analyses of overcommitment and ERI were compared to a model in which these variables were combined, to examine if their relation with symptoms was independent. Thirdly, multivariate models were tested that included the overcommitment variable, the categorized ERI-variable, a time-variable, the interaction terms overcommitment*time, ERI*time, overcommitment*ERI and overcommitment*ERI*time. Adjustments were made for age and repetitive movements. Physical activity in leisure time and body mass index were checked for confounding. As the inclusion of these variables did not influence the results they were not included in the models. From the final model all interaction terms that were not statistically significant were removed.

To illustrate the course of symptoms for subjects with different values on the independent variables the fitted values of symptom scores were computed. To calculate the fitted values a model was used that contained the independent variable, a time variable and the interaction term independent variable*time. As these statistical analyses adjust for missing cases at follow-up measurements, the fitted values of symptom scores for subjects with different values on the independent variables will be a more accurate estimation of future symptoms than the actual scores, due to prevention of selection bias resulting from loss to follow-up.

4.3 Results

4.3.1 Background characteristics

In Table 4.1 the background characteristics of the study population are presented, for men and for women. It shows that women were more often engaged in jobs with repetitive tasks. Women reported more often signs of overcommitment, whereas there was no noteworthy difference between men and women in ERI. Finally, a consistent finding was that women reported symptoms more often than men.

Tabel 4.1: Background characteristics

		men (n=1300)		women (n=1823)	
			valid n		valid n
age at baseline (mean years)		38	(1300)	39	(1823)
Physical exposure (baseline)		%		%	
shoulder movements/minute	reference group[1]	41	(462)	22	(382)
	1-15	31	(342)	44	(751)
	>15	28	(314)	34	(595)
hand movements/minute	reference group[1]	41	(462)	22	(384)
	1-12	33	(369)	35	(611)
	>12	26	(287)	42	(733)
Overcommitment (baseline)		%		%	
	0	57	(652)	46	(748)
	1	26	(300)	33	(525)
	2	9	(101)	12	(197)
	3-6	8	(95)	9	(147)
Effort/Reward (baseline)		%		%	
	no high effort, no low reward	43	(474)	45	(651)
	high effort, no low reward	23	(246)	22	(322)
	low reward, no high effort	16	(174)	17	(255)
	high effort and low reward	18	(200)	16	(232)
Symptom scores					
neck/shoulder baseline		12	(1236)	18	(1755)
neck/shoulder follow-up 1		16	(931)	20	(1376)
neck/shoulder follow-up 2		18	(779)	22	(1165)
neck/shoulder follow-up 3		19	(648)	23	(793)
elbow/wrist/hand baseline		10	(1231)	12	(1748)
elbow/wrist/hand follow-up 1		14	(937)	16	(1383)
elbow/wrist/hand follow-up 2		16	(781)	17	(1165)
elbow/wrist/hand follow-up 3		16	(649)	19	(789)

[1] According to workplace inspection by an ergonomist this group was classified as a reference group; their exposure to repetitive tasks was not assessed with video observations.

4.3.2 Interaction effort/reward

The model with effort and reward as continuous variables and their interaction term did not produce statistically significant results. Neither effort and reward separately nor the interaction effort*reward were associated with neck/shoulder symptoms or elbow/wrist/hand symptoms. The rest of the analyses, described below, were carried out with the categorized ERI-variable.

4.3.3 Independent effects of effort and reward

The inclusion of both overcommitment and ERI in the model did not lead to a substantial decrease in the coefficients of these variables compared to univariate analyses, indicating independent relations of overcommitment and ERI with symptoms.

4.3.4 Regression coefficients in the final models

In Table 4.2 and 4.3 the regression coefficients are presented of the final models. The interaction terms eri*time and overcommitment*time were only included in the model if they were statistically significant. For that reason, the cells in the tables are not always filled. The regression coefficients may need some explanation: the coefficients in the first column represent the overall increase in symptom score compared to the reference group, i.e. subjects with no high effort and no low reward or subjects with a score of zero on the overcommitment scale. A significant positive interaction term independent variable*time means that symptoms scores increased significantly more during follow-up. Regression coefficients in the following columns represent the increase in symptom score during follow-up that have to be added to the overall increase in the first column. For example, highly overcommitted women (score 3-6 on the overcommitment scale) had at second follow-up a symptom score of neck/shoulder symptoms that was 4.83+6.25=11.08 points (see Table 4.2) higher than women with a score of zero on the overcommitment scale.

For purposes of illustration, the fitted values for the course of symptoms are presented in figures 1 and 2. It was necessary for the calculation of the fitted values of symptom scores to use models that included the interaction term independent variable*time, but confounders had to be excluded. Hence, the regression coefficients could deviate to some extent from the coefficients in the final model. However, the differences were small and will not be discussed.

Neck/shoulder symptoms

The time-variable was statistically significant and positive, meaning that symptoms at follow-up were higher than symptoms at baseline. The interaction term eri*commitment was not statistically significant. In men, after adjustment for repetitive tasks and age, the interaction term eri*commitment*time was statistically significant ($p<0.05$). However, the coefficients were alternately positive and negative, with no visible pattern. In women, the interaction term eri*commitment*time was not statistically significant. In the final model the interaction terms eri*commitment and eri*commitment*time were not included.

In Table 4.2 the coefficients of the final model are presented, while figure 4.1 shows the fitted values of symptom scores. The regression coefficients show that overcommitted subjects and subjects with high effort, low reward or both reported statistically significantly more symptoms. In men only subjects with the highest score on the overcommitment scale reported significantly more symptoms. Only in women the interaction term overcommitment*time was statistically significant, meaning that their symptoms increased more during follow-up. However, the results as such were only statistically significant during the second follow-up.

Table 4.2: Regression coefficients and their confidence intervals for the analyses with neck/ shoulder symptoms in the final model[a]

Men								
	overcommitment				overcommitment*time			
overcommitment			1st follow-up		2nd follow-up		3rd follow-up	
0	reference							
1	0.38	(-1.91-2.67)	.	.	.	.	.	.
2	1.77	(-1.75-5.30)	.	.	.	.	.	.
3-6	6.29**	(2.46-10.12)	.	.	.	.	.	.
	ERI				ERI*time			
effort/reward imbalance			1st follow-up		2nd follow-up		3rd follow-up	
no high effort, no low reward	reference							
high effort	6.11**	(3.59-8.64)	.	.	.	.	.	.
low reward	4.59**	(1.70-7.49)	.	.	.	.	.	.
high effort and low reward	11.81**	(9.05-14.58)	.	.	.	.	.	.
Women								
	overcommitment				overcommitment*time			
overcommitment			1st follow-up		2nd follow-up		3rd follow-up	
0	reference		reference		reference		reference	
1	1.44	(-1.12-4.00)	-0.61	(-3.15-1.92)	3.68**	(0.91-6.44)	0.07	(-2.95-3.10)
2	5.12**	(1.52-8.73)	-2.38	(-5.90-1.14)	1.41	(-2.50-5.33)	0.68	(-3.54-4.89)
3-6	4.83*	(0.51-9.15)	2.33	(-1.82-6.48)	6.25**	(1.68-10.81)	2.92	(-2.95-3.10)
	ERI				ERI*time			
effort/reward imbalance			1st follow-up		2nd follow-up		3rd follow-up	
no high effort, no low reward	reference							
high effort	4.19**	(1.61-6.76)	.	.	.	.	.	.
low reward	4.02**	(1.25-6.79)	.	.	.	.	.	.
high effort and low reward	6.38**	(3.40-9.36)	.	.	.	.	.	.

a Included in the final model were the following variables: overcommitment, ERI, age, repetitive tasks, and time. The interaction terms overcommitment*time and ERI*time were only included if they were statistically significant.

* $p<0.05$

** $p<0.01$

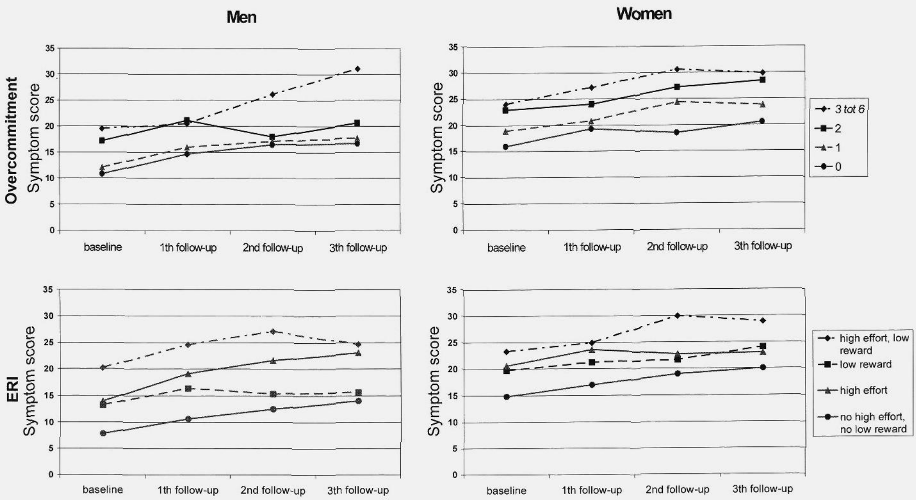

Figure 4.1: Fitted values of neck/shoulder symptoms for different values on overcommitment and ERI

Elbow/wrist/hand symptoms

The time-variable was statistically significant and positive, meaning that elbow/wrist/hand symptoms were higher at follow-up than at baseline. The interaction term eri*commitment was not statistically significant. In the model for men, the interaction term eri*commitment*time was statistically significant ($p<0.05$) after adjustment for repetitive tasks and age. However, like the model with neck/shoulder symptoms, no distinct pattern could be deduced. In women the interaction term eri*commitment*time was not statistically significant. In the final model the interaction terms eri*commitment and eri*commitment*time were not included.

In table 4.3 the coefficients of the final model are presented, while figure 4.2 shows the fitted values of symptom scores. It shows that highly overcommitted men and men with high effort and low reward reported statistically significantly more symptoms. Moreover, symptoms of men with high effort, low reward or both increased more during follow-up. However, symptoms of men with low reward only increased more at first follow-up.

Women with high scores on overcommitment did not report more symptoms at baseline than their colleagues. However, their symptom scores increased significantly during follow-up. High effort, low reward or both was also associated with symptoms, but symptoms of women with high effort or low reward did not increase significantly more during follow-up than symptoms of women without high effort or low reward.

Table 4.3: Regression coefficients and their confidence intervals for the analyses with elbow/wrist/hand symptoms in the final model[a]

Men

overcommitment	overcommitment		overcommitment*time 1st follow-up		2nd follow-up		3rd follow-up	
0	reference							
1	1.00	(-1.49-3.50)	.	.	.	.	.	.
2	1.53	(-2.32-5.37)	.	.	.	.	.	.
3-6	8.52**	(4.34-12.71)	.	.	.	.	.	.

effort/reward imbalance	ERI		ERI*time 1st follow-up		2nd follow-up		3rd follow-up	
no high effort, no low reward	reference		reference		reference		reference	
high effort	2.44	(-0.81-5.69)	3.41	(-0.02-6.83)	4.98**	(1.39-8.57)	5.09**	(1.37-8.80)
low reward	1.54	(-2.17-5.25)	3.99*	(0.05-7.92)	-0.23	(-4.55-4.10)	2.49	(-3.54-5.50)
high effort and low reward	8.43**	(4.89-11.96)	4.81*	(1.02-8.59)	6.25**	(2.29-10.22)	4.25*	(0.03-8.47)

Women

overcommitment	overcommitment		overcommitment*time 1st follow-up		2nd follow-up		3rd follow-up	
0	reference		reference		reference		reference	
1	-0.21	(-2.82-2.41)	3.38*	(0.69-6.07)	3.61*	(0.66-6.56)	3.18	(-0.03-6.39)
2	3.28	(-0.39-6.95)	-0.25	(-4.01-3.52)	0.96	(-3.22-5.14)	0.98	(-3.54-5.50)
3-6	1.71	(-2.70-6.12)	5.86**	(1.43-10.28)	8.86**	(3.99-13.73)	8.01**	(2.49-13.53)

effort/reward imbalance	ERI		ERI*time 1st follow-up		2nd follow-up		3rd follow-up	
no high effort, no low reward	reference							
high effort	5.58**	(2.99-8.16)	.	.	.	.	.	.
low reward	6.06**	(3.28-8.84)	.	.	.	.	.	.
high effort and low reward	5.53**	(2.55-8.50)	.	.	.	.	.	.

[a] Included in the final model were the following variables: overcommitment, ERI, age, repetitive tasks, and time. The interaction terms overcommitment*time and ERI*time were only included if they were statistically significant.

* $p<0.05$

** $p<0.01$

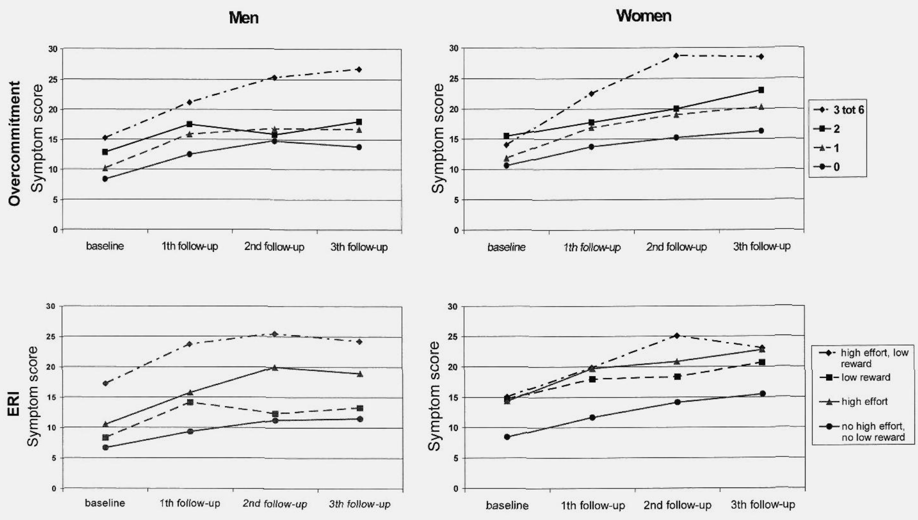

Figure 4.2: Fitted values of elbow/wrist/hand symptoms for different values on overcommitment and ERI

4.4 Discussion

4.4.1 Interpretation of the results

Although some longitudinal effects were found for overcommitment as well as effort-reward imbalance, the clearest effect was of a cross-sectional nature: overcommitted workers and workers with low reward and high effort reported more symptoms. Therefore, questions of causality could be raised. On the one hand, the symptoms of these workers might already be caused by their overcommitment and/or effort-reward imbalance. On the other hand, it could be possible that workers with symptoms estimate their commitment and their effort and reward in a more negative perspective than their healthier colleagues. However, the fact that in most cases symptoms increased more in subjects with high overcommitment and/or an adverse effort-reward imbalance suggests that these characteristics may, at least partly, have caused the symptoms.

The model with the continuous effort and reward variables and their interaction term did not produce statistically significant results. The absence of an association between effort and reward and symptoms in this model, while associations were found in the models with a cut-off point in the upper tertile, could indicate that the relationship is not linear.

4.4.2 Comparison with former research

Although research with the ERI-model used to be restricted to cardiovascular outcomes, other outcome measures have been studied in the meantime. The ERI-model and overcommitment have been related to behavioral and psychological outcomes as well[20]. However, little research has been done on the effect of the ERI-model on musculoskeletal symptoms. One cross-sectional study[25] found a higher prevalence of neck pain in subjects with a high score on overcommitment (upper tertile) and in subjects with an unfavorable effort/reward-imbalance (ratio computed according to Siegrist et al. 2004), but shoulder pain and pain in the upper extremities were associated with neither overcommitment nor ERI. However, as their study had a different design, a relatively small sample size (n=316) and another type of work profile (employees of a public transport company), the results are hardly comparable.

The concept of overcommitment resembles the concept of type A personality[14]. Some research has been done on the association between type A personality and musculoskeletal symptoms. A review of Malchaire et al. showed that type A behavior was associated with neck/shoulder symptoms in 3 studies out of 5[1]. However, the concept of type A and the concept of overcommitment are not entirely comparable. Type A is a broader concept, whereas overcommitment is focused on coping with work demands[14,15]. Probably, overcommitment has more explanatory power than type A in the field of unhealthy working behavior.

4.4.3 Limitations of the study

As in approximately half of the studies using the ERI-model[20], the measurement of ERI was not based on the validated instrument of Siegrist. In the present study, the reliability of the reward scale was satisfactory, but the effort scale did not show a strong Cronbach's alpha. This was partly due to the inclusion of the item on physical load, which is recommended for this type of working population, although the item does not fit very well in this scale. Comparing this proxy measure of effort to the one used in the Whitehall study of civil servants in the UK[18], in our scale two items on skill discretion and responsibility are lacking. The reason for not including these two items was that they did obviously not fit in the scale, as they are negatively correlated with most of the other items, while a positive correlation was expected. Probably, a high score on these questions is often rated positively in this population, whereas a high responsibility in a white-collar population is more often rated as a stressor. Nevertheless, we believe that the meaning of the scales of effort and reward, as constructed in this study, will be close to Siegrist's original instruments. Moreover, studies using original as well as proxy measures found support for the ERI model regardless of the measure being used[20]. Nevertheless, it is possible that the original measures might offer a more adequate estimation of the risk.

In former research with the ERI-model, all kind of variables were constructed to indicate ERI[20]. Siegrist himself suggested the construction of a ratio, using a pre-defined algorithm based on the effort and reward scales. This ratio could be dichotomized into a variable indicating imbalance or no imbalance[16]. There were two main reasons to deviate from this type of assessment in this study. Firstly, the original instrument was not available. Therefore, it would be arbitrary to determine the cut-off point for imbalance. Secondly, the relation between ERI and musculoskeletal symptoms has not been examined extensively before. Therefore, it was of interest to examine the separate effects of the components of the model as well as the combined effects. Nevertheless, it should be noted that another definition of the ERI-variable could have led to different results. This has already been shown in the present study, where the use of continuous variables led to different results, but also in former research with the model[16,22].

Studies on symptoms related to physical exposure at work, sometimes distinguish between symptoms of the right or left side of the body, depending on the dominant hand. Analyses could be restricted to the working parts of the body. We did not distinguish between right or left side in the analyses. Probably, it would not make any difference, as most symptoms will come from these parts anyhow.

Outcome measures as well as independent variables were self-reported. Associations between self-reported variables cannot uncritically be interpreted as causal relations, as the measurements are not independent when reported by the same individual. Therefore, biased results due to circularity between causes and suggested effects might occur. Although longitudinal associations are less sensitive for this bias, strong conclusions concerning causality cannot be drawn.

The working population of the PRIM-study contains exclusively blue-collar workers. Furthermore, three quarters of the workers had mainly repetitive job tasks. No published studies on the relation between ERI and musculoskeletal symptoms with a study population of white-collar workers are known to the authors. Therefore, the results of this study could not be generalized to an office working population. It would be interesting to examine the effects of ERI and overcommitment in a different population, for instance in an office environment.

The response during follow-up was smaller than at baseline. Only 50% of the workers at baseline returned the questionnaire at the third follow-up. Although the statistical techniques used in this study partly adjusted for this problem, the results still could be biased due to a selective loss to follow-up. However, subjects lost to follow-up did not report more symptoms at baseline, nor did their score on the overcommitment and effort-reward imbalance scales differ from subjects with complete follow-up data. Therefore, it can be concluded that bias due to loss to follow-up will be limited.

4.4.4 Implications for practice and future research

The results of the present study suggest that prevention of musculoskeletal symptoms should not focus exclusively on physical risk factors, but should pay attention to psychosocial factors as well. This was already demonstrated in previous research, but the concept of effort-reward imbalance offers still more points of attention. The approach of the adverse effects of overcommitment is more complicated. Mostly, in companies commitment of employees is highly appreciated. However, the boundaries between healthy commitment and unfavorable overcommitment are not easy to define. Companies should realize, unabated stimulation of commitment could have adverse effects.

There are indications in research that overcommitment is a relatively stable personality trait[16], and therefore hard to change. However, the personality trait probably will not cause adverse health effects directly, but indirectly through unhealthy working behavior. In unpublished results of a cross-sectional study (see Chapter 5), the influence of overcommitment could be explained by an adverse workstyle. This workstyle, based on the concept of Feuerstein's workstyle model[27], was characterized by long working hours, few breaks, working through pain and a high social reactivity. The concept of unhealthy working behavior could offer possibilities for prevention as it has a changeable nature, contrary to a personality trait. Therefore, future research should focus on the changeable behavioral effects of overcommitment. Furthermore, the interpretation of the associations between measures of exposure and effects would benefit much if these measures could be obtained independently of each other.

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Workstyle and overcommitment in relation to neck and upper limb symptoms

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5 Workstyle and overcommitment in relation to neck and upper limb symptoms

In a population of European office workers we examined whether a high-risk workstyle was a mediator in the relation of work-related exposure (job demands and VDU-work) and overcommitment with neck and upper limb symptoms. The Sobel Test was applied to test the intermediate effects. The results showed that the association between the independent variables and the outcome decreased after adjustment for workstyle scales, in particular for the scales Working Through Pain and Social Reactivity. The Sobel Test showed that most mediated effects were statistically significant, with the exception of Self Imposed Workload in the association of VDU-work with symptoms. Given the results with the Total Workstyle Score, 34% of the effect of prolonged VDU-work, 64% of the effect of Job demands and 84% of the effect of overcommitment was mediated by workstyle. However, due to possible bias in the assessment of the workstyle factor Working Through Pain, conclusions should be drawn with care.

5.1 Introduction

Initially, most research on neck and upper limb symptoms focused on work-related physical exposure. In these studies repetitiveness has been generally acknowledged as an important risk factor, especially in combination with forceful exertions[1,2,3]. Apart from physical factors, several recent prospective studies identified psychosocial work characteristics as risk factors for neck or upper limb symptoms[4,5,6,7,8,9,10,11,12]. Next to psychosocial work characteristics and physical factors, it has been suggested that personality traits could contribute to the onset of neck and upper limb symptoms: associations have been found between musculoskeletal symptoms and type A behavior[1], neurotic perfectionist traits[13] and overcommitment (chapter 4)[14].

It is unknown how a personality trait could lead to symptoms. It probably will not cause these effects directly, but the relation might be mediated through unhealthy behavior. A concept that operationalizes this kind of behavior is “workstyle”. The concept of workstyle was introduced by Feuerstein and colleagues[15], who found associations between a high-risk workstyle and neck and upper limb disorders[16,17]. A high-risk workstyle implies: taking shorter or fewer breaks or even skip breaks, working through pain, anticipating the possible negative reactions of colleagues, and making high demands on one’s own performances at work.

