Work-related risk factors for neck pain

Results of a prospective cohort study

The study presented in this thesis was performed at TNO Work and Employment in collaboration with the Institute for Research in Extramural Medicine (EMGO-Institute) and the Department of Social Medicine of the VU medical centre. The EMGO-Institute participates in the Netherlands School of Primary Care Research (CaRe), which was acknowledged in 1995 by the Royal Netherlands Academy of Arts and Sciences (KNAW).

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geboren te Dongen

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Chapter one

Introduction

Musculoskeletal complaints are a major health problem in The Netherlands. Next to back complaints, neck complaints warrant second place, considering the magnitude of the problem. According to Picavet *et al.*, almost three quarters of the general population in The Netherlands, 25 years of age and older, had a musculoskeletal complaint in 1998.[1] Low back complaints were the most prevalent (12-month prevalence 43.9%), followed by neck complaints (12-month prevalence 31.4%) and shoulders complaints (12-month prevalence 30.3%). Another study performed among the general working population in The Netherlands showed 12-month prevalence figures of 44.5%, 28.5% and 27.3% for low back, neck and shoulder complaints, respectively.[2]
The prevalence of neck pain varies among different occupational groups. In The Netherlands, the 12-month prevalence of self-reported work-related neck pain was highest among secretaries and typists (31%), followed by tailors (28%), loaders, unloaders and packers (24%), bricklayers and carpenters (23%), and administrative workers (23%). The lowest 12-month prevalence of neck pain was found in machine metal workers, but the prevalence in this group was still 12%. If the working force in The Netherlands was divided into industrial branches, the highest 12-month prevalence of self-reported work-related neck pain was found for the hotel, restaurant and other catering sectors (23%) and the financial services (23%). The lowest 12-month prevalence of neck pain was found for the wholesale trade and repair industry, but the prevalence in this group was still 17%.[3]
Prevalence figures for other countries are comparable. For a general Norwegian population aged 18-67 years, Bovim *et al.* reported 12-month prevalence figures of neck pain to be 29% and 40% for males and females, respectively.[4] For a general population in Hong Kong aged 30 years or older, 12-month prevalence figures were reported for neck pain, ranging from 10% to 18% for males in different age groups and from 10% to 24% for females in different age groups.[5] In several specific occupational settings, 12-month prevalence figures as high as 76% were reported.[6-9]

Neck symptoms are often combined with symptoms of the upper extremities. A variety of terms have been used to describe these combinations of symptoms: upper extremity musculoskeletal disorders (UEMSDs), repetitive strain injury (RSI), occupational cervicobrachial disorders (OCD), upper limb disorders (ULD) or cumulative trauma disorders (CTD). Research carried out by the Central Bureau for Statistics in The Netherlands showed a 12-month prevalence of neck and upper extremity symptoms of 19%.[10] In another study of the general population in The Netherlands, the 12-month prevalence of work-related neck and upper extremity symptoms was found to be 31%, the prevalence being highest in the hotel, restaurant and catering sectors (40%), followed by the construction industry (38%) and the production industry (33%).[3] Comparable prevalence figures in other (European) countries vary from 17% (Great Britain) to 40% (Belgium).[11]

From the above, it becomes clear that although neck pain may not be the most important musculoskeletal problem, it is still a considerable burden on society. Borghouts *et al.* estimated the total costs of neck pain in The Netherlands in 1996 to be US$ 868 million.[12] The total number of days of sickness absence related to neck pain was estimated to be 1.4 million, with a total cost of US$ 185.4 million.

Definition of neck pain

Pain in the neck may arise from various structures in the neck: the (vertebral) muscles, the synovial joints of the neck, the cervical intervertebral discs and their ligaments, and the cervical dura mater.[13,14] A relevant and simple distinction can be made between specific and non-specific neck pain. Specific neck pain includes diagnosed pathologies, such as spinal tumors, systematic rheumatic disorders, infections and fractures. However, most cases of neck pain can be labelled as non-specific, i.e., no direct cause for the pain can be detected.[15]
In epidemiologic studies, questionnaires are commonly used to obtain information from subjects. If a questionnaire is used, the definition of neck pain is based on the subject's personal experience of pain in the neck region. However, the validity and reliability of such self-reported data is often questioned. Several investigators have compared data on neck pain obtained from questionnaires with data derived from a clinical examination of the neck. Björkstén *et al.* reported a high questionnaire sensitivity (92%), implying that almost all the subjects who were diagnosed with neck pain on the basis of a clinical examination also reported neck pain on the questionnaire.[16] However, they also reported a relatively low questionnaire specificity (62%), since many subjects who were not diagnosed with neck pain on the basis of the clinical examination did report neck pain on the questionnaire. Ohlsson *et al.* also compared data on neck pain obtained from questionnaires with data derived from a clinical examination of the neck.[17] In contrast to the findings of Björkstén *et al.*, they reported a relatively low questionnaire sensitivity (66%) and a relatively high questionnaire specificity (84%). Both studies concluded that data obtained from questionnaires provide a fairly accurate assessment of the neck status, compared to data derived from a clinical examination. In other studies, the results of comparable analyses were less convincing.[18,19] It should be borne in mind, however, that a clinical examination of the neck also relies largely on subjective self-reported information from the patient and, moreover, many of the clinical tests used are considered to be unreliable. The assessment of non-specific neck pain will always be primarily based on symptoms. Therefore, this thesis will focus on data on non-specific self-reported neck pain obtained from a self-administered questionnaire (i.e., an adapted version of the Nordic Questionnaire).[20]