Workstyle is mainly a behavioral aspect and should not be confused with personality. It is conceptualized as a learned and reinforced strategy for coping with job demands that may affect musculoskeletal health[16]. Therefore, workstyle may not only be determined by personality traits, but also by working conditions, perceived organizational factors or organizational culture. Although it is assumed that work-related risk factors, such as high job demands, have a direct relation with musculoskeletal symptoms, this relation might also be mediated through a high-risk workstyle.
The relation between musculoskeletal symptoms and neither workstyle nor overcommitment has been examined thoroughly. Longitudinal studies examining the relation between overcommitment and musculoskeletal symptoms are scarce, as well as longitudinal studies using the concept of workstyle. Therefore, it is useful to examine the concepts of workstyle and overcommitment more thoroughly. In a study aimed at the prevention of work-related stress and neck and upper limb symptoms in a European company with long hours of computer work we explored the relationship of overcommitment and workstyle with neck and upper limb symptoms, and in particular the mediating role of workstyle. The aim of this study was to examine whether a high-risk workstyle was a mediator in the relation of work exposure (job demands and duration of VDU-work) and overcommitment with neck and upper limb symptoms.

5.2 Methods

5.2.1 Study population

Data were used from a survey in a European company, as part of a project aimed at the prevention of work stress and upper limb symptoms. The survey was conducted in three languages, English, French and German, and was administered at four offices, two in Germany, one in Austria and one in the Netherlands. The overall response rate (returned questionnaires) was 73%. For the present analyses, only data were used from respondents who returned the questionnaires with complete data. This concerned 65% (= 3,855) of all employees. Employees in this company performed relatively much VDU-work: 86% for more than 4 hours per day and 49% for more than 6 hours per day.

5.2.2 Workstyle

A measure of workstyle has been developed by Feuerstein and colleagues[18]. The preliminary workstyle measure contained 136 items, reflecting workplace stressors as well as individual behaviors and attitudes. Based on factor analyses in a preliminary study 10 scales were constructed. Of these scales 6 reflected stressors and symptoms not relevant for the present study, as we were particularly interested in behavior and attitude. A further selection was made from the items of the 4 remaining scales with the criteria that the items had to reflect aspects of behavior or attitude towards work and were not overlapping with other concepts in the questionnaire. The remaining items were measured on a 5-point scale ranging from "almost never"(0) to "almost always" or "very often"(4). The four scales constructed with these items were: breaks (2 items, e.g. "I take time to pause or stretch during a typical day at work"), social reactivity (5 items, e.g. "I can't take off from work because other people at work will think less of me"), self-imposed workload (3 items, e.g. "I push myself and have higher expectations than my supervisor and others that I have to deal with at work") and working through pain (3 items, e.g. "I continue to work with pain and discomfort so that the quality of my work won't suffer"). Cronbach's alpha of these scales were 0.77 (breaks), 0.82 (working through pain), 0.89 (social reactivity) en 0.64 (self imposed workload). Apart from these scales, a total workstyle score was constructed, consisting of all 13 items of the separate scales. This scale had a Cronbach's alpha of 0.86.

5.2.3 Overcommitment

Overcommitment was assessed with the short version of a standard questionnaire[19,20,21]. Subjects were asked if they strongly disagreed, disagreed, agreed or strongly agreed on 6 items (e.g. I get easily overwhelmed by time pressures at work). Scores were dichotomized (agree versus disagree) and the added scores on these items resulted in an overcommitment score ranging from 0 to 6. As scores higher than 3 were scarce (< 10%), the categories 3, 4, 5 and 6 were combined. Cronbach's alpha of this scale was 0.72.

5.2.4 Job demands

Job demands were assessed using the NOVA WEBA. The NOVA WEBA is originally a Dutch questionnaire, containing scales based on the main concepts of Karasek's Demand-Control Model[22,23]. Subjects were asked 5 questions referring to their amount of work and time pressure, which they could answer with yes or no. The added scores resulted in scale from 0 to 5, but scores of 4 and 5 were combined, since few respondents reached a score of 5 (< 10%). The Cronbach's alpha of this scale was 0.71.

5.2.5 Duration of VDU-work

Subjects were asked how long they usually worked with a computer. They could choose between the following categories: 0-1 hour, 1-2 hours, 2-4 hours, 4-6 hours, 6-8 hours or more than 8 hours per day. In this population, neither VDU-work for less than 4 hours, nor for more than 8 hours was reported often (< 10%). Therefore, this variable was categorized into 0-4 hours, 4-6 hours and > 6 hours.

5.2.6 Outcome measure

Subjects were asked to rate the occurrence of pain in neck, shoulders, elbows, wrists or hands in the previous 12 months on a four-point scale: "no, never", "yes, sometimes", "yes, regularly", "yes, prolonged". Subsequently, subjects were asked to estimate whether these symptoms were related to their work, which they could answer with "yes, completely", "yes, partly", "possibly" or "no". Subjects were defined as cases if they reported regular or prolonged pain in one or more of the regions mentioned, and if they did not answer 'no' at the question concerning the relation of the symptoms with their work. Finally, 8 possible specific causes of these symptoms were summed: sport injuries, accidents, skin diseases, a twist or sprain, a cut or burn, a congenital defect, rheumatic disorders and a slipped disc. Subjects reporting that their symptoms were related to one of these causes were not defined as cases.

5.2.7 Analysis

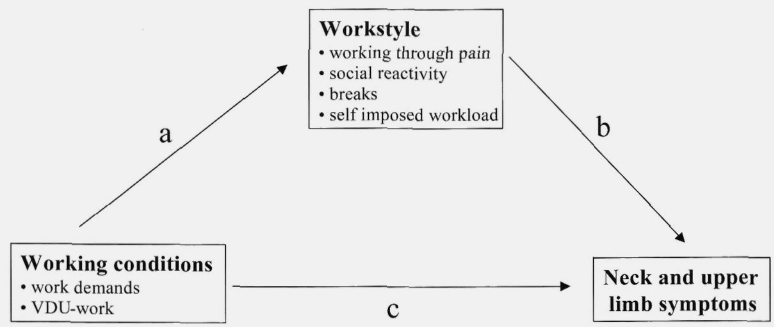

Figure 5.1: Model of the association between exposure at work and neck and upper limb symptoms as mediated by workstyle

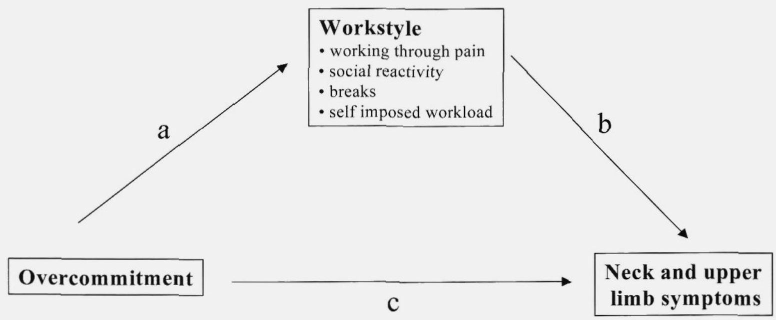

Figure 5.2: Model of the association between overcommitment and neck and upper limb symptoms as mediated by workstyle

If workstyle functions as a mediator in the associations between work exposure and neck and upper limb symptoms, the following conditions should be met: (1) work exposure should be associated with workstyle (path a; figure 5.1), (2) workstyle should be associated with neck and upper limb symptoms (path b; figure 5.1), (3) work exposure should be associated with neck and upper limb symptoms (path c; figure 5.1), (4) the association between work exposure and neck and upper limb symptoms should decrease, if the analysis is adjusted for workstyle[24]. Similar conditions should be met for the mediator function of workstyle in the relation between overcommitment and neck and upper limb symptoms (figure 5.2). Therefore, we first examined with ANOVA if the mean values of workstyle varied significantly for different values of job demands, duration of VDU-work and overcommitment (path a in both figures). Then, we examined with ANOVA if the workstyle scores of subjects with and without neck and upper limb symptoms varied significantly (path b in both figures). Subsequently, we carried out logistic regression analyses to examine if work exposure and overcommitment were associated with neck and upper limb symptoms (path c in both figures). Finally, to examine if workstyle functioned as a mediator in the relation between work exposure and neck and upper limb symptoms, these analyses were repeated with the inclusion, one by one, of workstyle factors that met the previous two conditions, that is being associated with work exposure as well as with neck and upper limb symptoms. The same procedure was carried out to examine if workstyle functioned as a mediator between overcommitment and neck and upper limb symptoms. As it was not clear on beforehand if overcommitment and workstyle are similar concepts, correlations were checked first to control for collinearity.

Baron and Kenny stated that perfect mediation has occurred if path c becomes nonsignificant after controlling for the mediator, but in practice partial mediation is more realistic[24]. Tests have been developed to estimate if the change in effect of the independent variable is statistically significant. The most well-known test is the so-called Sobel Test[25]. We applied software, available on the internet, to carry out this test[26]. Therefore, we first had to perform linear and logistic regression analyses to obtain the following statistics, needed for the test: the unstandardized regression coefficient for the association between the independent variable and the mediator (α), the standard error of α, the unstandardized regression coefficient for the association between the mediator and the dependent variable, adjusted for the independent variable (β), the standard error of β. Finally, to obtain a measure of the extent of mediation, the percentage of the total effect that is mediated by the workstyle scales was computed with the formula $\alpha\beta/[\alpha\beta + \tau']$, in which τ' is the coefficient for the association between the independent variable and the outcome, adjusted for the mediator[27].

5.3 Results

5.3.1 Associations between workstyle and the independent variables

In table 5.1 the mean values of workstyle scores are presented for different values of job demands, duration of VDU-work and overcommitment (path a, figures 5.1 and 5.2). Note that a high score is favorable for the workstyle scale 'breaks' (high=more breaks), whereas a high score on the other workstyle scales is unfavorable. These results show that subjects with high job demands and subjects with high overcommitment had statistically significantly more unfavorable workstyle scores. Subjects performing VDU-work for more than 6 hours per day had also more unfavorable workstyle scores, but the duration of VDU-work was not associated with self imposed workload. Furthermore, it shows that the first condition for the mediator function of workstyle, an association with the independent variables, was met for most relations, with the exception of the duration of VDU-work and Self Imposed Workload.

Table 5.1: Mean values of workstyle for different values of work exposure and overcommitment (n=3855)

		Breaks	**Working Through Pain**	**Social Reactivity**	**Self Imposed Workload**	**Total Workstyle Score**
job demands	*n*					
0 (reference)	*766*	4.23	3.79	2.75	2.36	12.66
1	*763*	3.89**	4.69**	3.70**	2.93**	15.42**
2	*791*	3.73**	4.97**	4.13**	3.37**	16.73**
3	*643*	3.45**	5.57**	5.00**	3.73**	18.84**
4-5	*892*	3.17**	6.42**	6.07**	4.36**	21.67**
duration of VDU-work						
0-4 hrs/day (reference)	*540*	3.77	4.90	4.06	3.38	16.57
4-6 hrs/day	*1438*	3.89	4.76	3.92	3.24	16.02
> 6 hrs/day	*1877*	3.50**	5.44**	4.79**	3.47	18.20**
overcommitment						
0 (reference)	*1376*	4.16	3.94	2.58	2.41	12.78
1	*992*	3.84**	4.81**	3.78**	3.20**	15.95**
2	*545*	3.46**	5.70**	4.74**	3.71**	18.70**
3-6	*942*	2.97**	6.80**	7.36**	4.75**	23.94**

* p<0.05
** p<0.01

5.3.2 Associations between workstyle and the outcome measure

Table 5.2 shows the difference in work style scores for subjects with and without symptoms (path b; figures 5.1 and 5.2). Taken into account that a high work style score is unfavorable, with the exception of Breaks (high=more breaks), the results of the ANOVA show that workers with symptoms had significantly more unfavorable workstyle scores than workers without symptoms. Furthermore, all workstyle factors were associated with the outcome measure, meaning that the second condition of the mediator function of workstyle was met.

Table 5.2: Mean values of workstyle factors for subjects with and without neck and upper limb symptoms (n=3855)

		Breaks	Working Through Pain	Social Reactivity	Self Imposed Workload	Total Workstyle Score
	n					
no symptoms	*2408*	3.87	4.18	3.62	3.15	15.08
symptoms	*1447*	3.38**	6.67**	5.61**	3.72**	20.62**

** $p<0.01$

5.3.3 Workstyle as a mediator

Table 5.3 shows the results of the logistic regression analyses with neck and upper limb symptoms as the outcome measure and work exposure and overcommitment as independent variables. The first column shows that the independent variables were significantly associated with neck and upper limb symptoms, which was the third condition for a mediator function of workstyle (path c; figures 5.1 and 5.2). The next columns show if the fourth condition of mediation was met: a decrease in the effect after the addition of workstyle factors in the model. The adjustment for Self Imposed Workload in the association between the duration of VDU-work and neck and upper limb symptoms was not included in the table as Self Imposed Workload was not associated with the duration of VDU-work and, therefore, could not be a mediator. Correlation coefficients of overcommitment with workstyle scales ranged from –0.24 to 0.37. This means that these variables can be analyzed in one model, as no collinearity is expected.

The results show a decrease in the effect estimates after adjustment for workstyle factors. This decrease is larger with overcommitment as the independent variable. The adjustments with the workstyle factors Working Through Pain and Social Reactivity caused the largest decrease in effect estimates.

Table 5.4 shows the mediated or indirect effect ($\alpha\beta$), which is the product of the coefficient relating the independent variable to the mediator (α) and the coefficient relating the mediator to the outcome, adjusted for the independent variable (β). It also shows the nonmediated or direct effect (τ'), expressed as the coefficient relating the independent variable tot the outcome, adjusted for the mediator[27]. Furthermore, a measure of the extent of mediation is given, expressed as the percentage of the total effect that is mediated.

The α-coefficients were all statistically significant, with the exception of the coefficient for the association between Self Imposed Workload and the duration of VDU-work. All β-coefficients were statistically significant. The Sobel Test indicated that all mediated effects (αβ-coefficients) were statistically significantly different from zero, with the exception of the indirect effect of Self Imposed Workload in the association between the duration of VDU-work and neck and upper limb symptoms. All τ'-coefficients were statistically significant, with the exception of the association between overcommitment and neck and upper limb symptoms, adjusted for the Total Workstyle Score. Given the results with the Total Workstyle Score, it seems that 34% of the effect of VDU-work, 64% of the effect of Job Demands, and even 84% of the effect of overcommitment was mediated by workstyle.

Table 5.3: Association between work exposure and overcommitment and neck and upper limb symptoms, with and without adjustment for workstyle factors (n=3855)

	without workstyle OR (95% C.I.)	adjusted for Breaks OR (95% C.I.)	adjusted for Working Through Pain OR (95% C.I.)	adjusted for Social Reactivity OR (95% C.I.)	adjusted for Self Imposed Workload OR (95% C.I.)	adjusted for Total Workstyle score OR (95% C.I.)
job demands						
0 (reference)	reference	reference	reference	reference	reference	reference
1	1.10 (0.89-1.37)	1.06 (0.85-1.32)	0.90 (0.71-1.13)	1.02 (0.82-1.28)	1.06 (0.85-1.32)	0.92 (0.74-1.16)
2	1.30 (1.05-1.61)	1.23 (0.99-1.53)	1.01 (0.81-1.27)	1.18 (0.95-1.46)	1.22 (0.98-1.51)	1.01 (0.81-1.26)
3	1.80 (1.44-2.24)	1.66 (1.33-2.07)	1.28 (1.01-1.61)	1.54 (1.23-1.92)	1.65 (1.32-2.06)	1.25 (0.99-1.57)
4-5	2.12 (1.73-2.60)	1.90 (1.55-2.34)	1.27 (1.02-1.58)	1.68 (1.37-2.08)	1.87 (1.51-2.30)	1.25 (1.00-1.55)
duration of VDU-work						
0-4 hrs/day (reference)	reference	reference	reference	reference	reference	reference
4-6 hrs/day	1.20 (0.97-1.48)	1.22 (0.99-1.51)	1.27 (1.02-1.59)	1.22 (0.98-1.51)		1.26 (1.01-1.57)
> 6 hrs/day	1.50 (1.23-1.84)	1.46 (1.19-1.80)	1.40 (1.12-1.73)	1.43 (1.17-1.76)		1.39 (1.13-1.72)
overcommitment						
0 (reference)	reference	reference	reference	reference	reference	reference
1	1.40 (1.18-1.67)	1.36 (1.15-1.62)	1.19 (0.99-1.43)	1.30 (1.09-1.54)	1.35 (1.13-1.60)	1.16 (0.96-1.38)
2	1.76 (1.43-2.16)	1.64 (1.34-2.02)	1.25 (1.00-1.56)	1.52 (1.23-1.88)	1.64 (1.33-2.02)	1.23 (0.99-1.52)
3-6	2.24 (1.88-2.66)	2.00 (1.67-2.39)	1.28 (1.06-1.54)	1.62 (1.35-1.95)	1.97 (1.64-2.37)	1.13 (0.92-1.37)

OR= odds ratio; C.I.=confidence interval

Table 5.4: Beta coefficients of the associations between the independent variables and workstyle (α), between workstyle and neck and upper limb symptoms (β), the indirect effect (αβ) *the direct effect (τ'), and the extent of mediation (αβ/[αβ + τ']).*

	α	β	αβ	τ'	αβ/[αβ + τ']
Job Demands					
Breaks	-0.256	-0.108	0.028	0.175	0.14
Working Through Pain	0.619	0.222	0.137	0.083	0.62
Social Reactivity	0.802	0.074	0.059	0.145	0.29
Self Imposed Workload	0.483	0.065	0.031	0.17	0.16
Total Workstyle Score	2.160	0.063	0.075	0.136	0.64
Duration of VDU-work					
Breaks	-0.199	-0.128	0.025	0.188	0.12
Working Through Pain	0.376	0.228	0.086	0.147	0.37
Social Reactivity	0.496	0.081	0.040	0.175	0.19
Self Imposed Workload	0.095	0.091	0.009	0.205	0.04
Total Workstyle Score	1.165	0.066	0.147	0.077	0.34
Overcommitment					
Breaks	-0.394	-0.099	0.039	0.228	0.15
Working Through Pain	0.946	0.221	0.209	0.08	0.72
Social Reactivity	1.538	0.069	0.106	0.162	0.40
Self Imposed Workload	0.761	0.054	0.041	0.225	0.15
Total Workstyle Score	3.638	0.064	0.043	0.233	0.84

5.4 Discussion

Results of this study show that a high-risk workstyle was associated with high Job Demands, prolonged VDU-work, overcommitment and neck and upper limb symptoms. The association of Job Demands, duration of VDU-work and overcommitment with neck and upper limb symptoms decreased after adjustment for workstyle scales, in particular for the scales Working Through Pain and Social Reactivity. Given the results with the Total Workstyle Score, 34% of the effect of prolonged VDU-work, 64% of the effect of Job demands and 84% of the effect of overcommitment was mediated by workstyle.

Few studies have been published with the workstyle concept. Preliminary analyses, before the concept was defined explicitly, showed support for the hypothesis that workstyle could have an adverse effect on musculoskeletal symptoms[16]. In one published study an association between a simple measure of workstyle and pain severity was found in a population of symptomatic female office workers[28]. Recently, a study has been published with the complete workstyle concept. The results of this study showed that workstyle predicted upper extremity symptoms and functional limitations at 3 months[17]. As the present study also showed an association between workstyle and upper limb symptoms, our results are consistent with the results of these former studies.

The relation between overcommitment and neck and upper limb symptoms was not studied extensively either. The results of the present study agree with findings of a longitudinal study (chapter 4)[14]. In this study an association was found between overcommitment and neck/shoulder symptoms and elbow/wrist/hand symptoms in a population of workers from industrial and service companies. One cross-sectional study[29] among employees of a public transport company found a higher prevalence of neck pain in subjects with a high score on overcommitment, but shoulder pain and pain in the upper extremities were not associated with overcommitment. However, the populations of both former studies were not comparable to the population of the present study, consisting of office workers. No studies are known to the authors that combined the concepts of overcommitment and workstyle in one study.

Conclusions have to be drawn with care as these data are from a cross-sectional study. The use of the method applied in this study presumes that the mediator is not caused by the dependent variable[24]. With respect to the association between workstyle and symptoms, it is possible that symptoms are (partly) caused by a high-risk workstyle, but it is also possible that symptoms have affected the workstyle. The association between overcommitment and symptoms suffers from the same limitations: symptoms might be caused by overcommitment, but it is also possible that symptoms influenced the answers to the questions on overcommitment. Furthermore, workstyle, overcommitment and symptoms might all be influenced by another factor. It is also possible that these variables measure more or less the same construct. However, they were not correlated that high to justify that explanation. Longitudinal research is needed to establish the direction of possible causality.

The analyses showed that the workstyle factor Working Through Pain was identified as a substantial mediator of the relation between job demands and overcommitment and neck and upper limb symptoms. However, there is a serious drawback involved in this conclusion, as the presence of pain will probably influence the response on questions about pain behavior. This could bias the results leading to an overestimation of the effect of the mediator. Therefore, conclusions concerning the workstyle factor Working Through Pain should be drawn with care. In symptomatic subjects with persistence of pain as an outcome measure, this problem would not occur.

A possibility to avoid bias with respect to Working Through Pain, is to omit this factor from the Total Workstyle Score. However, it has been recommended to include this scale, in spite of possible bias, as this kind of behavior appeared to be an important component of an adverse workstyle. It is often reported by many employees with neck and upper limb symptoms and this behavior may contribute to the maintenance of symptoms[17].

Although the results of this study should be regarded with care, they offer new points of interest in the prevention of work-related musculoskeletal symptoms. Main message is that, besides physical and psychosocial exposure, behavioral aspects might deserve attention as well. Further research is still needed to uncover the unique contribution of a high-risk workstyle to (the severity of) symptoms. Also, research is needed to examine determinants of a high-risk workstyle. The present study suggests that overcommitment is an important determinant for workstyle, as well as job demands and, to a lesser extent, prolonged VDU-work. However, besides these factors, workstyle could be determined by other work-related exposure or organizational culture.
Finally, it should be examined how to change unhealthy working behavior. This does not necessarily mean an individual approach. Organizational interventions could be directed at the prevention of factors that might encourage a high-risk workstyle. In addition, training in alternative approaches to a high-risk workstyle might be helpful. Controlled intervention studies are needed to study the effect of various interventions on workstyle. The experience acquired from lifestyle interventions should be integrated in the design of possible interventions.

In conclusion, most workstyle factors functioned as mediators in the relation between job demands and overcommitment and neck and upper limb symptoms. Due to possible bias, the results concerning the workstyle factor Working Through Pain should be drawn with care.

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The effect of physical activity in leisure time on neck and upper limb symptoms

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6 The effect of physical activity in leisure time on neck and upper limb symptoms

The purpose of this study was to examine the preventive effects of several forms of physical activity in leisure time on neck and upper limb symptoms as well as sickness absence due to these symptoms, in a working population. Data were used of a prospective cohort study with a follow-up period of three years. For this analysis a cohort of 1,742 employees was selected. Physical activity in leisure time was divided into sporting activities and physically active commuting. Outcome measures were neck or shoulder symptoms and elbow, wrist or hand symptoms as well as sickness absence and (long-term) sickness absence due to neck and upper limb symptoms. To analyze the data the generalized estimating equation (GEE) method was used. Practicing sports for at least 10 months a year was negatively associated with neck and shoulder symptoms (OR: 0.82; CI: 0.67-0.99), sickness absence (OR: 0.48; CI: 0.28-0.84) and long-term sickness absence (OR:0.37; CI: 0.17-0.84) due to neck and upper limb symptoms. A high mean intensity (≥ 3 hours per week) of sporting activities had less effect than the continuation of these activities throughout the year. No statistically significant results were found in the analyses with physically active commuting, yet a tendency towards a favorable effect could be detected. It was concluded that practicing sport for at least 10 months a year has a favorable effect on neck and shoulder symptoms and on sickness absence due to neck and upper limb symptoms. A statistically significant effect of physically active commuting could not be demonstrated, although there seems to be a tendency towards a favorable effect.

6.1 Introduction

In general, the assumption that a physically active lifestyle has a favorable effect on health is widely accepted[1]. Studies have shown the relationship between physical activity and several health outcomes such as mortality[1,2], cardiovascular diseases[1,3,4] and cancer[1,4,5,6]. Whether physical activity prevents musculoskeletal disorders, and especially neck and upper limb complaints, is not yet clear. Sports and exercises can cause musculoskeletal injuries. However, these injuries mainly concern the lower extremities[1]. In their review Hildebrandt et al. found associations between physical activity in leisure time and musculoskeletal symptoms, although the results of the studies were somewhat inconsistent[7]. In another review Hoogendoorn et al. found no evidence for an effect of physical activity during leisure time on low back pain[8]. However, the review of Vuori concluded that physical activity could be effective in preventing low back pain[9]. Studies on the association between physical activity and musculoskeletal complaints mostly concern low back pain, whereas studies on neck and upper limb complaints are rare. Ariëns et al. concluded in their review that there was inconclusive evidence for a relationship between sports and exercise and neck pain[10], but hardly any high quality studies were found. Miranda et al. evaluated the effects of physical activity and sports on shoulder pain among forestry workers and concluded that physical exercise had more protective than impairing effects on the shoulders[11].

Besides observational studies, the effectiveness of leisure time physical activity on the prevention of neck and upper limb disorders can be deduced from randomized controlled trials evaluating physical activity programs. In a recent review Proper et al. concluded that there was strong evidence for a positive effect of worksite physical activity programs on musculoskeletal disorders. However, most studies concerned low back pain[12]. In a randomized controlled trial Proper et al. studied the effects of an individual counseling intervention at the workplace on musculoskeletal symptoms[13], but found no significant effect regarding the upper extremities.

Summarizing, it may be said that there are indications that physical activity could have a favorable effect on neck and upper limb symptoms, but high quality studies on this subject are scarce. The present study can enlighten this subject with longitudinal data on physical activity as well as neck and upper limb symptoms. The objective of this study was to examine the effects of physical activity on neck and upper limb symptoms in a working population, as well as sickness absence due to these symptoms. As employees who perform physically demanding work are likely to derive less benefit from further physical activity than employees whose work is primarily sedentary, special attention was given to employees with sedentary jobs.

6.2 Methods

6.2.1 Study population

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a prospective cohort study with a follow-up period of three years, was initiated among a working population in The Netherlands. The main purpose of this study was to determine risk factors for musculoskeletal disorders, with a focus on low back, neck and shoulder disorders. The 34 participating companies were asked to select workers who had been employed in their current job for at least one year and who were working 24 hours per week or more. The population included blue-collar workers, white-collar workers, and workers in caring professions. At baseline, 1,789 (87%) of the 2,064 workers invited to participate in SMASH filled in a questionnaire. After exclusion of workers who did not meet the selection criteria mentioned above and who did not have another paid job for a substantial amount of time, 1,742 were eligible for participation in the present study. The study was approved by the Medical Ethical Committee of the Netherlands Organization for Applied Scientific Research (TNO).

6.2.2 Data collection

After the baseline measurement there were three follow-up measurements. In 1995, 1996 and 1997, a postal questionnaire was sent to the worker's home address. This questionnaire was similar to the baseline questionnaire and inquired, among others, about individual characteristics, physical activity, job characteristics and musculoskeletal complaints. Data on sickness absence were provided by 21 of the 34 participating companies and were collected annually and specifically for the study. Employees gave their written informed consent to use their sick leave records for the study.

Individual characteristics

Data on the individual characteristics age, gender, smoking habits and alcohol consumption were derived from the baseline questionnaire. The individual characteristics were considered as time-independent variables and were measured at baseline only.

Physical activity

Data on physical activity were collected at each yearly measurement using the question: 'Please state below which physically demanding sports you have practiced in the last 12 months'. The respondent was also asked about the intensity (number of hours per week and number of months per year). The researchers excluded sports that were not physically demanding, such as playing chess and fishing. With these data two variables were constructed: the first variable represented the number of months per year the respondent was engaged in sporting activities, categorized in 0-3 months, 4-9 months and at least 10 months. The second variable represented the mean number of hours per week spent in sporting activities, categorized in less than 1 hour per week, 1-3 hours and at least 3 hours.

Besides sporting activities, an important way of physical active behavior could be cycling or walking to work, particularly in the Netherlands. Questions concerning commuting were part of the baseline questionnaire and referred to the average length of the trip in time and the means of transport. A distinction was made between no walking or cycling to work, 10 to 150 minutes per week and at least 150 minutes per week.

Sedentary or active work

Data on the extent of activity on the job were measured yearly with the questionnaires. A distinction was made between employees who did a lot of sedentary work and those who did sedentary work only 'seldom' or 'now and then'.

Neck and upper limb symptoms

Data on these musculoskeletal complaints were collected with an adapted version of the Nordic Questionnaire[14]. Respondents were asked to rate the occurrence of neck, shoulder, elbow, wrist and hand symptoms in the previous 12 months on a 4-point scale (seldom/never, sometimes, regular, prolonged). To identify the correct area, anatomical drawings were presented in the questionnaire. Questions concerning these symptoms were part of each yearly questionnaire.

Sickness absence

A dichotomous variable was constructed to indicate the 12-month prevalence of sickness absence due to neck or upper limb symptoms by year. Furthermore, a dichotomous variable was constructed to indicate long-term sickness absence, which was defined as sick leave lasting more than three weeks at a time.

6.2.3 Statistical analysis

To calculate the prevalence of symptoms during follow-up, a subcohort of 1312 subjects was selected without missing values on symptoms at any follow-up measurement. Of 687 subjects data were available on sickness absence. To calculate the cumulative prevalence over three years of follow-up all subjects were included who participated in at least one follow-up measurement.

To examine the effects of physical activity the generalized estimating equation (GEE) method developed by Liang and Zeger was applied[15]. The Proc Genmod procedure in the statistical package SAS (version 6.12)[16] was used. Figure 6.1 shows the model that was analyzed with the GEE method.

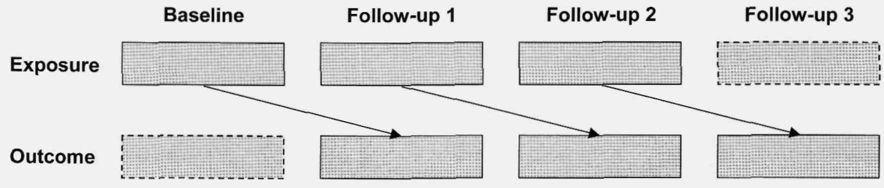

Figure 6.1 The GEE model that was used to analyze the data

Outcome measures were the 12-month prevalence of regular or prolonged pain, sickness absence and long-term sickness absence, due to neck and upper limb symptoms. The two variables concerning sporting activities were defined as exposure variables. The data on physically active commuting were only available at baseline. To carry out the analyses with commuting in a similar way, it was assumed that employees would not change their commuting habits. In that way, the value at baseline could be used as the value at first and second follow-up. As a physical active lifestyle could very well by associated with other lifestyle and personal characteristics, smoking, alcohol consumption, age and gender were regarded as covariates.

Since the outcomes under study were dichotomous, the link-function in Proc Genmod was specified as logistic. The working correlation structure for the repeated measurements of the outcome variable was specified as exchangeable, implying that all correlations of the outcome variable were assumed to be equal, irrespective of the time-period between the measurements. The exchangeable correlation structure is the most neutral option[15,17,18]. Also, the multivariate analyses were repeated with the correlation structure specified as respectively independent and unstructured to verify if this would change the results.

Firstly, univariate analyses were carried out, resulting in crude odds ratios with corresponding 95% confidence intervals for all exposure variables. Secondly, a multivariate model was tested, in which individual characteristics were included as well as the value of the outcome measure at the time of exposure measurement. This analysis resulted in adjusted odds ratios with corresponding 95% confidence intervals for all exposure variables.

The influence of physical activity in leisure time could be different for employees with sedentary jobs and for those with more active jobs. Therefore, a stratified analysis was carried out to examine the differences.

6.3 Results

6.3.1 Prevalence of symptoms and sickness absence

Of the 1312 subjects with complete data 17% reported neck or shoulder symptoms in the previous year at one follow-up, 11% at two follow-up and 12% at all three follow-up measurements. With regard to elbows, wrists or hands, 13% reported symptoms in the previous year at one follow-up, 6% at two follow-up and 4% at all three follow-up measurements. For 687 respondents complete data were available on sickness absence. Of these respondents 10% were on sick leave due to the symptoms mentioned for at least one day during one follow-up year, 2% during two years of follow-up, and 0.6% during all three years of follow-up. A period of sickness absence lasting at least 21 days during one year of the follow-up period was reported in 5%, during two years in 1% and during all years in 0.3% of the participants.

Table 6.1 shows the cumulative prevalence of neck and upper limb symptoms as well as sickness absence due to these symptoms. Note that the cumulative prevalence was not the outcome measure used in the analyses.

Table 6.1: 3-year cumulative prevalence of neck/shoulder symptoms, elbow/wrist/hand symptoms and sickness absence due to these symptoms

	Total[1] respondents	Total[2] observations	Cumulative prevalence[3] % (n)	
neck/shoulder symptoms	1624	4444	40	(646)
elbow/wrist/hand symptoms	1624	4444	22	(360)
sickness absence due to neck or upper limb symptoms	1058	2669	13	(135)
long-term (> 3 weeks) sickness absence due to neck or upper limb symptoms	1058	2669	7	(70)

1 Number of respondents whose data on the respective outcome measurements were available

2 For every worker a maximum of 3 observations was available, matching with the three times the outcome was measured, that is at the first, second and third follow-up

3 The cumulative prevalence was calculated over three years of follow-up; all subjects were included who participated in at least one follow-up measurement.

6.3.2 Lifestyle and personal characteristics

Table 6.2 shows the association between the type of work, lifestyle and personal characteristics on the one hand and the categories of physical activities on the other hand. Employees with sedentary work were more often engaged in sporting activities than their colleagues with more active jobs. Furthermore, physically active individuals were less often present smokers. Employees who spent at least 150 minutes per week in physically active commuting were somewhat older. In women the mean number of hours per week of sporting activities was less than in men. However, their sporting activities were less often limited to only a few months a year. Finally, there were more heavy drinkers (> 20 glasses per week) among the physically active commuters.

Table 6.2: Type of work, lifestyle and personal characteristics, divided into the different categories of physical activity, at the time of exposure measurement

		sporting activities throughout the year			sporting activities mean intensity per week			physically active commuting per week		
		< 4 months %	4-9 months %	≥ 10 months %	< 1 h/week %	1-2 h/week %	≥ 3 h/week %	no pac* %	10-150 m/week %	≥150 m/week %
		55	15	30	60	19	21	48	42	10
type of work	sedentary	34	43	50	36	48	46	40	40	42
	more active	66	57	50	64	52	54	60	60	58
alcohol consumption	0-20	92	94	95	93	94	93	93	95	89
	> 20 glasses/week	8	6	5	7	6	7	7	5	11
smoking habits	never smoked	29	35	38	30	35	37	32	32	36
	used to smoke	25	29	27	25	29	27	22	27	35
	smokes nowadays	46	36	35	45	36	36	47	41	29
gender	male	71	67	67	69	63	77	68	70	80
	female	29	33	33	31	37	23	32	30	20
		mean	mean	mean	mean	mean	mean	mean	mean	mean
age	*mean*	38	36	36	37	36	36	35	35	38

* pac=physically active commuting

6.3.3 Sporting activities

In Table 6.3 the results are presented of the univariate and multivariate GEE analyses with symptoms and sickness absence as the outcome measurement and sporting activities as exposure. The analyses with another specification of the correlation structure, i.e. independent or unstructured, did not produce noteworthy differences in the results.

Table 6.3: Results of the GEE-analyses concerning the influence of sporting activities

	valid observations[1] % (n)		Crude OR (95% CI)[2]	Adjusted OR (95% CI)[3]
neck/shoulder symptoms				
practiced sport 0-3 months per year	55%	(2385)	1.00	1.00
practiced sport 4-9 months per year	15%	(630)	0.97 (0.80-1.16)	0.99 (0.79-1.25)
practiced sport at least 10 months per year	30%	(1310)	0.87 (0.74-1.01)	**0.82 (0.67-0.99)***
practiced sport less than 1 hour per week	60%	(2582)	1.00	1.00
practiced sport 1 to 3 hours per week	19%	(837)	0.90 (0.76-1.07)	0.93 (0.75-1.14)
practiced sport at least 3 hours per week	21%	(905)	0.91 (0.76-1.09)	0.93 (0.75-1.15)
elbow/ wrist/ hand symptoms				
practiced sport 0-3 months per year	55%	(2385)	1.00	1.00
practiced sport 4-9 months per year	15%	(630)	1.10 (0.87-1.40)	1.15 (0.88-1.50)
practiced sport at least 10 months per year	30%	(1310)	1.00 (0.82-1.23)	0.96 (0.77-1.21)
practiced sport less than 1 hour per week	60%	(2582)	1.00	1.00
practiced sport 1 to 3 hours per week	19%	(837)	1.00 (0.80-1.26)	1.04 (0.80-1.35)
practiced sport at least 3 hours per week	21%	(905)	0.93 (0.74-1.18)	0.90 (0.69-1.16)
sickness absence due to neck or upper limb symptoms				
practiced sport 0-3 months per year	55%	(1385)	1.00	1.00
practiced sport 4-9 months per year	14%	(342)	0.95 (0.59-1.54)	1.13 (0.67-1.93)
practiced sport at least 10 months per year	31%	(777)	**0.42 (0.25-0.69)****	**0.48 (0.28-0.84)***
practiced sport less than 1 hour per week	59%	(1486)	1.00	1.00
practiced sport 1 to 3 hours per week	19%	(481)	**0.57 (0.35-0.92)***	0.69 (0.40-1.18)
practiced sport at least 3 hours per week	21%	(536)	**0.58 (0.35-0.96)***	0.62 (0.34-1.11)
long-term sickness absence (>3 weeks) due to neck or upper limb symptoms				
practiced sport 0-3 months per year	55%	(1385)	1.00	1.00
practiced sport 4-9 months per year	14%	(342)	0.97 (0.51-1.85)	1.12 (0.56-2.27)
practiced sport at least 10 months per year	31%	(777)	**0.28 (0.13-0.59)****	**0.37 (0.17-0.84)***
practiced sport less than 1 hour per week	59%	(1486)	1.00	1.00
practiced sport 1 to 3 hours per week	19%	(481)	0.56 (0.29-1.08)	0.75 (0.37-1.49)
practiced sport at least 3 hours per week	21%	(536)	**0.35 (0.16-0.76)****	**0.39 (0.15-0.97)***

[1] Observations for which neither the exposure variable nor the outcome variable was missing

[2] OR and 95% CI resulting from univariate GEE analysis;

[3] OR and 95% CI resulting from multivariate GEE analysis, adjustment were made for alcohol consumption, smoking habits, age, gender and the value of the outcome measure at the time of exposure

* $p<0.05$

** $p<0.005$

To practice sport for at least 10 months a year had a favorable effect on neck/shoulder symptoms and on sickness absence due to neck or upper limb symptoms. The effect was even more favorable for long-term sickness absence. A high intensity of sporting activities (≥ 3 hours per week) had less effect than the continuation of these activities throughout the year. No relationship was found between sporting activities and elbow/wrist/hand symptoms.

6.3.4 Physically active commuting

Odds ratios presented in Table 6.4 refer to the effects of physically active commuting, which means going to work on foot/by bicycle, or partly on foot/by bicycle and partly by public transport. The analyses with another specification of the correlation structure, i.e. independent or unstructured, did not produce noteworthy differences in the results.

Table 6.4: Results of GEE- analyses concerning the influence of physically active commuting

	valid observations[1] %	(n)	Crude OR[2] (95% CI)	Adjusted OR[3] (95% CI)
neck/shoulder symptoms				
no walking/cycling	47%	(2082)	1.00	1.00
10-150 minutes per week	42%	(1861)	1.03 (0.85-1.26)	1.13 (0.95-1.35)
at least 150 minutes per week	10%	(454)	0.70 (0.49-0.99)*	0.90 (0.66-1.21)
elbow/ wrist/hand symptoms				
no walking/cycling	47%	(2082)	1.00	1.00
10-150 minutes per week	42%	(1861)	1.00 (0.78-1.29)	1.05 (0.85-1.31)
at least 150 minutes per week	10%	(454)	0.81 (0.54-1.21)	0.86 (0.60-1.23)
sickness absence due to neck or upper limb symptoms				
no walking/cycling	48%	(1297)	1.00	1.00
10-150 minutes per week	41%	(1078)	0.86 (0.59-1.27)	0.94 (0.63-1.41)
at least 150 minutes per week	11%	(280)	0.57 (0.29-1.12)	0.68 (0.32-1.42)
long-term sickness absence (>3 weeks) due to neck or upper limb symptoms				
no walking/cycling	48%	(1297)	1.00	1.00
10-150 minutes per week	41%	(1078)	0.91 (0.55-1.53)	1.05 (0.61-1.82)
at least 150 minutes per week	11%	(280)	0.40 (0.12-1.37)	0.40 (0.09-1.81)

1 Observations for which neither the exposure variable nor the outcome variable was missing

2 OR and 95% CI resulting from univariate GEE analysis;

3 OR and 95% CI resulting from multivariate GEE analysis, adjustment were made for alcohol consumption, smoking habits, age, gender and the value of the outcome measure at the time of exposure

* p<0.05

Table 6.4 shows that to walk or cycle to work (or to the train station, for instance) could have a favorable effect on neck and upper limb symptoms.

However, the results of the multivariate analyses were not statistically significant. No effects were found for sickness absence.

6.3.5 Sedentary work

The results of the stratified analyses for employees with sedentary and more active work are presented in Table 6.5. Due to sample size, stratified analyses could not be carried out with sickness absence as the outcome measure and commuting as the independent variable and with long-term sickness absence as the outcome measure for all variables.

Table 6.5: Results of the stratified analyses concerning the influence of sporting activities

	sedentary work			more active work		
	valid observations[1] % (n)		OR (95% CI)[2]	valid observations[1] % (n)		OR (95% CI)[2]
neck/shoulder symptoms						
practiced sports 0-3 months	46%	(795)	1.00	61%	(1541)	1.00
practiced sports 4-9 months	16%	(270)	0.83 (0.58-1.20)	14%	(353)	1.11 (0.82-1.52)
practiced sports ≥10 months	38%	(645)	0.70 (0.53-0.94)*	26%	(651)	0.93 (0.71-1.21)
practiced sports < 1 hour per week	53%	(903)	1.00	64%	(1628)	1.00
practiced sports 1-3 hours per week	23%	(393)	0.77 (0.56-1.04)	17%	(433)	1.07 (0.80-1.44)
practiced sports ≥3 hours per week	24%	(413)	0.83 (0.60-1.16)	19%	(484)	1.01 (0.76-1.34)
no walking/cycling	46%	(778)	1.00	48%	(1215)	1.00
10-150 minutes per week	44%	(739)	1.20 (0.91-1.59)	42%	(1050)	1.07 (0.85-1.34)
≥150 minutes per week	10%	(175)	1.02 (0.67-1.56)	10%	(257)	0.85 (0.56-1.28)
elbow/ wrist/ hand symptoms						
practiced sports 0-3 months	46%	(795)	1.00	61%	(1541)	1.00
practiced sports 4-9 months	16%	(270)	1.19 (0.77-1.83)	14%	(353)	1.11 (0.78-1.58)
practiced sports ≥10 months	38%	(645)	1.05 (0.72-1.54)	26%	(651)	0.89 (0.66-1.20)
practiced sports < 1 hour per week	53%	(903)	1.00	64%	(1628)	1.00
practiced sports 1-3 hours per week	23%	(393)	1.00 (0.65-1.52)	17%	(433)	1.08 (0.77-1.52)
practiced sports ≥3 hours per week	24%	(413)	0.99 (0.64-1.53)	19%	(484)	0.80 (0.56-1.13)
no walking/cycling	46%	(778)	1.00	48%	(1215)	1.00
10-150 minutes per week	44%	(739)	1.01 (0.71-1.42)	42%	(1050)	1.10 (0.83-1.46)
at least 150 minutes per week	10%	(175)	0.93 (0.52-1.67)	10%	(257)	0.92 (0.58-1.45)
sickness absence due to neck or upper limb symptoms						
practiced sports 0-3 months	45%	(506)	1.00	64%	(861)	1.00
practiced sports 4-9 months	14%	(163)	0.97 (0.30-3.10)	13%	(177)	1.43 (0.79-2.60)
practiced sports ≥10 months	41%	(469)	0.51 (0.17-1.52)	23%	(303)	0.59 (0.31-1.11)
practiced sports <1 hour per week	50%	(568)	1.00	67%	(899)	1.00
practiced sports 1-3 hours per week	24%	(275)	0.48 (0.15-1.52)	15%	(202)	0.98 (0.54-1.80)
practiced sports ≥3 hours per week	26%	(294)	0.61 (0.19-1.95)	18%	(240)	0.72 (0.36-1.43)

1 Observations in which employees were engaged in sporting activities, respectively, for at least 10 months and at least 3 times per week, and for which neither the exposure variable nor the outcome variable was missing

2 OR and 95% CI resulting from multivariate logistic regression analysis, adjustment were made for alcohol consumption, smoking habits, age, gender and the value of the outcome measure at the time of exposure

* $p<0.05$

The results show that the effect of sporting activities for at least 10 months a year on neck/shoulder symptoms are only statistically significant in the group employees with sedentary work. Apart from that these stratified analyses showed no noticeable differences between employees with sedentary and more active jobs.

6.4 Discussion

6.4.1 Sporting activities throughout the year and mean intensity per week

Particularly notable is the effect of sporting activities on sickness absence. Employees not practicing sports are at an almost 3-fold risk of long-term sickness absence due to neck or upper limbs symptoms compared to employees practicing sports at least 10 months a year. A statistically significant effect of physically active commuting on neck and upper limb symptoms could not be demonstrated, although there seems to be a tendency towards a favorable effect.

Two measures of sporting activities were distinguished: the number of months per year the respondent was engaged in sporting activities, and the mean number of hours per week. Both measures showed favorable effects on neck/shoulder symptoms and on sickness absence. However, the effects of sporting activities that were carried on throughout the year were stronger than the effects of sporting activities with a high intensity per week. It appears to be more advantageous to remain active the whole year round, than to be very active only during a limited number of months, for instance only in the summer season.

6.4.2 Comparison with results from other studies

The few existing prospective studies concerning the relation between physical activity and neck and shoulder symptoms show favorable effects[7,11]. The results of this study confirm the results of these earlier studies. No studies have been found on the effect of physical activity in leisure time on elbow/wrist/hand symptoms.

Several studies have indicated the advantageous effects of physically active commuting, such as improved physical performance[19], improved fitness[20] and a favorable change in cardiovascular risk factors[21]. Moreover, physically active commuting can be successfully promoted by low cost measures, and consequently offers a substantial potential as health and fitness enhancing measure[22]. No studies have been found on the relation between physically active commuting and musculoskeletal symptoms. No significant effects were found in the present study. However, a tendency towards a favorable effect could be demonstrated. Although the physical activity acquired with commuting might be insufficient for significant outcomes from a statistical point of view, it certainly will contribute to the total amount of one's physical activity.

Hildebrandt et al. concluded in their review that, particularly in employees with sedentary tasks, physical activity was associated with musculoskeletal symptoms[7]. Moreover, earlier analyses with the present data showed that the relation between physical inactivity and sickness absence in general was stronger in employees with sedentary work[23]. In this study, the effects of physical activity were also stronger in employees with sedentary work than in employees with more active work, particularly for neck/shoulder symptoms and sickness absence due to neck or upper limb symptoms. However, the differences in effects were only marginal.

6.4.3 Limitations and potential sources of bias

The model used in this study is a time-lag model, implying that the repeated measurements of the exposure were related to outcome reported at one measurement point later. With the use of such a time lag model temporal sequence of cause and effect is taken into account. In this model the time lag of one year was studied. This could be considered an appropriate time lag, as earlier analyses with the present data indicated that the effect of sporting habits on perceived health was observed mainly after one year and that the total number of physically active years in the past was not associated with total days of sick leave[23]. Although more specific health outcomes were studied in the present analysis, it may be assumed that the time lag of effects of physical activity is comparable.

As in most epidemiological studies questionnaires were used to assess physical activity. More objective measures, such as motion sensors or pedometers, are not widely used, which has to do with the cost and complexity of these measures. Yet, the validity of these self-reported data is a subject of concern, considering factors such as recall bias and social desirability bias, which might lead to misclassification of the amount of activity. However, it was repeatedly shown that self-reports in questionnaires on physical activity are both practical and valid in epidemiological studies[24,25,26,27]. Moreover, there are no reasons to believe that misclassification as to physical activity would be differential, i.e. related to one or more of the studied outcomes. This means that if the results were biased due to self-reports, it would be underestimation of the effects, rather than overestimation.

6.5 Conclusion

Practicing sports for at least 10 months a year had a favorable effect on neck/shoulder symptoms and on sickness absence due to neck and upper limb symptoms. Therefore, it should be recommended to remain active the whole year round, instead of practicing sports incidentally during a limited number of months. Probably physically active commuting could contribute to this more active lifestyle.

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Effects of software programs stimulating regular breaks and exercises on work-related neck and upper limb disorders

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7 Effects of software programs stimulating regular breaks and exercises on work-related neck and upper limb disorders

This study evaluated the effects on work-related neck and upper limb symptoms among computer workers stimulated (by a software program) to take regular breaks and perform physical exercises. Possible effects on sick leave and productivity were studied as well. A randomized controlled design was used with cluster randomization. Altogether 268 computer workers with symptoms in the neck or upper limb from 22 office locations were randomized into a control group, one intervention group stimulated to take extra breaks and one intervention group stimulated to perform exercises during the extra breaks during an 8-week period. Questionnaires were administered before and after the intervention, and questions were generated by the software during the intervention period. Computer usage was recorded online. The data on self-reported recovery suggested a favorable effect: more subjects in the intervention groups than in the control group reported recovery (55% versus 34%) from their symptoms and fewer reported deterioration (4% versus 20%). However, a comparison between the pre- and postintervention scores on the severity and frequency of the symptoms showed no significant differences in the change among the three groups. No effects on sick leave were observed. The subjects in the intervention groups showed higher productivity. It was concluded that the software program contributes to perceived recovery from neck and upper limb symptoms. There seems to be no additional effects from performing physical exercises during these breaks.

7.1 Introduction

A rapidly increasing number of people are involved in computer work for increasing periods of time. Data from the European Foundation of Living and Working Conditions show that the percentage of workers who are involved in computer work 'all the time' or 'almost all the time' is 19 % in the European Union[1]. Other studies show that the daily amount of time performing computer work is positively related to the prevalence of neck and upper limb disorders[2]. Hence, a growing number of people in the European Union are at risk of neck and upper limb disorders.
Personal, organizational, work place and task factors have been identified as contributors to musculoskeletal risk[3,4,5]. In the literature attention is drawn to strategies for reducing the intensity of physical load by redesigning the work

station. Indeed, work station optimization, keyboard and mouse re-design and the use of lower arm supports were found to be effective in reducing physical load and local discomfort[6,7,8]. However, the effectiveness of these strategies in reducing neck and upper limb disorders remains questionable. Particularly neck and shoulder disorders seem rather impervious to these work station improvements[9]. Since the intensity of physical load is relatively low in computer work, it has been suggested that changes in the temporal pattern of the working task (e.g. extra rest breaks allowing for periods of recovery from the monotonous load) might be more effective than strategies reducing load intensity.

Currently, software programs are available that stimulate computer workers to take frequent breaks during the day. A warning signal on the screen indicates the advisability of a break. The signal appears at specific intervals, which in some programs depend on the intensity of the work. Some programs also recommend the performance of light exercises during the breaks. The effectiveness of these programs in reducing the prevalence rates of neck and upper limb disorders has not yet been evaluated. However, several findings reported in the literature support the effectiveness of these programs.

First, a cross-sectional study among 260 computer workers showed that those who had a limited opportunity to take rest breaks had more musculoskeletal symptoms in the neck, shoulders, arms and hands than others[3]. Second, an experimental study among 42 data-entry operators showed that the implementation of additional breaks (4 times a day about 5 minutes) led to less local (short-term) discomfort in the upper extremities. In addition, the day-to-day increase in local discomfort during the week, which is present at the 'normal' work-rest scheme, is eliminated by extra breaks[10]. The favorable effect of extra breaks on musculoskeletal symptoms or discomfort has been shown in others studies as well[11,12,13]. Third, an experimental study showed that microbreaks of several seconds led to less local discomfort in the upper extremities among computer workers[14]. Fourth, an experimental field study among 12 word processor operators showed that operators with active breaks reported less muscle discomfort than those with passive breaks[15]. Finally, extra breaks did not lead to less productivity[10,16,17]. Sometimes even higher productivity was found[13].

The objective of this study was to evaluate the effects of a software program that stimulates extra breaks and exercises, on the recovery from neck and upper limb symptoms among computer workers. In addition, effects on sick leave and productivity were studied.

7.2 Methods

7.2.1 Design

A randomized controlled trial was performed, including one control group and two intervention groups. Cluster randomization was used for office locations. In all groups workplaces were ergonomically screened and adjusted if necessary. In the first intervention group a software program (an adjusted version of WorkPace, Niche Software Ltd., New Zealand) was installed that stimulated the workers to take frequent breaks. In the second intervention group, the workers were additionally stimulated by means of the software program to perform exercises during their regular breaks. The study was approved by the Medical Ethics Committee of TNO. Measurements were made 3 weeks before the intervention period and again after 3 months.

7.2.2 Subjects

Subjects were recruited from a large office organization (GAK Nederland) dealing with social security allowances. All employees (about 12,000) were requested to answer a short questionnaire on work and health characteristics. They were asked if they were working at least four days a week in the office, were involved in computer work for at least five hours a day, had their own personal computer at work, had currently had symptoms in neck, shoulders, arms, wrists, hands or fingers for at least two weeks, considered their symptoms work-related and were not under medical treatment for these symptoms. They were asked to return the questionnaire only if they met the criteria. About 1,700 employees returned the questionnaire, and about 1,000 met the criteria for the study (Figure 1). For each of the 22 locations, the first 20 employees who returned the questionnaire and met the criteria were invited to a final screening by the allied occupational health physician. The physician checked the aforementioned criteria and determined whether the symptoms could be regarded as Repetitive Strain Injuries according to the definition of the Health Council of the Netherlands[18]. Employees who needed treatment for their symptoms, according to the judgment of the physician, were excluded, as were employees with other health problems (including medicine intake) that may affect behavior at work. The age of the participants had to be between 18 and 50 years.

Not all the occupational health physicians had the time and opportunity to invite as much as 20 employees for the screening. In addition, some employees did not pass the final screening. Eventually, this procedure resulted in the inclusion of 280 persons, who received a questionnaire with an informed consent form. Altogether 268 returned the questionnaire and filled out the informed consent form. The 22 office locations were randomized into the control group, the first intervention group and the second intervention group. A randomization procedure in a spreadsheet program was used that randomly assigned each location a figure between 1 and 3.

The randomization assigned the employees in 6 locations to the control group (n=90), those in 8 locations to the intervention group that was stimulated to take breaks (n=97) and those in 8 locations to the intervention group that was stimulated to take both breaks and exercises (n=81). Baseline characteristics of the control and intervention groups are presented in Table 7.1.

Table 7.1: Baseline characteristics of the control group and the intervention groups

		control group (n=90)	breaks (n=97)	breaks and exercises (n=81)
Gender	male	43%	46%	66%
	female	57%	54%	34%
Age		37	39	42
Frequency symptoms[1]	neck	0.59	0.52	0.60
	shoulders	0.58	0.52	0.55
	upper arms	0.34	0.24	0.42
	elbows	0.25	0.19	0.27
	fore arms	0.31	0.31	0.41
	wrists	0.39	0.40	0.44
	hands/fingers	0.39	0.39	0.42
Severity symptoms[2]	neck	4.64	4.20	4.57
	shoulders	4.52	4.21	3.97
	upper arms	2.85	2.42	2.96
	elbows	2.37	1.90	2.29
	fore arms	2.70	2.86	3.14
	wrists	3.11	3.52	3.29
	hands/fingers	3.06	3.45	3.24

[1] participants could choose between 4 categories: 0=no pain, 0.33=1 day, 0.67=2-3 days, 1=4-7 days in the previous week

[2] participants could indicate the severity of their pain in the previous week on a scale from 1 (no pain) to 10 (severe pain)

After the intervention period the participants had to fill out a second questionnaire including their name to match the data before and after the intervention. Seven questionnaires were not traceable to their senders. Altogether 219 subjects returned the second questionnaire with their name on it: 74 in the control group, 79 in the intervention group with breaks and 66 in the intervention group with breaks and exercises. Reasons for not returning the questionnaire (or returning it anonymously) were unknown for 39 subjects, 7 subjects did not return the questionnaire because no software was installed, 2 subjects changed work and 1 subject was on long-term sick leave (figure 7.1).

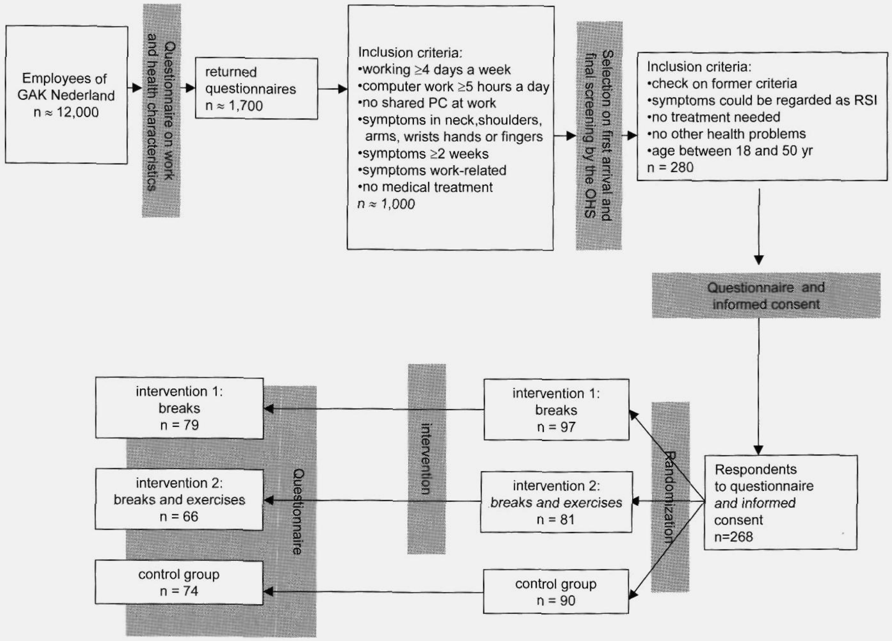


Figure 7.1. Participants flow. (PC=personal computer, OHS=occupational health service, RSI=repetitive strain injuries)

To check whether the participants performed the exercises we had to rely on their own reports. In the intervention group that was invited to perform exercises, the software generated questions after each rest break on how they spent their rest breaks and whether they performed the exercises. In the general questionnaire after the intervention period they were also asked whether they performed the exercises. According to the answers in the general questionnaire 74% of the participants performed the exercises most of the time, 18% now and then and 8% rarely or never. According to the questions posed after each rest break all the exercises were performed in 78% of all rest breaks; the exercises were ignored completely in 9% of the rest breaks and in 13% of the rest breaks some of the exercises were performed, but not all of them. There were large individual differences: 3% of the participants did none of the exercises, while 17% did them all during the whole intervention period, during each prompted break.

7.2.3 Intervention

The duration of the intervention period was 8 weeks. Before the intervention, the position of the seat, table height, position of the monitor, keyboard and mouse was checked in all groups and, if necessary, individually adjusted according to current ergonomic standards, recommended by the Dutch Labor

Inspectorate[19]. In 30% of the cases an adjustment was made. There was no difference between the three groups in the percentage of adjustments. In addition, all participants received a small attractive booklet with general information on neck and upper limb disorders, as well as a neck and upper limb disorder risk test.

In the first intervention group the participants were prompted by a signal on the screen to take a rest break of 5 minutes after each period of continuous computer usage of 35 minutes, and a microbreak of 7 seconds after each period of continuous computer usage of 5 minutes. This signal was not given when these periods were already interrupted by a 'natural' rest break or microbreak of the same duration or longer than the prompted breaks. Rest breaks could be postponed once for 15 minutes. During the breaks the computer was blocked. After the break the computer was automatically activated. Microbreaks could not be ignored. In this way the participants were not able to evade the break scheme.

In the second intervention group, the same scheme of rest breaks and microbreaks was applied. In addition, the workers in this group were stimulated to perform four physical exercises (lasting 45 seconds each) at the start of each rest break. The exercises were presented on the screen (see Figure 7.2). They were relatively easy and most of them could be performed while seated. After 45 seconds the 'done' button needed to be pressed to go to the next exercise. During the remaining period of the rest break the computer was blocked and people were free to do something else.

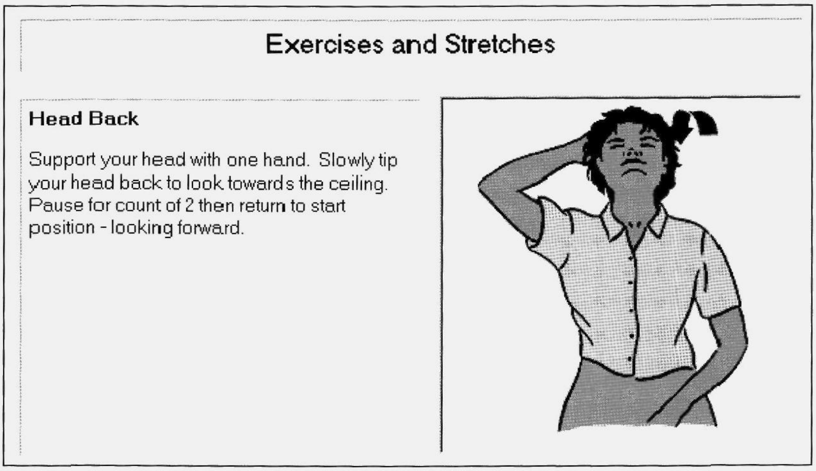


Figure 7.2 One of the exercises presented on the screen during a prompted rest break.

7.2.4 Measurements

At baseline, all subjects completed a questionnaire on symptoms (location, frequency and severity), on their sick leave due to these symptoms, on personal factors (e.g. gender, age, leisure time activities) and on work characteristics (e.g. tasks, working hours, psychosocial work characteristics). Psychosocial work characteristics were measured by means of the Job Content Questionnaire[20]. Furthermore, participants were asked if they could agree on some propositions with regard to their expectations of the break and exercise stimulating software. Positive and negative expectations were listed in the questionnaire.

After the intervention period, all subjects completed a similar questionnaire. Questions were added concerning the 'after usage' opinion on the software, on the recommended breaks and exercises (in the intervention groups), and on the perceived recovery of the symptoms (in all groups).

In all groups, software was installed that measured the computer usage of the participants. The software generated questionnaires as well. In the intervention groups, after each rest break, the participants were asked how they spent their rest breaks. In an automatically activated pop-up menu they could choose between one or more of the following activities: making telephone calls, reading or writing, waiting till the computer became active again, doing nonwork activities like drinking coffee or chatting with colleagues, doing work activities like collecting mail or walking to printer. Participants in the second intervention group who were stimulated to do exercises were also asked if they actually performed the exercises.

7.2.5 Outcomes

Main outcome was the perceived overall recovery from symptoms after the 8-week intervention period, measured with a questionnaire on a 7-point scale, where 1 = complete recovery, 2 = much improvement, 3 = little improvement, 4 = no change, 5 = slight deterioration, 6 = much deterioration, 7 = worse than ever before.

One of the secondary outcomes concerned the frequency and severity of symptoms. The frequency of symptoms was measured by asking the participants how often they felt discomfort or pain in their neck, shoulders, upper arms, elbows, fore arms, wrists and hands or fingers during the previous week. They could choose between the categories "no pain", "1 day", "2-3 days" or "4-7 days". The severity of the symptoms was measured by asking the participants to rate it on a scale from 1 to 10.

In addition self-reported sick leave in the data from the questionnaires formed a secondary outcome. In both questionnaires, participants were asked if they had been on sick leave as a result of their symptoms during the last 3 months. They were also asked to estimate the number of days of their sick leave.

For productivity, a third secondary outcome, the mean number of key strokes a day was computed during the intervention period. For the error rate, the mean number of key strokes of the backspace key and the delete key was computed. With these data the accuracy rate was computed according to the following criteria equation:

Accuracy rate = 1-(number of backspace + delete key strokes)/total number of key strokes

A power analysis indicated that at least 80 workers per arm were needed to detect a difference of 20% between groups on the main outcome (alpha .05, beta .20).

7.2.6 Analysis

Although group randomization was used, the analyses were executed in the same manner as an individually randomized trial. According to the authors, this can be considered a sound procedure as the population was highly homogeneous. The office locations shared exactly the same tasks, work methods, procedures and the like and were under the management of the same head-office.

To analyze the differences among the three groups with respect to the main outcome a crosstab procedure was used. Adjusted standardized residuals were calculated to determine any significant differences[21]. The frequency and severity scores were analyzed for the separate body regions. To summarize the effects on musculoskeletal symptoms, we grouped the body regions into 'neck and shoulders' and 'arms, elbows, wrists and hands or fingers'. Both the average score and the highest score across body regions were analyzed. To determine whether the frequency and severity of symptoms for the separate and the grouped body regions had changed during the intervention period, we used a paired T-test. An analysis of variance (ANOVA) was used to examine whether the changes in the intervention groups differed significantly from the changes in the control group. Because the intervention groups and the control group differed in gender and age, the ANOVA was repeated with adjustment for these variables and the adjusted means were computed. To adjust the analysis by self-reported recovery, the ANOVA procedure was used as well.

Interaction terms were studied for the variables 'expected effectiveness of the software' and 'job demands'. To avoid collinearity we centered the interaction terms by first subtracting their means from the variables before multiplying them[22]. To determine whether the interaction terms were significant, regression analyses were performed with models consisting of a variable concerning the group, the variable under study and the centered interaction term of both variables. The variables of the symptoms in the grouped body regions and self-reported recovery served as the dependent variables. In these analyses the intervention groups were treated as one group.

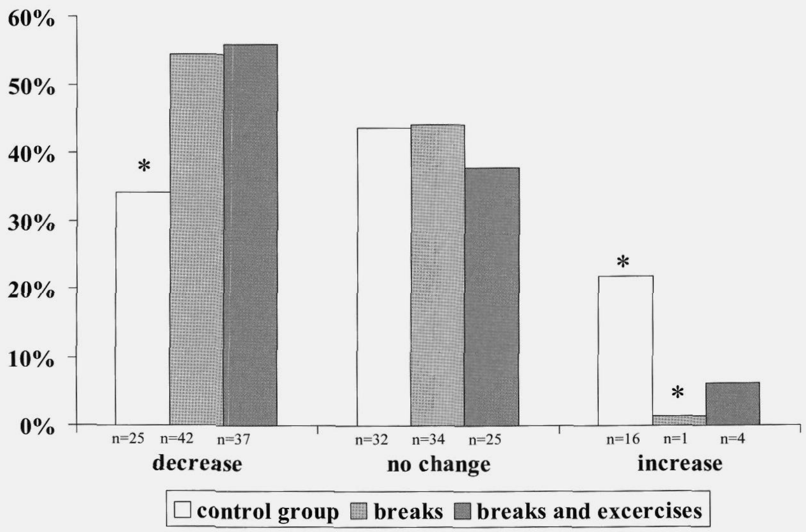
To determine whether sick leave due to neck or upper limb disorders had changed during the intervention period, a paired T-test was used. An ANOVA was used to study whether the changes in sick leave in the intervention groups differed significantly from the changes in the control group.

An ANOVA was used to study whether the intervention groups differed significantly from the control group on productivity. Because the number of key strokes and the accuracy in typing was strongly associated with gender, age and level of education, and because the control group and intervention groups differed on these variables, the results were adjusted for gender, age and education level.

7.3 Results

7.3.1 Perceived recovery

Figure 7.3 gives the self-reported recovery of symptoms as obtained directly after the period of intervention. Compared with the controls, the subjects in the intervention groups more frequently reported a recovery from their symptoms, while they less frequently reported deterioration. No difference was observed between the intervention groups.



* indicates a significant deviation from the expected value, based on the value of the standard adjusted residual in this cell (<-2 or >2)

Figure 7.3 Self-reported change in symptoms

7.3.2 Musculoskeletal symptoms

In all groups, frequency and severity of most symptoms decreased during the intervention period. The severity of symptoms concerning the neck, shoulder, upper arm, forearm, wrist and hands or fingers and the frequency of neck and shoulder symptoms decreased; only the frequency of elbow, wrist and hand/fingers symptoms increased. The changes in frequency and severity of symptoms in the intervention groups did not significantly differ from those in the control group (results not shown).

Table 7.2 shows the changes in frequency and severity of the symptoms for the grouped body regions, adjusted for gender and age. “Highest” refers to the maximum score for frequency and severity in these regions, respectively, and the “Mean” refers to the mean score of all symptoms for these regions. The means for self-reported recovery are presented as well. No statistically significant differences in the change of symptoms were found between control group and intervention groups. After adjustment for gender and age, self-reported recovery was still significantly higher in the intervention groups.

Table 7.2: Scores of the change in frequency and severity of symptoms and their 95% confidence interval (95% CI), adjusted for gender and age (a negative score indicates a decrease in frequency or severity).

			Intervention group			
Change in complaints	**Control group**		**Breaks**		**Breaks and exercises**	
	(n=70)		(n=75)		(n=64)	
Frequency score	change	C.I.	change	C.I.	change	C.I.
Highest for neck and shoulders	0.06	(-0.15;0.03)	0.06	(-0.15;0.03)	0.09	(-0.19 ;0.01)
	-0.09	(-0.17;-0.02)	-0.02	(-0.10;0.05)	-0.10	(-0.18;-0.02)
Highest for arms, elbows, wrists, hands or fingers	-0.05	(-0.15;0.04)	0.00	(-0.09;0.09)	0.01	(-0.09;0.11)
Mean for arms, elbows, wrists, hands/fingers	0.03	(-0.03;0.09)	0.09	(0.03;0.15)	0.03	(-0.03;0.10)
Highest for all body regions	-0.15	(-0.21;-0.08)	-0.08	(-0.14;-0.01)	-0.04	(-0.12;0.03)
Mean for all body regions	-0.01	(-0.06;0.05)	0.05	(0.00;0.11)	-0.01	(-0.06;0.05)
	(n=68)		(n=74)		(n=63)	
Severity score	change	C.I.	change	C.I.	change	C.I.
Highest for neck and shoulders	-1.7	(-2.3;-1.1)	-1.5	(-2.1;-0.9)	-1.8	(-2.5;-1.1)
Mean for neck and shoulders	-1.5	(-2.1;-1.0)	-1.2	(-1.7;-0.6)	-1.6	(-2.2;-1.0)
Highest for arms, elbows, wrists, hands/fingers	-1.4	(-2.0;-0.8)	-1.5	(-2.1;-0.9)	-1.1	(-1.7;-0.4)
Mean for arms, elbows, wrists, hands/fingers	-0.6	(-.9;-0.2)	-0.3	(-0.7;0.0)	-0.4	(-0.8;0.0)
Highest for in all body regions	-2.1	(-2.7;-1.5)	-2.1	(-2.7;-1.6)	-2.0	(-2.6;-1.4)
Mean for all body regions	-0.9	(-1.2;-0.5)	-0.6	(-0.9;-0.3)	-0.7	(-1.1;-.4)
	(n=71)		(n=76)		(n=65)	
Self-reported change in complaints	3.7	(3.5;4.0)	▼3.3	(3.0;3.5)	▼3.3	(3.0;3.6)

▼ indicates a significant (p<0.05%) lower value compared to the control group based on the contrast results in ANOVA.

7.3.3 Sick leave

Only a small number of participants was not able to continue working as a result of their symptoms, both before and after the intervention. This finding was not surprising because persons with severe symptoms, needing medical treatment, were excluded from the study. Before the intervention 8.7% had had to go on sick leave due to neck or upper limb disorders in the previous 4 months; during the intervention period the corresponding rate was only 5%. Table 7.3 shows the sick leave of the control group and the intervention groups. There were no statistically significant differences between the groups.

Table 7.3: Sick leave due to neck or upper limb disorders, before and after the intervention

		Intervention group	
Sick leave	**Control group** (n=74)	**Breaks** (n=79)	**Breaks and exercises** (n=65)
	(%)	(%)	(%)
Before intervention	9.5	6.3	10.8
After intervention	5.4	3.8	6.2
Change	-4.1	-2.5	-4.6

7.3.4 Productivity

Table 7.4 presents the differences between the control group and the intervention groups in key strokes and accuracy rate. This table shows that productivity, expressed as the number of key strokes, was statistically significantly higher in the intervention group with breaks and no exercises than in the control group. The accuracy rate in both intervention groups was higher than in the control group. The most striking difference between the groups was the number of delete key strokes, which was much higher in the control group than in the intervention groups.

Table 7.4: Differences in key strokes, correction key strokes and accuracy rate between control group and intervention groups, adjusted for gender, age and level of education, during the intervention period

		Intervention group	
	Control group (n=75)	**Breaks** (n=89)	**Breaks and exercises** (n=69)
Mean daily number of key strokes	5351	▲ 6460	6034
Mean daily number of backspace key strokes	199	263	252
Mean daily number of delete key strokes	215	▼ 71	▼ 72
Accuracy rate*	93	▲ 95	▲ 95

▼▲ indicates a significant ($p<0.05$) lower or higher value compared to the control group based on the contrast results in ANOVA.

* 1 – (backspace + delete)/total key strokes

7.3.5 Interaction effects

The regression analyses produced several significant interaction terms. Most of them concerned the variable 'expectations of the software at baseline', the sum of the positive expectations agreed upon. Significant interaction terms were found for this variable with most variables concerning the frequency of symptoms (strongest effect in highest frequency of neck and shoulders) and self-reported change as the dependent variable. The results indicate that, in the intervention groups, positive expectations of the software are associated with more perceived recovery and a decrease in symptoms. In the control group the finding was the reverse in that positive expectations were associated with less perceived recovery and an increase in symptoms.

Another significant interaction term with self-reported change as the dependent variable was job demands. The results indicate that there was no association between job demands and perceived recovery in the intervention groups, whereas in the control group high job demands are associated with more perceived recovery.

7.3.6 Expectations and experiences

Nearly all subjects were completely unfamiliar with break-stimulating software. Only four subjects had used such a program in the past. Most of the subjects (65%) did not expect the software without exercises to help reduce their symptoms. With respect to the software with exercises, the expectations were more positive, as 78% of the subjects expected a positive effect on their symptoms. Another positive expectation mentioned in the questionnaire concerned "more relaxation" and it was agreed on by 43% of the subjects. Negative expectations mentioned in the questionnaire and agreed on by more than 20% of the subjects were "loss of productivity" (33%) and "embarrassment to perform exercises in the presence of colleagues" (25%).

After the intervention period, the opinions of the subjects in the intervention groups were rather positive as can be seen in Table 7.5. In the intervention group that used the software without the exercises, 56% was satisfied to very satisfied, while 9% were dissatisfied to very dissatisfied. In the group with exercises 65% of the subjects were satisfied to very satisfied and only 5% were dissatisfied. Of all the users, 90% would recommend other computer workers with neck or upper limb disorders to use the software. Table 7.5 also shows that agreement on the positive propositions on the software is much larger than concerning the negative propositions.

Table 7.5 Satisfaction with the program and agreements on positive and negative propositions, mentioned in the questionnaire

	Intervention group			
	Breaks		Breaks and exercises	
Satisfaction with the program	%	(n)	%	(n)
– satisfied to very satisfied	56	(44)	65	(42)
– not satisfied not dissatisfied	35	(27)	31	(20)
– dissatisfied to very dissatified	9	(7)	5	(3)
– would recommend persons with initial complaints to use the software	90	(68)	91	(58)
Agree or strongly agree with the following propositions				
positive propositions:				
– the program caused more relaxation	46	(36)	55	(36)
– you have to get used to it, then it is fine and it will have effect	48	(37)	61	(39)
– the program is irritating but it will have effect	30	(23)	29	(19)
– after this study I want to continue using the program	56	(44)	70	(44)
– after this study I want to continue using this program and performing the exercises			64	(41)
negative propositions:				
– as a result of the extra breaks I had problems finishing my work	6	(5)	14	(9)
– colleagues think I overreact by working with this software	4	(3)	12	(8)
– you have to get used to it, then it is fine, but it has no effects	23	(18)	16	(10)
– the program is irritating and it has no effect	13	(10)	10	(6)

There were also some impeding factors for using the program. Table 7.6 shows the percentages of subjects who judged the factors mentioned as important or very important. The factors judged to be important or very important by more than 20% are “doing sufficient other things to reduce my symptoms” and “no connection assumed between symptoms and program”. In the intervention group with exercises the loss of productivity was also judged to be an important impeding factor by more than 20%. The impeding factors for performing the exercises were not often judged to be important.

Tabel 7.6: Impeding factors for using the program, mentioned in the questionnaire, judged important or very important by the subjects

	Intervention group			
	Breaks		Breaks and exercises	
impeding factors for using the program	%	(n)	%	(n)
– no time for this	13	(10)	18	(11)
– doing sufficient other things to reduce my complaints	27	(21)	23	(14)
– my supervisor doesn't think this is a solution	7	(5)	2	(1)
– my colleagues don't want to share in these activities	7	(5)	10	(6)
– my productivity will suffer by this program	15	(11)	22	(14)
– my complaints don't have anything to do with this	24	(18)	18	(11)
impeding factors for performing the exercises				
– I don't understand most of them			13	(8)
– it hurts to much			14	(8)
– I don't have the energy			10	(6)
– my colleagues would laugh at me			3	(2)
– I would feel embarrassed			10	(6)
– there are better ways to spend my time			17	(10)
– I don't feel like doing it			9	(5)
– exercises don't have effect on me			9	(5)

7.4 Discussion

7.4.1 Symptoms

The results on the effects of the software program seem to contradict each other. The comparison of the pre- versus postintervention scores of severity and frequency did not reveal any differences between the control and intervention groups, whereas the results concerning (post-intervention) perceived recovery revealed a favorable effect for the stimulation of regular breaks.

This favorable effect might have been caused by the presence of the intervention only, known as intervention bias. The software program may have placated people, just because their symptoms were paid attention to. They were able to express this positive feeling when they were asked to indicate recovery from their symptoms. Asking them to quantify the level of their symptoms (instead of the change) did not offer the opportunity to react positively, as most people would not remember their baseline scores when filling in the post intervention scores.

However, this result could also be due to a favorable and meaningful effect of the software program in that it could have initiated a process of consciousness that possibly led to more favorable behavior (e.g. working postures, muscle relaxation and extra breaks) and obviously a more positive attitude to one's symptoms. Possibly, the pain and discomfort had yet not diminished greatly, but the subjects expected that they could deal with it in such a manner that it would diminish further in the future.

Another factor that could have influenced the results is that a reduction of symptoms was observed in all the groups. The overall decrease in symptoms may have been caused either by the work place adjustments or the information booklet provided in all the groups. Furthermore, when a population of subjects has symptoms at the start of the intervention, the phenomenon 'regression to the mean' is likely to occur. Be that as it may, it is obviously harder to determine favorable effects of software when the level of symptoms also diminishes in the control group.

Finally, a period of three months might not have been long enough to show effects on the symptoms. It would be important to assess the long-term effects of the software and evaluate whether the high perceived recovery found in the intervention groups persists over a longer follow-up period.

7.4.2 Productivity

When people take more breaks it can be expected that the productivity of these people will decrease, as their working time is shorter. However, the results of this study, and comparable results from other studies[10,13,16,17] suggest this appears to be a misunderstanding, as no negative effects on productivity were found.

As no data on keystroke usage were available for the period before the intervention, the results in this study remain open to question. Although the results were adjusted for the most obvious factors, the differences in productivity between the groups could be attributed to already existing differences before the intervention period. Therefore, further study is needed with measurements on productivity before the intervention.

7.4.3 Break scheme and exercises

In the standard version of the software program used, a scheme was recommended of a 10-minute rest break after each period of continuous computer usage of 20 minutes, when people had initial symptoms. In this study a less stringent break scheme was applied with microbreaks of 7 seconds each 5 minutes and rest breaks of 5 minutes each 35 minutes. The reason for not using a more stringent break scheme was that subjects had limited possibilities for ignoring the breaks in the adjusted version of the program that was used for the study. A more stringent scheme could seriously disrupt the normal work activities and reduce the willingness of subjects to participate in the study.

Possibly a scheme including more frequent or longer breaks would have led to different results. However, there is no support for such a stringent scheme in the literature. Favorable effects on discomfort or symptoms have been found for rest breaks of 10 minutes after every hour of work[11], supplementary rest breaks of 5 minutes during each hour which otherwise did not contain a break[10] and microbreaks of 30 seconds taken at 20-minute intervals. However, no studies have been found concerning subjects with initial symptoms exclusively. Additional studies are needed to determine the effects of more stringent schemes on symptoms and to determine the compliance of computer workers with these schemes.

It is noteworthy that no favorable effect of additional exercises was observed on the symptoms of the subjects in this study, whereas in several studies the potential effect of active rest breaks has been demonstrated[15,16] and participants themselves expected such an additional effect as well. However, these studies did not concern the decrease in symptoms but other matters instead such as productivity, performance and perceived discomfort. Furthermore, the participants in the intervention group without exercises spent their breaks more often active (walking around) than inactive (waiting, reading or using the phone). It is also possible that natural breaks, not prompted by the software, were spent active as well, but we do not have information on this issue.

7.4.4 Study population

As the study population consisted of people with symptoms in the neck or upper limbs, it was not possible to determine the preventive effect of the software in a healthy population (i.e. the extent to which it can prevent the occurrence of neck and upper limb symptoms among healthy computer workers). The effectiveness of the software program depends on the willingness of people to use it. Possibly the willingness of healthy people to work with a break-stimulating software program is much lower than of people with neck and upper limb disorders. This factor would disrupt the preventive effect of the software.

The low response on the initial screening may have resulted in selection bias. Unfortunately no data on non-respondents were available. However, it seems likely that workers without symptoms, as well as workers who were not willing to use the software did respond less. This occurrence may explain, to some extent, the very high satisfaction figures found for the participants with respect to the software used.

7.4.5 Interaction effects

The interaction effects indicate that computer workers with positive expectations of the software profited more from the software. An explanation could be that these workers already suspected their symptoms were due to their attitudes concerning computer usage, whereas the workers who did not hold these expectations contributed their symptoms to other sources. Another explanation could be that workers with few positive expectations of the software were irritated using it. This irritation could cause some form of stress which could influence their symptoms. In the control group the knowledge that they did not have the opportunity to use the software could irritate the computer workers with positive expectations, which could have adverse effects on their symptoms in the same manner.

The interaction effect concerning job demands is more difficult to interpret. It was expected that workers with relatively high job demands may profit less from the software if they are not able, or not willing, to follow the break scheme. However, there was no association between job demands and perceived recovery in the intervention groups of our study. It is not clear why job demands were associated with more perceived recovery in the control group.

7.4.6 Randomization procedure

The analyses were based on the assumption that the office locations were highly comparable and, therefore, no correction was needed for the use of group randomization. Since only a few computer workers from every location were included in the study population it would have made no sense to determine the variance between the office locations as opposed to the variance between the workers. If the first variance were considerably higher, it could have led to an overestimation of the statistical significance. However, for reasons mentioned earlier, we do not consider this possibility to be likely.

7.4.7 Concluding remarks

Although this study showed no effect of the software on the frequency and severity of symptoms, it was found that computer workers with symptoms in the neck or upper limbs who use break-stimulating software perceived more recovery from their symptoms. An extra benefit from exercises was not observed. No effects were found on sick leave. Productivity expressed as the number of key strokes was higher in the intervention groups. The workers were satisfied with the software and most of them would advise other computer workers with initial symptoms to use it. The workers who had positive expectations of the software before the intervention seemed to profit more from the software than workers who did not have these positive expectations.

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General Discussion

8 General Discussion

The purpose of this thesis was to shed light upon the aetiology of neck and upper limb symptoms. In Chapter 1 a conceptual model was presented to illustrate possible causes and pathways. This model is presented in this chapter again. On the basis of this model the main findings will be discussed.

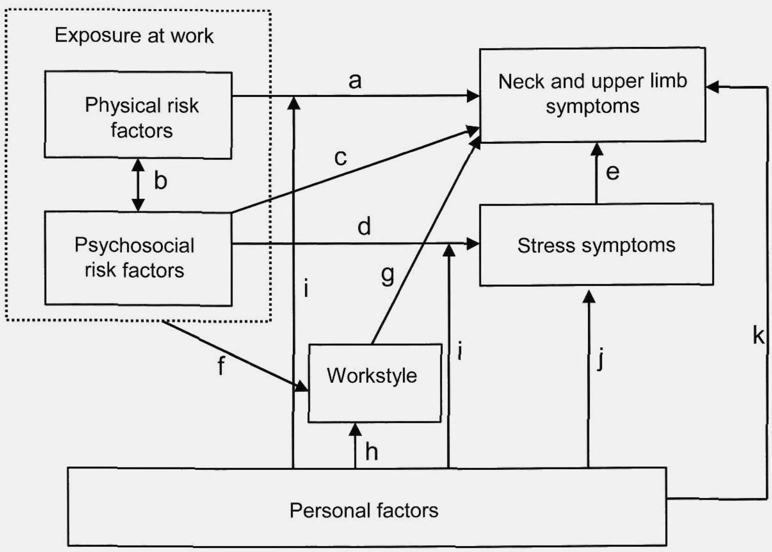

Figure 8.1

8.1 Summary of findings

What is the influence of physical exposure at work on neck and upper limb symptoms (a)?

The relation between physical exposure at work and neck and upper limb symptoms was studied in a population of office workers. The results of the analyses were presented in chapter 2. Neck rotation was identified as a risk factor for neck/shoulder symptoms. Neck extension was also statistically significantly associated with neck/shoulder symptoms, but only self-reported data were available. An indication was found of an adverse effect of long working days. None of the factors of physical exposure, examined in the present study, were statistically significantly associated with elbow/wrist/hand symptoms, although an indication of an adverse effect was found of wrist flexion and of full-time work or longer compared to part-time work.

In conclusion, only a limited number of physical risk factors could be identified for office workers. However, neck posture, in particular neck rotation, was consistently associated with neck/shoulder symptoms. This finding seems to be in accordance with a recent review, in which it was concluded that posture is an independent risk factor of modest magnitude for neck and upper limb symptoms[1]. However, high quality studies on working postures among computer users are still scarce and there are few studies that have examined the effects of working with a rotated neck in an office population. With respect to other risk factors examined in the present study, there are hardly any consistent results concerning office workers, with the exception of mouse usage[2,3,4,5,6], which was not assessed in the present study.

What are the main effects of psychosocial work characteristics on neck and upper limb symptoms (c)?

In chapter 3 the results were presented of analyses, using psychosocial work characteristics based on the Demand-Control-Support model[7] as independent variables. The results showed that high job demands was a risk factor for both neck/shoulder symptoms and elbow/wrist/hand symptoms. Low co-worker support was identified as a risk factor for elbows/wrist/hand symptoms, but not for neck/shoulder symptoms.

In chapter 4 the results were presented of analyses with the Effort-Reward Imbalance model[8,9]. The analyses showed that workers with high effort as well as workers with low reward reported more symptoms. The assumption of the model is that the combination of high effort and low reward is more unfavorable than the addition of their separate effects. Moreover, the effect of Effort-Reward Imbalance is assumed to be more unfavorable in overcommitted subjects. However, no interaction effects were found in the present study.

In conclusion, the results described in chapter 3 and 4 suggest that psychosocial work characteristics, in particular high job demands, low co-worker support, high effort and low reward, have an independent effect on neck and upper limb symptoms. High effort and low reward did not reinforce each other. The adverse effects of effort and reward were not stronger in overcommitted subjects. These results confirm findings from previous studies that identified psychosocial factors as risk factors for neck and upper limb symptoms[10,11,12,13,14,15,16,17,18]. These previous studies concern mostly psychosocial factors based on Karasek's Demand-Control-Support model. A relatively new result of the present study is the finding that psychosocial factors derived from the Effort-Reward Imbalance model also seem to affect neck and upper limb symptoms. Usually, studies on the effect of this model focus on stress-related disorders such as cardiovascular diseases[19,20,21,22].

To what extent can the relationship between psychosocial work characteristics and neck and upper limb symptoms be explained by work-related physical exposure (b,a)?

The results of the multivariate analyses, as presented in chapter 3, showed a decrease in most effect estimates of psychosocial factors after the adjustment for physical exposure. This decrease may be partly explained by an increase in exposure to physical risk factors, caused by the high job demands. If assumed that physical exposure causes neck and upper limb symptoms (a), psychosocial factors will have an indirect effect on these symptoms.

Contrary to the decrease in relative risks of the other psychosocial factors, the adjustment for physical risk factors resulted in an increase in the relative risk of social support of co-workers. A possible explanation is that the effect of social support is different for employees with high and low exposure to physical risk factors. Then, the estimation of the effect of social support could be moderated if social support is distributed unevenly over the different exposures. Additional analyses showed that the effect of social support of co-workers is indeed higher if the exposure to physical risk factors is high. However, no conclusive evidence could be found to support this possible explanation.

In conclusion, the results suggest that the effect of psychosocial exposure is partly explained by an increase in physical exposure. Although it has been suggested in the literature that some sort of interaction may take place between psychosocial and physical factors[23], this pathway has not been extensively examined before.

To what extent is the relationship between psychosocial work characteristics and neck and upper limb symptoms mediated by stress symptoms (d,e)?

The adjustment for stress symptoms in the multivariate analyses, as presented in chapter 3, showed a decrease of the relative risk of high job demands. This may indicate that stress symptoms play an intermediate role: high job demands lead to stress symptoms, after which stress symptoms lead to a physiological response that causes musculoskeletal symptoms. Nevertheless, the values of the relative risks of high job demands were still almost 2 after the inclusion of stress symptoms.

In conclusion, the role of high job demands in the aetiology of neck and upper limb symptoms is partly mediated by the stress symptoms they might cause. However, the results show that the association between high job demands and neck and upper limb symptoms is not entirely explained by an intermediate role of stress symptoms. These results confirm assumptions of various multivariable models that try to offer an understanding of the possible pathways in the relation between psychosocial factors and musculoskeletal symptoms[24]. The pathway psychosocial factors $\rightarrow$ stress symptoms $\rightarrow$ neck and upper limb symptoms has not been extensively examined before.

What is the influence of overcommitment on neck and upper limb symptoms (i,k)?
In chapter 4 the results were presented of analyses showing that overcommitted subjects reported more symptoms, at baseline as well as during follow-up. Longitudinal effects were found in the analyses with women: the interaction term overcommitment*time was significant in the analyses with women, for both neck/shoulder symptoms and elbow/wrist/hand symptoms. This means that symptoms of overcommitted women increased more over time than symptoms of women with more favorable scores on the overcommitment scale. In men the interaction term overcommitment*time was not statistically significant.
In conclusion, overcommitted subjects report more symptoms. In overcommitted women these symptoms increase stronger over time than in women who are not overcommitted. Although it has been suggested in the literature that personality traits may contribute to the onset of neck and upper limb symptoms[25,26], the effects of overcommitment on neck and upper limb symptoms has not been studied before with longitudinal data.

To what extent is the relation between work-related exposure and neck and upper limb symptoms mediated by a high-risk workstyle (f,g)?
In chapter 5 the results were presented of analyses with the workstyle concept[27]. The results show that a high-risk workstyle was associated with unfavorable work-related exposure (i.e. high job demands and prolonged VDU-work) and with neck and upper limb symptoms. High job demands and prolonged VDU-work were also associated with neck and upper limb symptoms. The analyses showed that the association between work-related exposure and neck and upper limb symptoms was partly mediated by workstyle.
In conclusion, the results suggest that the relation between working conditions and neck and upper limb symptoms is mediated by workstyle. However, a large part of the mediated effect is accounted for by the scale Working Through Pain. This scale could be biased as the presence of pain will probably influence the response on questions about pain. Therefore, conclusions should be drawn with care. These results confirm the findings of a limited number of studies examining the relation between workstyle and neck and upper limb symptoms[28,29]. No studies have been published on the mediating role of the workstyle concept.

To what extent is the relation between overcommitment and neck and upper limb symptoms mediated by a high-risk workstyle (h,g)?
The results in chapter 5 showed an association of a high-risk workstyle with overcommitment, as well as an association of overcommitment with neck and upper limb symptoms. The association of overcommitment and neck and upper limb symptoms decreased after adjustment for workstyle scales, in

particular for the scales Working Through Pain and Social Reactivity and the analyses showed that the effect of overcommitment was largely mediated by workstyle.
In conclusion, the results suggest that the relation between overcommitment and neck and upper limb symptoms is largely mediated by workstyle. However, the same drawback as in the previous research question should be taken into consideration. No studies have been published that combined the role of workstyle and overcommitment.

What is the effect of physical activity in leisure time on neck and upper limb symptoms and sickness absence due to these symptoms (i,k)?
In chapter 6 results were presented showing that practicing sports for at least 10 months a year decreased the risk of neck/shoulder symptoms, sickness absence and long-term sickness absence due to neck or upper limb symptoms. A high mean intensity (≥ 3 hours per week) of sporting activities had less effect than the continuation of these activities throughout the year. An effect of physically active commuting could not be demonstrated, although there was a tendency towards a favorable effect on sickness absence. Stratified analyses for subjects with sedentary and more active work showed that the effect of sporting activities for at least 10 months a year were only statistically significant in the group of subjects with sedentary work.
In conclusion, sustained sporting activities have a favorable effect on neck/shoulder symptoms, especially in subjects with sedentary work. These activities also have a favorable effect on sickness absence due to neck or upper limb symptoms. There is no consensus in the literature on the effect of physical activity on musculoskeletal symptoms[30,31], but there were only few high quality studies. However, several recent intervention studies concluded that physical activity had a positive effect on neck or shoulder symptoms[32,33,34]. The difference in effect between a high mean intensity and sustained activities has not been studied before.

What is the effect of software programs stimulating regular breaks and exercises on neck and upper limb symptoms (g)?
In chapter 7 the results were presented of a randomized controlled trial among computer workers to evaluate the effects of a software program that stimulated regular breaks and exercises. The participants were assigned to either a control group, or an intervention group stimulated to take extra breaks or an intervention group stimulated to perform exercises during the extra breaks during an 8-week period. The results showed no significant differences in change between the self-reported pre- and postintervention scores on the severity and frequency of symptoms among the three groups. However, participants were satisfied with the program and self-reported recovery was higher in the intervention groups. Moreover, productivity, expressed as the

number of key strokes, was statistically significantly higher in the intervention group. However, no data on keystroke usage were available for the period before the intervention.
In conclusion, no unequivocal effects were found of a software program stimulating regular breaks and exercises. There seems to be no effects of performing physical exercises during these breaks. The effects of a software program have not been studied before on such a large scale.

8.2 Methodological considerations

Study population
All studies used in this thesis concerned the working population. However, there are some important differences between the studies. The study population of SMASH consisted of a variety of workers, including blue-collar workers, white-collar workers, and workers in caring professions from 34 companies. Although in the analyses concerning work-related physical exposure (chapter 2) a selection was made of office workers, the companies they worked for varied. The other study populations were more homogeneous. The study population of PRIM consisted of blue-collar workers who had mainly repetitive job tasks. The company survey and the randomized controlled trial consisted of a relatively homogeneous group of office workers. The differences between the study populations should be taken into account when comparing or generalizing the different risk factors. Exposure will not be similar in different work settings. Moreover, the relevance of risk factors may vary. Whether some type of work-related exposure is a risk factor could be dependent on other characteristics of the job.
Most analyses in the present study were restricted to office workers. The main difference with industrial workers is their physical exposure at work. The most known risk factors for industrial workers, repetitiveness and force exertion, will hardly be observed in an office population. Moreover, the exertion of force might make a welcome change to other, mostly passive tasks and may not be a risk factor at all for office workers. Therefore, different risk factors will be found in an industrial population.
The study population of the analyses with the effort-reward-imbalance model (chapter 4) consisted of blue-collar workers with repetitive tasks. Possibly, the results would be different, if this study was carried out in a white-collar population. It can be hypothesized that the effort-reward-imbalance is a more important risk factor among office workers, as blue-collar workers with repetitive tasks endure more potential risk factors. This is however a speculative statement.

Healthy worker effect

A common problem in occupational cohort studies is the healthy worker effect[35,36]. Firstly, this effect refers to the selection of the study population, since an individual must be relatively healthy to be employed in the workforce. In addition, in the populations of SMASH and PRIM, at baseline, subjects had already been working for almost 10 year on average at their present workplace. These relatively healthy subjects may be less susceptible to symptoms or disorders, but they may also have learned a strategy to deal with work demands. Therefore, the risk of exposure at work could be underestimated.

Secondly, the healthy worker effect refers to the tendency for workers with starting symptoms to leave their jobs. This does not have to mean they leave the active workforce, but they may move to jobs with less unfavorable exposure. Workers will be more inclined to do so if their work demands have caused their symptoms.

Both effects might have biased the results. It is unclear to what extent the first effect might have influenced the results. To minimize this kind of bias the best design would be a prospective cohort study with newly hired workers[35]. However, this kind of studies is still scarce, which is not surprising as the conditions of these studies are rather complicated. Therefore, it remains unclear to what extent this effect may have led to an underestimation of the risks.

Concerning the second effect, the results in chapter 2 showed that in SMASH subjects reported considerably more symptoms at baseline than at follow-up (Table 2.1). This could suggest that workers with starting symptoms have left their job and were lost to follow-up. Although in PRIM subjects reported more symptoms at follow-up (Table 4.1), the response rates decreased considerably at follow-up and the problem of selective loss to follow-up could still have occured. To estimate how far this effect could have influenced the results, the dropout of subjects with symptoms at baseline was compared to the dropout of subjects without symptoms. In addition, the exposure of subjects who were lost to follow-up was compared to the exposure of subjects without missing data.

In SMASH, subjects who reported symptoms at baseline did not drop out more often than subjects without symptoms. On physical exposure there were hardly any differences between subjects who dropped out and subjects who did not. However, concerning exposure to psychosocial work characteristics, subjects who were lost to follow-up reported more often low skill discretion, low decision authority and, to a lesser extent, poor social support. This may have caused an underestimation of the risks, when these unfavorable work characteristics caused symptoms and subsequently dropout from work. However, dropout might also be due to other causes.

In PRIM, subjects lost to follow-up did not report more complaints at baseline, but were more exposed to repetitive tasks. However, their scores on the overcommitment and effort-reward imbalance scales did not differ from subjects with complete follow-up data. Therefore, it can be concluded that bias due to loss to follow-up was limited in this study.

Assessment of physical exposure

Self-reports as well as observational measurement techniques were used to assess physical exposure at work. Self-reported physical exposure was assessed with the standardized Dutch Musculoskeletal Questionnaire. Although this questionnaire is suitable for identifying high-risk groups, a comparison with observed data showed that workers could not accurately report frequency and duration of their movements and postures. However, simple qualitative questions seemed adequate[37].

Nevertheless, the use of self-reported data has more drawbacks compared to observed data than a lack of accuracy in frequency and duration. One important disadvantage is that exposure assessment could be influenced by symptoms. Subjects with symptoms are probably more aware of possible disadvantageous postures or actions at work than subjects free of symptoms. The reason could be that they feel pain exerting these actions or remaining in these postures, or because they attribute their symptoms to more or less known risk factors. In analyses using self-reported data, this differential misclassification of exposure could lead to an overestimation of the risks. Although this problem is particularly present in studies with cross-sectional designs, when exposure and symptoms assessment are carried out simultaneously, this problem might still occur in longitudinal studies, as subjects with symptoms had often also had symptoms at the previous measurement, when the exposure was assessed.

Apart from self-reports, data on physical exposure were assessed with video-observations. A group-based measurement strategy was used in SMASH as well as in PRIM. As physical exposure was a central determinant in one of the analyses with SMASH data (chapter 2), and physical exposure was used as a confounder in the analyses with PRIM data (chapter 4), only the measurement strategy of the SMASH study will be discussed here.

The choice of a group-based measurement strategy as opposed to an individual-based strategy is dependent on the estimation of variance in exposure between and within workers[38]. In general, individual-based strategies generate precise, though biased, estimates and group-based strategies generate less precise but essentially unbiased estimates[39]. In SMASH, the choice for a group-based strategy was also based on reasons of efficiency.

To prevent misclassification in a group-based measurement it is important to minimize the within-group variance and maximize the between-group variance[39,40]. Grouping on the base of job-title is usually too crude. To minimize misclassification in the present study, groups were composed on the base of the estimation of the comparability of jobs during onsite inspections. As a consequence, it is not possible to measure individual differences within these homogeneous work groups. Furthermore, misclassification of exposure for individual workers may still have occurred due to differences between individuals within a group.

Assessment of psychosocial exposure

Both in SMASH and in PRIM, self-reports were used for the assessment of psychosocial exposure (chapter 3 and 4). Independent assessment tools for psychosocial factors, like supervisor or coworker evaluations or direct observations, are still rare. As the emphasis of these factors is on the perception of the individual, self-reports probably are the best method to collect data[41]. The two most widely used models to assess psychosocial exposure are Karasek's Demand-Control-Support model and Siegrist's Effort-Reward-Imbalance model.

In SMASH (chapter 3), data on psychosocial exposure were assessed with a Dutch version of the Job Content Questionnaire (JCQ)[42], which measures all dimensions of the Demand-Control-Support model[7]. Various items were combined to form dimensions of job demands, skill discretion, decision authority and social support. The Demand-Control-Support model has been frequently used in research on the effects of psychosocial factors on neck and upper limb symptoms[10].

In the analyses with PRIM data (chapter 4), Siegrist's Effort-Reward Imbalance Model (ERI)[8,9] was used to describe the psychosocial work characteristics. The theory of this model is that a combination of high effort and low reward could lead to adverse health effects. As the original items of Siegrist's effort-reward questionnaire were not available in the PRIM study, proxy measures were constructed.

Both models are based on an interaction hypothesis. In the Demand-Control-Support model the hypothesis is that the strongest effects will occur when high job demands are combined with low decision latitude. In the ERI model the hypothesis is that the combination of high effort and low reward will generate the most adverse effects, more than the addition of both factors. In addition, a second interaction hypothesis has been formulated: it is assumed that this process will be intensified by overcommitment. However, the results of the analyses with PRIM data (chapter 4) did not support the two interaction hypotheses of the ERI model. The analyses with SMASH data (chapter 3) showed that subjects in the most unfavorable quadrant (high demands, low control) reported more symptoms, but the interaction hypothesis of the Demand-Control-Support model was not examined explicitly. However, additional analyses were performed to test this hypothesis and no support for this interaction hypothesis was found either.

The absence of support for the interaction hypothesis is not surprising. A recent review of the effects of the Demand-Control-Support model concluded that only modest support was provided for the hypothesis that a combination of high demands and low control results in high job strain. Usually, support for the interaction hypothesis was in the form of additive effects[43]. There is still a diversity of methods to operationalize the co-occurrence of high effort and low reward and there have hardly been any studies that have examined the interaction hypothesis Effort*Reward explicitly[22]. Although there are more studies that have tested the second interaction hypothesis, ERI*overcommitment, results are still scarce and inconsistent. Therefore, conclusions could not be drawn[22].

The advantage of using Karasek's JCQ is that it is the most widely used questionnaire in research on psychosocial factors. Therefore, results can be compared with other studies. The reason to study the effects of the ERI model as well is that this model contains a personality component. In public opinion as well in previous research[25,26], it has been suggested that personality traits could have an effect on neck and upper limb symptoms. However, due to a lack of research on this subject there is still no evidence.

The purpose of the study with the ERI-model was not to compare its effects with the Demand-Control-Support model. Due to the use of proxy measures, effort in the ERI model bears too close a resemblance to job demands in the Demand-Control-Support model. Moreover, the study populations of the two studies are different.

Assessment of workstyle

For the assessment of workstyle the questionnaire developed by Feuerstein and colleagues[44] has been used. The preliminary workstyle measure contained 136 items, reflecting workplace stressors as well as individual behaviors and attitudes. Of the original items, only 13 items were used for the study described in chapter 6. This might seem a rather drastic reduction. However, many items reflected stressors and symptoms and were not relevant for the present study, as stressors and symptoms were assessed with different measures. Only items were selected that represented behavior and attitude. Moreover, previous analyses (results not published) carried out with a short form of the questionnaire indicated that the short form is a reliable and valid measure of workstyle (personal communication research group Feuerstein).

Assessment of symptoms

Self-reports were used to assess symptoms, with the exception of the study described in chapter 6, where registered sickness absence due to symptoms was also used as an outcome measure. Self-report is the most common method in present research practice on musculoskeletal symptoms as most of the reported symptoms of this region are nonspecific, without well-defined clinical diagnoses[41]. The methods to assess symptoms were not always similar in the different analyses performed for this thesis as they were based on the data of several studies. The design of these studies diverged and different questionnaires were used for assessment. As a consequence outcome variables differed and, partly as a result of that, different kind of effect estimates were applied. In SMASH the outcome is dichotomous and effect estimates refer to the risk of occurrence of neck and upper limb symptoms in chapter 3, but also at persistence and disappearance in chapter 2 and 6. In PRIM the outcome is continuous and effect estimates refer to the increase or decrease of symptoms during follow-up. In the company survey no longitudinal data were available and effect estimates refer to the cross-sectional association of exposure and symptoms. Furthermore, in the company survey symptoms were not divided into the neck/shoulder and elbow/wrist/hand region and symptoms that did not have any relation to work were excluded as cases. In the intervention study, described in chapter 7, only participants were included that were screened by an occupational health physician who determined whether the symptoms could be regarded as Repetitive Strain Injuries according to the definition of the Health Council of the Netherlands. Among others, the outcome measure was the change in self-reported pre- and postintervention scores on the severity and frequency of symptoms.

These differences in symptom assessment and the resulting outcome variable have to be considered when the results of different kind of risk factors are compared. For example, the results in chapter 2 suggest that several work-related physical factors are not associated with neck and upper limb symptoms. However, the possibility could not be dismissed that associations would have been found if a continuous outcome measure similar to the PRIM study was used. Possibly, these work-related physical factors influenced the worsening of symptoms. Therefore, a comparison of the different kind of risk factors in this thesis should also take into account the differences in symptom assessment.

Incidence versus prevalence as an outcome measure

In prospective cohort studies with a dichotomous outcome measure, there are two main approaches to estimate risk ratios. The first is to carry out the analyses in a sub-cohort of subjects who do not report symptoms at baseline, and to use the incidence during follow-up as the outcome measure. The second approach is to carry out the analyses with the complete cohort and to use the prevalence during follow-up as an outcome measure, while the analyses are adjusted for the outcome at baseline. The consequences of these approaches are discussed below.

Firstly, there is one fundamental difference between the two approaches. Measuring incidence in a symptom-free cohort means to determine the risk of the onset of symptoms. Measuring prevalence in a complete cohort means to determine the risk of onset, persistence and recurrence of symptoms. These risk factors do not necessarily converge.

An important drawback of the incidence approach is related to the selection of subjects. There could be several reasons why subjects in a symptom-free sub-cohort do not have symptoms. Is it because their exposure to risk factors was less or for a shorter period of time? Or have we selected subjects with a relatively high physical capacity? If subjects with a high physical capacity are selected this might lead to an underestimation of the risk. Furthermore, the selection is somewhat arbitrary. Since the course of these type of symptoms is probably rather episodic, it is not evident that subjects in the selection have not had a history of symptoms. If they have, not incidence but recurrence of symptoms is measured and then there is little difference with the prevalence approach. An additional problem is that reduction of subjects also means a reduction of statistical power.

A drawback of the prevalence approach when using self-reports for the exposure assessment is that this kind of exposure assessment at baseline could be biased by symptoms. As the subjects with symptoms at baseline are often the same subjects as those with symptoms at follow-up this might result in an overestimation of the risk. However, to a lesser extent, this problem might also occur in a selection of symptom-free subjects as their exposure assessment might be biased by previous symptoms.

In the studies in this thesis, exposure assessment was mostly self-reported and subjects could already have had symptoms and could have had previous exposure. In this case both approaches have their pros and cons. The choice for one of them depends on the estimation of the impact of the different drawbacks. Moreover, it is important to realize that risk factors for incidence could differ from risk factors for persistence or recurrence.

In most of the analyses in this thesis, a complete cohort was used with prevalence of symptoms as the outcome measure. However, in the analyses with psychosocial characteristics in SMASH (chapter 3) the incidence approach was chosen. The main reason was that preliminary analyses showed that most risk factors did not affect the workers who already reported symptoms at baseline. The conclusion was that psychosocial risk factors for the onset of symptoms were different from risk factors for the persistence or recurrence of symptoms. Preliminary analyses in the other studies did not demonstrate substantial differences in risk factors between the incidence and prevalence approach.

Time-lag model

In some longitudinal studies in this thesis a time-lag model was applied, meaning that the independent variables were assessed some point in time preceding the assessment of the outcome. There are several reasons for using a time-lag. One reason is that most exposure assessment in these studies is based on self-report. Therefore, the presence of symptoms could have influenced the exposure assessment. Another reason is that without a time-lag the direction of causality is not always clear. For example, sporting activities is associated with fewer symptoms, but in a cross-sectional study it is unclear if these activities caused a decrease in symptoms or if subjects with symptoms are less inclined to engage in sporting activities. Therefore, a temporal sequence of cause and effect should be taken into account and the assessment of the independent variable should precede the assessment of the outcome variable in time.

Although the time-lag model seems to be the proper approach to examine the relation between independent variable and outcome, there are some issues that need to be considered. The most important one is that it is unknown how long it takes before the presumed effect of the independent variables will occur. The independent variable and the outcome might covary continuously resulting in a very short interval between cause and effect. Then, a long time interval would be inappropriate as the simultaneous exposure would be a far more important determinant of the present symptoms. Moreover, if a long time interval is applied the exposure could have changed or measures could have been taken to cope with the exposure. Neck and upper limb symptoms are of an episodic nature. During a long time interval symptoms could occur and disappear again, possibly due to changes at work or in personal circumstances during the time interval. From additional analyses with SMASH data it appeared that of subjects with symptoms at baseline, 32% had persistent symptoms throughout the follow-up period, 25% had no symptoms during the complete follow-up period, and 43% had symptoms during some follow-up measurements. A time interval could also be too short. The exposure might need to last for a certain time before an effect will occur.

Another issue is that a time-lag does not guarantee causality. Even if the independent variable is statistically significantly associated with the outcome, and if the independent variable precedes the outcome, the outcome may still be caused by other determinants, if the analyses are not adjusted for these potential confounders. Furthermore, if both independent variable and outcome are based on self-reports, then biased results could still occur due to circularity. After all, measurements are not independent when reported by the same individual, even when there is a time interval between the two measurements. Subjects with symptoms at the time of outcome measurement often had symptoms before, either at the time of the assessment of the independent variable or earlier in time. Therefore, the assessment of symptoms could also be biased by symptoms in a time-lag model.

Although it is clear a time-lag model does not overcome all drawbacks in cohort studies with mostly self-reported data, it still seems a sound choice. Furthermore, with data of the SMASH study there is an additional reason to apply a time-lag model that concerns the assessment of exposure and outcome.

In the questionnaires outcome was assessed with a question aimed at symptoms in the last twelve months, while exposure was assessed with questions that contained no time-perspective. If no time-lag was applied, the undesirable situation could occur that symptoms of some time ago would be related to exposure that only recently began.

8.3 Final conclusion

Several risk factors of neck and upper limb symptoms were identified. These risk factors were of diverse origin, by which the assumed multifactorial aetiology of these symptoms is confirmed. There is only limited support for the effect of work-related physical exposure on neck and upper limb symptoms in office workers. Although indications for other associations were found, only neck rotation was consistently identified as a statistically significant risk factor. Previous studies produced mostly inconsistent results.

The present study confirmed findings from previous studies that identified psychosocial work characteristics as risk factors for neck and upper limb symptoms. Moreover, independent effects of high job demands and social support of co-workers were found, that were not, or only partly, explained by an increase in work-related physical exposure or stress symptoms.

Apart from these work-related risk factors, associations between personal and behavioral aspects and neck and upper limb symptoms were found. The effects of these aspects have hardly been studied before. In the present study it was found that the personality trait overcommitment may have an unfavorable effect on neck and upper limb symptoms. The influence of overcommitment and work-related exposure on neck and upper limb symptoms was probably mediated by a behavioral concept, defined as a high-risk workstyle. Another behavioral aspect is physical activity in leisure time. It was found that sustained sporting activities decreased the risk of neck/shoulder symptoms and (long-term) sickness absence due to neck or upper limb symptoms.

Part of a high-risk workstyle is to skip or delay breaks. One possible intervention to influence workstyle is to implement a software program, designed to stimulate regular breaks and exercises. However, a randomized controlled trial showed that there were no unequivocal effects of such a program on neck and upper limb symptoms. Nevertheless participants were satisfied and self-reported recovery was higher among participants using the program than among those of the control group.

8.4 Implications for prevention

Findings of the studies, presented in this thesis emphasize the multifactorial origin of neck and upper limb symptoms. Therefore, an integral approach for prevention seems the most promising strategy. This approach should pay attention to workplace design, work organization, organizational culture and lifestyle.

The study on physical factors in this thesis was restricted to an office population. Therefore, only consequences for office design could be deduced from the results. It is imperative that workplace design is an important issue in the prevention of neck and upper limb symptoms. However, this study produced only a limited number of statistically significant results. Nevertheless, the results confirm findings from previous studies and suggest that in workplace design in an office setting, attention should be paid to working postures. As computer work is nowadays the most common activity at work, this will have consequences for the position of chair, monitor and keyboard.

Attention should be paid to work organization to improve the psychosocial work environment, in particular job demands and social support of colleagues. Another aspect of the psychosocial work environment refers to the organizational culture. In most companies commitment of employees is highly appreciated and stimulated. However, although engagement of employees may be a healthy and desirable condition, overcommitment is not. Employers should realize that the boundaries between healthy engagement and unfavorable overcommitment are not always easy to define and unabated stimulation of commitment could have adverse effects, starting with a high-risk workstyle. Supervisors should be aware of this kind of behavior at the workplace. Training in an alternative workstyle might be helpful. However, experiences in this field are still scarce. Software programs stimulating breaks and exercises may be helpful, although their effects are not yet sufficiently supported by the literature.

As the results of this thesis suggest that physical activity in leisure time may be helpful in the prevention of neck and upper limb symptoms, attention should also be paid to this lifestyle issue. Companies could implement worksite physical activity programs or organize promotion activities to stimulate physical activity in leisure time. As these interventions will have other favorable effects as well, the prevention of neck and upper limb symptoms could be an extra incentive to start such activities.

8.5 Recommendations for future research

Studies with newly employed workers could be recommended for two different reasons. Firstly, in prospective cohort studies there is always some bias due to a healthy worker effect. Subjects included in the study are relatively healthy and may be less susceptible to symptoms or disorders. Moreover, they may have learned a strategy to deal with work demands. Therefore, the risk of exposure at work could be underestimated. Studies with newly employed workers will give some insight into the strength of this effect. Secondly, these studies could indicate how long an exposure has to last to induce an effect.

Studies are needed to examine the time-interval between work-related exposure and neck and upper limb symptoms. Until now the time-lag used in longitudinal studies has been determined more often by practical considerations than on the basis of theoretical assumptions.

Longitudinal studies are needed to establish the direction of causality between work-related exposure and workstyle, between neck and upper limb symptoms and workstyle, and between overcommitment and neck and upper limb symptoms. Until now, findings were mainly of a cross-sectional nature.

Apart from work demands and overcommitment, research is needed to examine other possible determinants of a high-risk workstyle. One of these determinants could be connected to aspects of organizational culture, for example a competitive atmosphere, an unsupportive climate or a too large emphasis on commitment. This is a relatively unknown territory for research on musculoskeletal symptoms and it will be a challenge to operationalize aspects of organizational culture that are possible determinants of a high-risk workstyle.

Controlled intervention studies are needed to study the effect of various interventions on workstyle. Organizational interventions could be directed at the prevention of factors that might encourage a high-risk workstyle. In addition, training in alternative workstyles might be helpful.

Although no unequivocal effects have been found of a program stimulating breaks and exercises, the satisfaction and high productivity of the participants working with the program are promising. More research is needed to examine long-term effects and the effect on productivity.

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Summary

Summary

In this thesis the aetiology of neck and upper limb symptoms is examined. Neck and upper limb symptoms are a common health problem, especially in the working population. Data from the European Foundation for the Improvement of Living and Working Conditions, based on fifteen European countries, showed that 25% of the subjects reported work-related neck/shoulder pain, and 15% reported work-related arm pain.
These symptoms may cause sickness absence and sometimes even long-term disability for work. Data from the Dutch Workers Insurance Authority show that new cases of chronic disability for work due to neck and upper limb symptoms increased every year from 1998 till 2001. In 2001, over 6000 new cases were registered, which represented 0.1% of the working population and 6% of the total number of new disability benefits. After 2001 incident disability for work due to neck and upper limb symptoms has decreased, which could be partly attributed to a general decrease in all disability benefits, due to a change in the policy for granting benefits. Symptoms did not decrease, according to recent figures from a Dutch survey.
It is assumed that neck and upper limb symptoms have a multifactorial aetiology. These factors are not isolated, but interact and reinforce or weaken each other. Initially, most research on neck and upper limb symptoms focused on work-related physical exposure. Meanwhile, there is sufficient evidence that work-related physical exposure is a risk factor in industrial workers. However, results concerning office workers are often inconsistent.
Next to physical factors, psychosocial factors seem to be important as well. How these factors could lead to symptoms, and how they interact with physical factors remains unclear. It has often been suggested that behavioral aspects, such as workstyle and physical activity in leisure time are of importance in the aetiology of neck and upper limb symptoms. However, studies concerning these factors are still scarce. Also, there is little evidence that personality traits could have an effect on neck and upper limb symptoms, due to a lack of studies on this subject. In this thesis several risk factors for neck and upper limb symptoms have been examined, as well as their mutual influence.

In chapter 2 the influence of physical exposure at work was studied in a population of office workers. Data were used from the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH). SMASH is a prospective cohort study in a Dutch working population with a

follow-up period of 3 years. The 34 participating companies were asked to select workers who had been employed in their current job for at least one year and who were working 24 hours per week or more. The population included blue-collar workers, white-collar workers, and workers in caring professions. For the analyses in this chapter, only office workers were selected (n=398).
Data on physical exposure at work were obtained using questionnaires as well as video observations. The questions were derived from the standardized Dutch Musculoskeletal Questionnaire and were part of all yearly questionnaires. Video observations were based on four video-recordings of 10-14 min of each subject during one working day at baseline. A group based measurement strategy was applied. The video-recordings of one fourth of the subjects in each group were observed according to a standard protocol. All individuals within a group were assigned the group's mean values of the exposure variables, based on the individuals observed in that group. Neck and upper limb symptoms were assessed yearly with an adapted version of the Nordic Questionnaire. Subjects were identified as cases if they reported regular or prolonged pain in these regions in the previous 12 months. Combined outcome measures were made for neck/shoulder symptoms and elbow/wrist/hand symptoms.
The effects of physical exposure at work were examined with the generalized estimating equation (GEE) method. A time-lag of one measurement (= 1 year) was built into the model to relate the independent variables (physical exposure) at one point in time to the dependent variable (symptoms) in the following year, as assessed in the next measurement.
The results showed that only a limited number of work-related physical factors were related to neck and upper limb symptoms in office workers. Working with a rotated neck ($\geq 45°$) had an adverse effect on neck/shoulder symptoms. Neck extension was also statistically significantly associated with neck/shoulder symptoms, but only self-reported data were available. An indication was found of an adverse effect of long working days. None of the factors of physical exposure, examined in the present study, were identified as risk factors for elbow/wrist/hand symptoms, although an indication of an adverse effect was found for wrist flexion and for full-time work or longer compared to part-time work.

In chapter 3 the relationship between psychosocial work characteristics and neck and upper limb symptoms was studied. Dimensions of the demand-control-support model were used as independent variables. The theory of this model is that subjects in high strain jobs (high demands, low control) are more at risk for adverse health effects. However, the separate dimensions of the model might have independent effects as well. For this study, the emphasis is on the independent effects of the separate psychosocial factors.

Besides the main effects of these dimensions, it was examined to what extent these relationships could be explained by an increased physical exposure due to unfavorable psychosocial factors, and to what extent these relationships were mediated by stress symptoms. For this study data from SMASH were used as well. A selection was made of subjects who did not report having had regular or prolonged pain in the previous year in neck, shoulders, elbows, wrists or hands, at baseline (n=1029).

Data on psychosocial work characteristics were assessed at baseline with a Dutch version of Karasek's Job-Content-Questionnaire. Various items were combined to form dimensions of job demands, skill discretion, decision authority and social support. As in the previous chapter, subjects were identified as cases if they reported regular or prolonged pain in neck, shoulders, elbows, wrists or hands in the previous 12 months, and neck/shoulder symptoms were distinguished from elbow/wrist/hand symptoms. Outcome measure was the 3-year cumulative incidence.

The main effects of the various psychosocial factors were analyzed using the Cox regression procedure, with a constant risk-period for all subjects. Age, gender, work-related physical risk factors and personal factors were included in the model to adjust for their potential confounding effect. To examine to what extent the relationship between psychosocial work characteristics and the outcome measure was influenced by work-related physical risk factors and stress symptoms, multivariate analyses were performed with either additional adjustment for work-related physical risk factors or for stress symptoms.

High job demands was identified as a risk factor for both neck/shoulder symptoms and elbow/wrist/hand symptoms. Low social support of co-workers was identified as a risk factor for elbow/wrist/hand symptoms, but not for neck/shoulder symptoms. The adjustment for physical risk factors hardly affected the risk estimates for neck/shoulder symptoms, but resulted in a decrease in most risk estimates for elbow/wrist/hand symptoms. However, these risk estimates were still rather high. The adjustment for stress symptoms resulted in a decrease of the risk estimates of high job demands, but nevertheless, the risk estimates were still considerable. This implies that the relationship between high job demands and low social support and neck and upper limb symptoms was partly, but not exclusively, explained by an increased exposure to physical risk factors and increased stress symptoms.

In chapter 4, the influence of work-related psychosocial factors was examined as well. A theoretical stress model was used that combines psychosocial and personal factors, Siegrist's effort-reward imbalance model. The theory of this model is that a combination of high effort and low reward (both psychosocial factors) could lead to adverse health effects. Overcommitment (personality factor) could reinforce the unfavorable effect of effort-reward imbalance (ERI). Furthermore, overcommitment might have an independent effect.

Data were used from the Project on Research and Intervention in Monotonous Work (PRIM), a prospective cohort study in a working population in Denmark, with a follow-up period of 3 years. The study population comprised 3123 workers from 19 different companies. The selection of the companies was aimed at obtaining a variety of repetitive work tasks. Three quarters of the workers had mainly repetitive job tasks, while a quarter had more varied jobs.
Data on effort, reward and overcommitment were assessed at baseline. As the original items of Siegrist's effort-reward questionnaire were not available in this study, proxy measures were constructed. Overcommitment was assessed with the standard questionnaire on this concept. Outcome measure was a symptom score, based on four questions: subjects were asked to rate on a scale ranging from 0 (no symptoms at all) to 9 (pain as bad as could be) the level of the worst pain, the level of the average pain, the level of impairment due to pain, and the severity of pain in the last seven days. These scores were added for each body part separately, resulting in a symptom score with a possible range of 0-36. Again, a distinction was made between neck/shoulder symptoms and elbow/wrist/hand symptoms.
Random coefficient analysis was used to examine the relation between ERI and overcommitment at baseline and neck/shoulder symptoms and elbow/wrist/hand symptoms at all measurements. Interaction terms of overcommitment and ERI with time were used to examine if the symptoms of subjects with unfavorable scores on overcommitment and ERI increased more during follow-up than symptoms of subjects with more favorable scores. The interaction between effort and reward and the interaction between ERI and overcommitment were tested as well. Men and women were analyzed separately.
The analyses showed that overcommitted subjects and subjects with low reward and high effort reported more symptoms. Symptoms of women with high overcommitment and elbow/wrist/hand symptoms of men with high effort increased more during follow-up than symptoms in the reference group. No interaction effects were found for either effort and reward, or for ERI and overcommitment. In conclusion, overcommitment, high effort, and to a lesser extent low reward may have an unfavorable effect on neck and upper limb symptoms.

In chapter 5 the mediating role of workstyle was examined in the relation of work-related exposure (job demands and VDU-work) and overcommitment with neck and upper limb symptoms. The concept of workstyle has been developed by Feuerstein and it has been conceptualized as a learned and reinforced strategy for coping with job demands that may affect musculoskeletal health. A high-risk workstyle implies, for instance, taking shorter or fewer breaks or even skip breaks, working through pain,

anticipating the possible negative reactions of colleagues, and making high demands on one's own performances at work.
For this analysis data were used of 3,855 subjects, who participated in a survey at a large European company. Employees in this company performed relatively much VDU-work. Workstyle was measured with parts of the questionnaire developed by Feuerstein. Five scales were constructed assessing Breaks, Social Reactivity, Self-Imposed Workload, Working Through Pain and a Total Workstyle Score. Overcommitment was assessed with the standard questionnaire, as in chapter 4. Job demands was assessed with the NOVA WEBA, a Dutch questionnaire resembling Karasek's Job-Content-Questionnaire. The duration of VDU-work was also assessed by questionnaire. Subjects were defined as cases if they reported regular or prolonged pain in neck, shoulders, elbows, wrists or hands in the previous 12 months, that was at least partly work-related.
To examine if workstyle functions as a mediator, first linear regression analyses were performed to test the associations between the independent variables (job demands, VDU-work, overcommitment) and the mediator variables (workstyle scales). Subsequently, logistic regression analyses were performed to test the associations between the mediator variables and the outcome (neck and upper limb symptoms) and between the independent variables and the outcome. With the statistics obtained from these tests, beta coefficients and standard errors, the Sobel test was performed to test the statistical significance of the indirect effect of the mediators. Finally, to obtain a measure of the extent of mediation, the percentage of the total effect that is mediated by the workstyle scales was computed by dividing the indirect effect by the total effect.
Results showed that a high-risk workstyle was associated with unfavorable work-related exposure, overcommitment and neck and upper limb symptoms. The association of work-related exposure and overcommitment with neck and upper limb symptoms decreased after adjustment for workstyle scales, in particular for the scales Working Through Pain and Social Reactivity. The effect of work-related exposure and the effect of overcommitment were statistically significantly mediated by workstyle. However, a large part of the indirect effect of workstyle can be accounted for by the scale Working Through Pain. This scale could be biased, since the presence of pain will probably influence the response on questions about pain behavior. Therefore, conclusions should be drawn with care.

In chapter 6 it was examined if physical activity in leisure time could have a preventive effect on neck and upper limb symptoms and on sickness absence due to these symptoms. For this study, data from SMASH were used from 1742 subjects. Data on physical activity were self-reported. At each yearly measurement, subjects were asked which physically demanding sports they

had practiced in the last 12 months, and they were also asked about the intensity of their sporting activities. With these data two variables were constructed representing the number of months per year and the mean number of hours per week they spent on sporting activities. Subjects were also asked about their commuting habits. As in chapter 2 and 3, subjects were identified as cases if they reported regular or prolonged pain in neck, shoulders, elbows, wrists or hands in the previous 12 months, and neck/shoulder symptoms were distinguished from elbow/wrist/hand symptoms. Besides symptoms, sickness absence due to these symptoms was studied. Data on sickness absence were provided by 21 of the 34 participating companies. Two dichotomous variables were constructed, indicating 1) if a subject had been on sick leave due to neck and upper limb symptoms and 2) if a subject had been on sick leave due to these symptoms for more than 3 weeks at a time.
To examine the effects of physical activity, the generalized estimating equation method (GEE) was applied. A time-lag of one measurement (= 1 year) was built into the model to relate the physical activity at one point in time to the dependent variables (symptoms and sickness absence) in the following year. A stratified analysis was carried out to examine if the influence of physical activity was different for subjects with sedentary jobs and for those with more active jobs.
The results of the analyses showed that practicing sports for at least 10 months a year decreased the risk of neck/shoulder symptoms, sickness absence and long-term sickness absence due to neck or upper limb symptoms. A high mean intensity ($\geq$ 3 hours per week) of sporting activities had less effect than the continuation of these activities throughout the year. An effect of physically active commuting could not be demonstrated, although there was a tendency towards a favorable effect on sickness absence. Stratified analyses for subjects with sedentary and more active work showed that the effect of sporting activities for at least 10 months a year was only statistically significant for the group of subjects with sedentary work.

In chapter 7 the effects were evaluated of a software program stimulating regular breaks and exercises on the recovery from neck and upper limb symptoms among computer workers. In a large organization with several locations throughout the country, a randomized controlled trial was performed. Cluster randomization was used for office locations. Altogether 268 computer workers with neck and upper limb symptoms from 22 office locations were randomized into a control group, one intervention group stimulated to take extra breaks and one intervention group stimulated to perform exercises during the extra breaks during an 8-week period. Questionnaires were administered before and after the intervention, and questionnaires were generated by the software during the intervention period. Computer usage was recorded online.

A comparison between the reported pre- and postintervention scores on the severity and frequency of the symptoms showed no significant differences in changes among the three groups. No effects on self-reported sick leave were observed. However, subjects in the intervention group were mostly satisfied with the program and reported more often recovery from their symptoms. Moreover, productivity, expressed as the number of key strokes, was statistically significantly higher in the intervention group. However, since no data on keystroke usage were available for the period before the intervention, it is not clear whether the increased productivity is related to the intervention.

Chapter 8 contains the general discussion. The main findings were summarized in the context of the conceptual model and the main research questions, as given in the introduction. Furthermore, some methodological considerations were discussed. Attention was paid to the study population, the healthy worker effect, the assessment of exposure and symptoms, incidence versus prevalence as an outcome measure and the implications of a time-lag model. Subsequently, the final conclusions of this thesis were presented:

Several risk factors of neck and upper limb symptoms were identified. These risk factors were of diverse origin, by which the assumed multifactorial aetiology of these symptoms is confirmed. There is only limited support for the effect of work-related physical exposure on neck and upper limb symptoms in office workers. Although indications for other associations were found, only neck rotation was consistently identified as a statistically significant risk factor. Previous studies produced mostly inconsistent results.

The present study confirmed findings from previous studies that identified psychosocial work characteristics as risk factors for neck and upper limb symptoms. Moreover, independent effects of high job demands and social support of co-workers were found, that were not, or only partly, explained by an increase in work-related physical exposure or stress symptoms.

Apart from these work-related risk factors, associations between personal and behavioral aspects and neck and upper limb symptoms were found. The effects of these aspects have hardly been studied before. In the present study it was found that the personality trait overcommitment may have an unfavorable effect on neck and upper limb symptoms. The influence of overcommitment and work-related exposure on neck and upper limb symptoms was probably mediated by a behavioral concept, defined as a high-risk workstyle. Another behavioral aspect is physical activity in leisure time. It was found that sustained sporting activities decreased the risk of neck/shoulder symptoms and (long-term) sickness absence due to neck or upper limb symptoms.

Part of a high-risk workstyle is to skip or delay breaks. One possible intervention to influence workstyle is to implement a software program, designed to stimulate regular breaks and exercises. However, a randomized controlled trial showed that there were no unequivocal effects of such a program on neck and upper limb symptoms. Nevertheless participants were satisfied and self-reported recovery was higher among participants using the program than among those of the control group.

Finally, implications for prevention and recommendations for future research were given, based on the final conclusions. Implications for prevention of neck and upper limb symptoms included the recommendation of an integral approach, containing workplace design, attention to the psychosocial work environment and lifestyle issues. Recommendations for future research included studies with newly employed workers to prevent a healthy worker effect, studies examining the time-interval between work-related exposure and the occurrence of neck and upper limb symptoms and longitudinal studies examining the workstyle concept. Also intervention studies are needed to examine the effects of possible interventions focusing on workstyle. Further, more research is needed to examine long-term effects of software programs stimulating breaks and exercises and the effect on productivity.

Samenvatting

Samenvatting

Dit proefschrift gaat over het ontstaan van klachten aan nek, schouders, ellebogen, armen, polsen of handen. In Nederland wordt dit type klachten meestal RSI genoemd, Repetitive Strain Injuries. Deze term klopt niet helemaal, omdat er niet altijd sprake is van letsel (injury). Omdat de term echter nog steeds veelvuldig gebruikt wordt, zal ik hem in deze samenvatting toch hanteren.
RSI-klachten zijn een veel voorkomend gezondheidsprobleem, vooral in de beroepsbevolking. Gegevens van de European Foundation for the Improvement of Living and Working Conditions, gebaseerd op onderzoek bij vijftien Europese landen, laten zien dat 25% van de werkende mensen werkgerelateerde nek/schouderpijn rapporteren en 15% werkgerelateerde armpijn.
RSI-klachten kunnen ziekteverzuim veroorzaken en zelfs langdurige arbeidsongeschiktheid. Gegevens van het UWV (uitvoering werknemersverzekeringen) laten zien dat de WAO-intrede door RSI van 1998 tot 2001 elk jaar is gestegen. In 2001 werden ruim 6000 nieuwe gevallen geregistreerd. Dat betekende 0,1% van de beroepsbevolking en 6% van de totale WAO-intrede in dat jaar. Na 2001 is het aantal nieuwe gevallen weer gedaald. Dit kan echter grotendeels worden toegeschreven aan een algehele daling van de WAO-intrede, ten gevolge van een politieke beleidsverandering in het toekennen van uitkeringen. Uit recent onderzoek blijkt dat het voorkomen van RSI-*klachten* niet gedaald is.
Aangenomen wordt dat er verschillende factoren zijn die bijdragen aan het ontstaan van RSI-klachten. Deze factoren opereren niet geïsoleerd, maar beïnvloeden elkaar. Aanvankelijk was het meeste onderzoek naar risicofactoren gericht op werkgerelateerde fysieke belasting. Inmiddels is er voldoende bewijs dat werkgerelateerde fysieke belasting een risicofactor is voor werknemers in de industrie. Bevindingen met betrekking tot kantoorpersoneel zijn echter niet consistent.
Naast fysieke factoren lijken werkgerelateerde psychosociale factoren van belang te zijn. Via welke mechanismen deze factoren tot klachten kunnen leiden en hoe ze in wisselwerking staan met fysieke belasting blijft nog onduidelijk. Ook wordt wel gesuggereerd dat gedragsmatige aspecten, zoals werkstijl en bewegen in de vrije tijd, van belang zijn voor het ontstaan van RSI-klachten. Onderzoek naar dit type factoren in relatie tot RSI is echter schaars. Er zijn ook aanwijzingen dat persoonlijkheidsfactoren van invloed kunnen zijn op het ontstaan van RSI-klachten, maar door een gebrek aan studies op dit terrein is hiervoor onvoldoende bewijs. In dit proefschrift worden verschillende

risicofactoren voor het ontstaan van RSI-klachten onderzocht, waarbij ook aandacht wordt besteed aan hun wederzijdse beïnvloeding.

In hoofdstuk 2 wordt verslag gedaan van onderzoek naar de invloed van werkgerelateerde fysieke belasting bij kantoorpersoneel. Gegevens zijn gebruikt van de Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH). SMASH is een prospectieve cohort studie in een werkende populatie met een follow-up periode van 3 jaar. De 34 deelnemende bedrijven zijn gevraagd werknemers te selecteren die minstens een jaar werkzaam waren in hun huidige werk en die minstens 24 uur per week werkten. De populatie bestond uit werknemers uit de industrie, kantoorpersoneel en verzorgend personeel. Voor de analyses in dit hoofdstuk is alleen het kantoorpersoneel geselecteerd (n=398).
Gegevens over fysieke belasting zijn zowel verkregen door vragenlijsten als door video-observaties. De vragen waren afkomstig uit de Vragenlijst BewegingsApparaat (VBA) en zijn tijdens elke jaarlijkse meting gesteld. Voor de video-observaties zijn werknemers in groepen ingedeeld met een geschatte gelijke fysieke belasting, waarna de opnames van een kwart van de individuen in een groep zijn geobserveerd volgens een standaard protocol. Binnen een groep kreeg iedereen het groepsgemiddelde toegekend. RSI-klachten zijn jaarlijks gemeten met behulp van een aangepaste versie van de veel gebruikte 'Nordic Questionnaire'. Personen zijn als RSI-gevallen gedefinieerd wanneer zij aangaven regelmatig of langdurig pijn te hebben gehad in nek, schouders, ellebogen, polsen of handen. Vervolgens is onderscheid gemaakt in nek/schouderklachten en arm/pols/handklachten.
De effecten van werkgerelateerde fysieke belasting zijn onderzocht met behulp van de generalized estimating equation (GEE) methode. In het model is een time-lag van 1 meting (= 1 jaar) gebouwd om de onafhankelijke variabelen (fysieke belasting) te relateren aan de afhankelijke variabele (RSI-klachten) tijdens de volgende meting, 1 jaar later.
De resultaten laten zien dat slechts een beperkt aantal werkgerelateerde fysieke factoren verband hield met RSI-klachten bij kantoorpersoneel. Werken met een gedraaide nek ($\geq$ 45°) had een ongunstig effect op nek/schouderklachten. Werken met een achterovergebogen nek was ook statistisch significant geassocieerd met nek/schouderklachten, maar hierover waren alleen zelfgerapporteerde gegevens beschikbaar. Er is een aanwijzing gevonden dat lange werkdagen een ongunstig effect zouden kunnen hebben. Van geen van de onderzochte fysieke factoren kon een negatief effect op elleboog/pols/handklachten aangetoond worden, hoewel er aanwijzingen waren voor een ongunstig effect van het werken met een gedraaide pols en van fulltime werk of langer op elleboog/pols/handklachten.

In hoofdstuk 3 wordt verslag gedaan van onderzoek naar de relatie tussen werkgerelateerde psychosociale factoren en RSI-klachten. Modules van Karasek's 'Demands-Control-Support model' zijn gebruikt als onafhankelijke variabelen. De theorie van het model is dat de combinatie van hoge taakeisen en weinig regelmogelijkheden tot ongunstige gezondheidseffecten kan leiden. Daarnaast wordt ervan uitgegaan dat de afzonderlijke modules van het model ook onafhankelijk van elkaar tot effecten kunnen leiden. In dit onderzoek ligt de nadruk niet op de combinatie van modules, maar op de effecten van de afzonderlijke psychosociale factoren.

Behalve de hoofdeffecten van deze psychosociale factoren, is onderzocht in hoeverre gevonden verbanden verklaard kunnen worden door een verhoogde fysieke belasting ten gevolge van ongunstige psychosociale factoren, en in hoeverre stressklachten een intermediaire rol spelen in deze relatie. Voor dit onderzoek zijn eveneens gegevens gebruikt uit SMASH. Voor de analyses is een selectie gemaakt van personen zonder RSI-klachten in de 12 maanden voorafgaand aan de basismeting (n=1029).

Gegevens over psychosociale werkkenmerken zijn verzameld met een Nederlandse versie van de 'Job-Content-Questionnaire' van Karasek. Verschillende items zijn gecombineerd tot de modules taakeisen, vakmanschap, regelmogelijkheden en sociale steun. Evenals in het vorige hoofdstuk zijn personen die aangaven regelmatig of langdurig pijn te hebben gehad in nek, schouders, ellebogen, polsen of handen gedefinieerd als RSI-gevallen, en ook is weer onderscheid gemaakt in nek/schouderklachten en arm/pols/handklachten. De uitkomstmaat was de 3-jarige cumulatieve incidentie van RSI-klachten.

De hoofdeffecten van de verschillende psychosociale factoren zijn geanalyseerd met de Cox regressie-procedure, met een constante tijdsvariabele voor alle personen. Leeftijd, geslacht, werkgerelateerde fysieke belasting en persoonlijkheidsfactoren zijn toegevoegd aan het model om te corrigeren voor hun mogelijk verstorende effect. Om te onderzoeken in hoeverre de relatie tussen psychosociale factoren en de uitkomstmaat beïnvloed wordt door werkgerelateerde fysieke belasting en stressklachten, zijn multivariate analyses uitgevoerd met additionele correctie óf voor fysieke factoren óf voor stressklachten.

Hoge taakeisen bleek een risicofactor te zijn voor zowel nek/schouderklachten als voor elleboog/pols/handklachten. Een lage sociale steun van collega's bleek een risicofactor te zijn voor elleboog/pols/handklachten, maar niet voor nek/schouderklachten. De correctie voor fysieke risicofactoren had nauwelijks invloed op de effectmaten voor nek/schouderklachten, maar had wel een daling tot gevolg van de meeste effectmaten voor elleboog/pols/handklachten. De effectmaten van taakeisen en sociale steun van collega's bleven echter tamelijk hoog. Dit houdt in dat de relatie tussen psychosociale factoren, met name taakeisen en sociale steun van collega's, en RSI-klachten gedeeltelijk, maar niet volledig, verklaard kan worden door een verhoogde blootstelling aan fysieke factoren en verhoogde stressklachten, met name bij de elleboog/pols/ handklachten.

In hoofdstuk 4 wordt eveneens verslag gedaan van onderzoek naar de invloed van werkgerelateerde psychosociale factoren. In dit onderzoek is een ander theoretisch stress-model gebruikt, dat psychosociale en persoonlijkheidsfactoren combineert, namelijk Siegrist's Effort-Reward-Imbalance Model (ERI). De theorie van dit model is dat een combinatie van een hoge inspanning op het werk (effort) en een lage materiële en immateriële beloning (reward) tot ongunstige gezondheidseffecten kan leiden. De persoonlijkheidsfactor overcommitment, oftewel een overmatige betrokkenheid, kan het ongunstige effect van ERI versterken. Bovendien heeft overmatige betrokkenheid mogelijk een onafhankelijk effect.
Voor dit onderzoek zijn gegevens gebruikt van het 'Project on Research and Intervention in Monotonous Work (PRIM)', een prospectieve cohort studie in Denemarken, met een follow-up periode van 3 jaar. De onderzoekspopulatie bestond uit 3123 werknemers van 19 verschillende bedrijven. De selectie van bedrijven had als doel om een gevarieerd scala aan repeterende arbeid te verkrijgen. Het werk van driekwart van de werknemers bestond hoofdzakelijk uit repeterende taken, terwijl een kwart meer gevarieerd werk had.
Gegevens over inspanning, beloning en betrokkenheid zijn verzameld tijdens de basismeting. Omdat de originele items van de effort-reward vragenlijst van Siegrist niet beschikbaar waren in deze studie, zijn vervangende maten gebruikt. Voor het verkrijgen van gegevens met betrekking tot betrokkenheid was de standaardvragenlijst wel beschikbaar. Uitkomstmaat was een klachtenscore die op vier vragen was gebaseerd. Men is gevraagd om per lichaamsdeel met betrekking tot de afgelopen drie maanden te scoren op een schaal van 0 (geen klachten) tot 9 (ergst mogelijke pijn): het niveau van de ergste pijn, het niveau van de gemiddelde pijn, het niveau van beperkingen ten gevolge van pijn en tenslotte de ernst van de pijn in de laatste zeven dagen. Deze scores zijn voor elk lichaamsdeel opgeteld, waarbij een score van 0 tot 36 werd verkregen. Vervolgens is wederom onderscheid gemaakt tussen nek/schouderklachten en elleboog/pols/handklachten door de scores, behorende bij deze regio, bij elkaar op te tellen.
Random coëfficiënt analyse is gebruikt om de relatie te onderzoeken tussen ERI en overmatige betrokkenheid tijdens de basismeting en nek/schouderklachten en elleboog/pols/handklachten op alle metingen. Interactietermen van overmatige betrokkenheid en ERI met een tijdsvariabele zijn gebruikt om te onderzoeken of de klachten van personen met ongunstige scores op overcommitment en ERI sneller zouden stijgen dan de klachten van personen met gunstigere scores. De interactie tussen inspanning en beloning en tussen ERI en overmatige betrokkenheid zijn eveneens getest. Alle analyses zijn steeds apart uitgevoerd voor mannen en vrouwen.

De resultaten laten zien dat overmatig betrokken personen en personen met een lage beloning en een hoge inspanning meer RSI-klachten rapporteren. RSI-klachten van overmatig betrokken vrouwen en elleboog/pols/hand-klachten van mannen met hoge inspanning en lage beloning stegen meer tijdens de follow-up periode dan de klachten in de referentiegroep. Noch voor inspanning en beloning, noch voor ERI en overmatige betrokkenheid zijn interactie-effecten gevonden. Geconcludeerd kan worden dat overmatige betrokkenheid, een hoge inspanning en in iets mindere mate een lage beloning, een ongunstig effect zou kunnen hebben op RSI-klachten.

In hoofdstuk 5 wordt verslag gedaan van het onderzoek naar de rol van werkstijl als mediator voor de effecten van werkgerelateerde blootstelling (taakeisen en beeldschermwerk) en overmatige betrokkenheid op RSI-klachten. Het concept 'werkstijl' is ontwikkeld door Feuerstein en heeft betrekking op gedrag en attitude van de werknemer. Het duidt niet zozeer op een aangeboren persoonlijkheidskenmerk, maar eerder op een aangeleerde strategie om te kunnen voldoen aan en kunnen omgaan met de eisen die het werk stelt. Een werkstijl die ongunstig is voor RSI-klachten houdt in: weinig pauze nemen, niet luisteren naar pijnsignalen van het eigen lichaam, het anticiperen op eventuele negatieve reacties van collega's en het stellen van hoge eisen aan zichzelf op het gebied van het werk.
Voor deze analyse zijn de gegevens gebruikt van 3.855 werknemers die deelgenomen hebben aan een vragenlijstonderzoek binnen een Europees bedrijf in de zakelijke dienstverlening. In het bedrijf werd vrij veel computerwerk uitgevoerd. Werkstijl is gemeten met delen van een standaardvragenlijst die voor dit doel door Feuerstein en collega's is ontworpen. Met behulp van de items in deze vragenlijst zijn vijf modules samengesteld: 'breaks', 'working through pain', 'social reactivity', 'self-imposed workload' en een totale werkstijlscore. Betrokkenheid is gemeten met de standaardvragenlijst, zoals ook in hoofdstuk 4 gebruikt is. Taakeisen is gemeten met de NOVA WEBA, een Nederlandse vragenlijst die lijkt op de Job-Content-Questionnaire van Karasek. De duur van beeldschermwerk is eveneens met een vragenlijst gemeten. Personen zijn gedefinieerd als geval van RSI-klachten wanneer zij aangaven regelmatig of langdurig pijn in nek, schouders, ellebogen, polsen of handen te hebben gehad in de laatste 12 maanden, die in ieder geval gedeeltelijk werkgerelateerd was.
Om te onderzoeken of werkstijl als een mediator functioneert is allereerst lineaire regressie uitgevoerd om de associatie te testen tussen de onafhankelijke variabelen (taakeisen, beeldschermwerk en overmatige betrokkenheid) en de intermediaire variabelen (werkstijlmodules). Vervolgens zijn logistische regressie-analyses uitgevoerd om de associatie te testen tussen de intermediaire variabelen en de uitkomstmaat (RSI-klachten), en tussen de onafhankelijke variabelen en de uitkomstmaat. Met behulp van de beta-coëfficienten en standaardfouten uit deze testen is de Sobel-test uitgevoerd om de statis-

tische significantie van het indirecte effect van de mediators te bepalen. Om een maat te verkrijgen voor de mate van mediatie, is het percentage berekend van het totale effect dat is bepaald door de intermediaire rol van de werkstijlschalen. Hiervoor is het indirect effect gedeeld op het totale effect.
De analyses laten zien dat een risicovolle werkstijl geassocieerd is met ongunstige werkgerelateerde blootstelling, overmatige betrokkenheid en RSI-klachten. De associaties van werkgerelateerde blootstelling en overcommitment met RSI-klachten namen af na correctie voor de werkstijlmodules, vooral voor de modules working through pain en social reactivity. Werkstijl speelt een statistisch significante intermediaire rol in de effecten van werkgerelateerde blootstelling en overmatige betrokkenheid op RSI-klachten. Echter, een groot deel van het indirecte effect van werkstijl komt voor rekening van de schaal working through pain. Dit kan een vertekend beeld opgeleverd hebben, aangezien de aanwezigheid van pijn waarschijnlijk de antwoorden op de vragen zal beïnvloeden. Daarom kunnen conclusies alleen met voorzichtigheid getrokken worden.

In hoofdstuk 6 wordt verslag gedaan van een onderzoek naar het effect van bewegen in de vrije tijd op RSI-klachten en op ziekteverzuim vanwege deze klachten. Voor dit onderzoek zijn de gegevens gebruikt uit SMASH, van 1742 personen. Gegevens over bewegen waren zelfgerapporteerd. Tijdens elke jaarlijkse meting is aan de deelnemers gevraagd welke lichamelijk inspannende sporten zij hadden uitgevoerd in de laatste 12 maanden, gedurende hoeveel maanden per jaar en uren per week. Met deze gegevens zijn twee variabelen samengesteld die respectievelijk het aantal maanden per jaar en het gemiddeld aantal keren per week weergaven dat men sportte. Tevens is gevraagd naar het woon-werkverkeer. Evenals in hoofdstuk 2 en 3, zijn personen die aangaven regelmatig of langdurig pijn te hebben gehad in nek, schouders, ellebogen, polsen of handen gedefinieerd als RSI-gevallen, en is weer onderscheid gemaakt in nek/schouderklachten en arm/pols/handklachten. Behalve klachten is ook ziekteverzuim als het gevolg van deze klachten onderzocht. Gegevens over het ziekteverzuim zijn aangeleverd door 21 van de 34 deelnemende bedrijven. Twee dichotome variabelen zijn samengesteld die aangaven of 1) iemand het afgelopen jaar verzuimd heeft als gevolg van RSI-klachten, 2) iemand het afgelopen jaar meer dan 3 weken verzuimd heeft als gevolg van RSI-klachten.
Om het effect van bewegen op RSI-klachten te onderzoeken is gebruik gemaakt van de generalized estimating equation (GEE) method. In het model is een time-lag van 1 meting (= 1 jaar) gebouwd om de onafhankelijke variabele (bewegen) te relateren aan de afhankelijke variabelen (RSI-klachten en ziekteverzuim) tijdens de volgende meting, 1 jaar later. Tevens is een gestratificeerde analyse uitgevoerd om te onderzoeken of de invloed van bewegen in

de vrije tijd anders was voor werknemers met zittend werk dan voor werknemers met actiever werk.
De analyses laten zien dat sportbeoefening van tenminste 10 maanden per jaar de kans vermindert op nek/schouderklachten en ziekteverzuim door RSI. Een hoge intensiteit van sportbeoefening (≥ 3 uur per week) heeft minder effect dan tenminste 10 maanden doorgaan met sporten. Er kon geen effect worden aangetoond van actief woon-werkverkeer, hoewel er aanwijzingen zijn voor een mogelijk gunstig effect op ziekteverzuim. De gestratificeerde analyse liet zien dat het effect van bewegen alleen statistisch significant is voor werknemers met zittend werk.

Hoofdstuk 7 beschrijft de resultaten van een onderzoek naar de effecten van een pauzesoftware-programma op het herstel van RSI-klachten bij computerwerkers. In een grote organisatie met diverse vestigingen door het hele land is een randomized controlled trial uitgevoerd. Voor de diverse vestigingen is clusterrandomizatie gebruikt. In totaal zijn 268 computer werkers met RSI-klachten, afkomstig uit 22 vestigingen, ingedeeld in een controlegroep, een interventiegroep die gestimuleerd werd om extra pauzes te nemen en een interventiegroep die bovendien gestimuleerd werd om in die pauzes oefeningen te doen. De interventieperiode duurde 8 weken. Schriftelijke vragenlijsten zijn voor en na de interventie afgenomen, en tijdens de interventie zijn elektronische vragenlijsten gegenereerd door het softwareprogramma. Computergebruik werd online geregistreerd.
De verandering van de scores op ernst en frequentie van de pijn tussen voor- en nameting was niet significant verschillend voor de controlegroep en de interventiegroepen. Ook zijn er geen effecten op zelfgerapporteerd ziekteverzuim gevonden. Wel zijn de deelnemers uit de interventiegroepen vaker van mening dat hun klachten verbeterd zijn en zijn zij meer tevreden over het programma. Bovendien was de productiviteit bij de nameting, uitgedrukt in aantal toetsaanslagen, hoger in de interventiegroep. Aangezien er geen gegevens zijn over productiviteit van voor de interventieperiode is het niet duidelijk of dit verband houdt met de interventie.

Hoofdstuk 8 bevat de algemene discussie. De belangrijkste bevindingen worden samengevat in the context van het model en de belangrijkste onderzoeksvragen, zoals weergegeven in de inleiding. Verder worden enkele methodologische overwegingen besproken. Aandacht wordt besteed aan de onderzoekspopulaties, het healthy worker effect, de dataverzameling met betrekking tot de onafhankelijke en afhankelijke variabelen, incidentie versus prevalentie als uitkomstmaat en het time-lag model. Vervolgens wordt de slotconclusie van dit proefschrift gegeven:

Verscheidene risicofactoren voor RSI-klachten zijn gevonden, van verschillende aard, waarmee de multifactoriële aard van de klachten bevestigd wordt. Er is slechts beperkte steun gevonden voor het effect van werkgerelateerde fysieke factoren op RSI-klachten bij kantoorpersoneel. Hoewel er aanwijzingen zijn gevonden voor andere associaties, bleek alleen werken met een gedraaide nek consequent als statistisch significante risicofactor naar voren te komen. Eerdere studies met betrekking tot werkgerelateerde risicofactoren in kantoorpopulaties leverden vooral inconsistente resultaten.
De studies in dit proefschrift bevestigen de bevindingen van andere studies, die hebben gevonden dat psychosociale werkkenmerken risicofactoren zijn voor RSI-klachten. Bovendien blijkt dat de relatie tussen psychosociale factoren, met name taakeisen en sociale steun van collega's, en RSI-klachten gedeeltelijk verklaard kan worden door een verhoogde blootstelling aan fysieke factoren en verhoogde stressklachten, maar dat er daarnaast ook onafhankelijke effecten zijn.
Naast werkgerelateerde risicofactoren zijn er associaties gevonden tussen RSI-klachten en persoonlijkheids- en gedragsaspecten. Naar deze mogelijke verbanden was nog nauwelijks onderzoek gedaan. In deze studie is gevonden dat het persoonlijkheidskenmerk overcommitment, oftewel overmatige betrokkenheid, een ongunstig effect kan hebben op RSI-klachten. Ook is gevonden dat een gedragsaspect, namelijk de individuele werkstijl van de werknemer, een intermediaire rol speelt in de invloed van overmatige betrokkenheid en van werkgerelateerde blootstelling op RSI-klachten. Een ander gedragsaspect is bewegen in de vrije tijd. In deze studie is gevonden dat sportbeoefening het risico vermindert op nek/schouderklachten en op ziekteverzuim ten gevolge van RSI-klachten. Daarbij is continuïteit belangrijker dan frequentie.
Onderdeel van een risicovolle werkstijl is het uitstellen of overslaan van pauzes. Een mogelijke interventie om de werkstijl te bevorderen is het invoeren van een pauzesoftware programma. In deze studie zijn echter geen eenduidige effecten van zo'n programma gevonden. Desalniettemin waren deelnemers tevreden en was het ervaren herstel hoger bij de deelnemers die het programma gebruikten.

Tenslotte worden naar aanleiding van de slotconclusies implicaties gegeven voor preventie van RSI-klachten en worden aanbevelingen gedaan voor toekomstig onderzoek. Voor de preventie van RSI-klachten wordt een integrale aanpak aanbevolen. Naast ergonomische aspecten moet aandacht worden besteed aan de psychosociale werkomgeving, aan werkstijl en aan leefstijl, met name aan fysieke activiteit. Aanbevelingen voor toekomstig onderzoek bevatten studies met werknemers die net in dienst zijn, waarmee het healthy worker effect kan worden voorkomen, studies naar het tijdsinterval tussen werkgerelateerde blootstelling en het optreden van RSI-klachten en longitudinale studies die het concept werkstijl verder onderzoeken. Ook zijn interventiestudies nodig om de effecten van mogelijke interventies op werkstijl te onderzoeken. Tenslotte is er meer onderzoek nodig om de lange termijn-effecten van pauzesoftware te onderzoeken en het effect van deze programma's op de productiviteit.

Dankwoord

Dankwoord

Het was een lange, en zeker geen rechte weg. Niet zozeer vanaf het eerste idee van een proefschrift tot het eindpunt, maar vooral van de 'Drs' tot de 'Dr'. Bier tappen, vrijwilligerswerk, lanterfanten, typen, typen en nog eens typen, sommetjes maken, interviewen, analyseren, onderzoek, nog wat meer onderzoek, echt onderzoek, publicaties, en zo begon het erop te lijken. Uiteindelijk ligt er een heus proefschrift.

Op die route zijn er een aantal mensen heel belangrijk geweest. Als eerste, chronologisch gezien, is dat Ineke van de Zande. Vele jaren geleden was ik als student-assistent verbonden aan het JOL-project (Jongerenwerkers Onderzoek Leiden), waar jij projectleider van was. Behalve afwassen, kinderoppas e.d. mijn eerste echte werkervaring en dus ook mijn eerste kennismaking met onderzoek doen. Je was altijd heel inspirerend en hebt me enthousiast gemaakt voor het onderzoeksvak. Ik kan me nog heel goed de discussies over methodologie herinneren. We waren toen met kwantitatieve data-analyse bezig, dus methodologisch gezien op een heel andere manier dan nu, maar het heeft me wel op een spoor gezet.
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Klachten aan nek, schouders, ellebogen, armen, polsen of handen zijn een veel voorkomend gezondheidsprobleem, vooral onder werknemers. In Nederland wordt dit type klachten meestal RSI genoemd. RSI-klachten kunnen ziekteverzuim veroorzaken en zelfs langdurige arbeidsongeschiktheid. Aangenomen wordt dat er verschillende factoren zijn die bijdragen aan het ontstaan van RSI-klachten. Deze factoren opereren niet geïsoleerd, maar beïnvloeden elkaar.

In dit proefschrift worden verschillende risicofactoren voor het ontstaan van deze klachten onderzocht. Daarvoor is gebruik gemaakt van de gegevens van twee prospectieve cohortstudies, één bedrijfssurvey en een interventiestudie.

De resultaten van dit onderzoek bevestigden de multifactoriële aard van de klachten. Er kon slechts beperkte steun voor het effect van fysieke risicofactoren gevonden worden in een populatie van kantoorwerkers. Het effect van psychosociale werkkenmerken werd bevestigd, met name het effect van hoge taakeisen en beperkte sociale steun van collega's. Ook zijn er associaties gevonden tussen RSI-klachten en persoonlijkheids- en gedragsaspecten, met name het persoonlijkheidskenmerk overcommitment, ofwel overmatige betrokkenheid, de individuele werkstijl van de werknemer, en bewegen in de vrije tijd.