Risk factors for neck pain

Neck pain is assumed to be of multi-factorial origin, implying that a number of risk factors can contribute to its development. These risk factors can be divided into three main groups: physical risk factors, psychosocial risk factors, and individual risk factors. Moreover, these risk factors can be work-related or not. Based on the model designed by Bongers *et al.*, a conceptual model was developed to illustrate how different groups of risk factors are related to each other, and how these groups of risk factors contribute to the development of neck pain (Figure 1.1).[21]

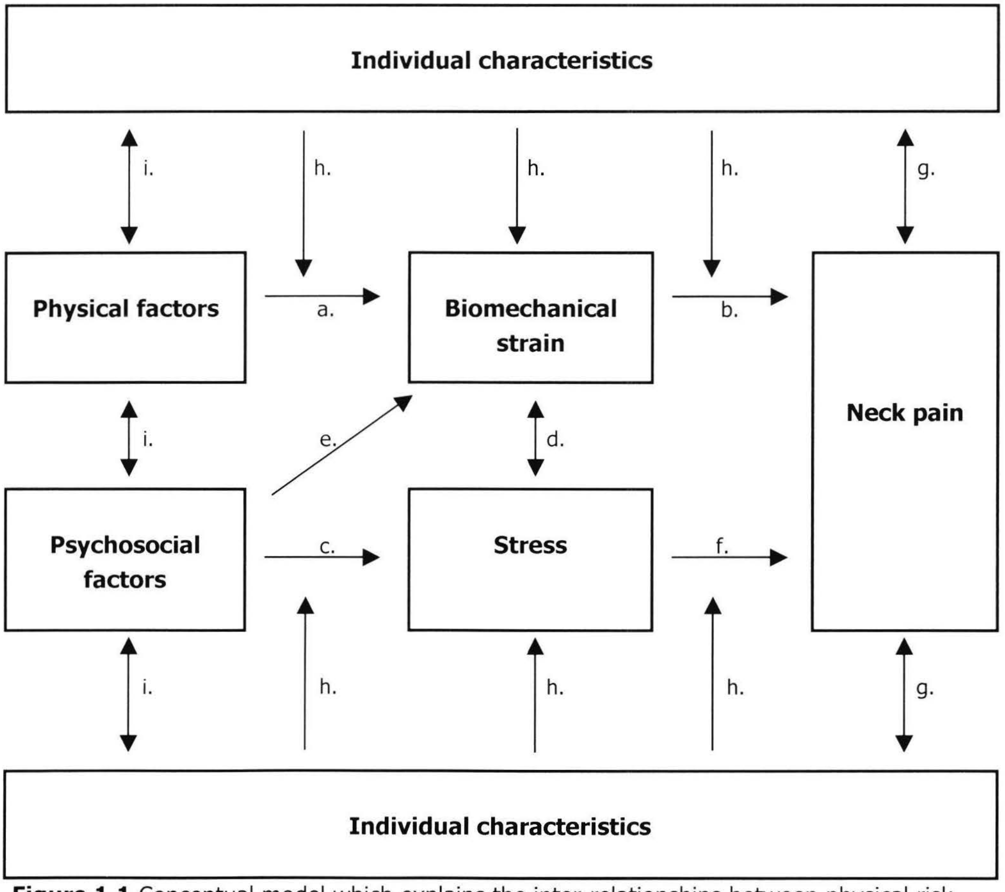

Figure 1.1 Conceptual model which explains the inter-relationships between physical risk factors, psychosocial risk factors and individual characteristics, and the relationship between these risk factors and the development of neck pain

Physical load (at work or during leisure time) will induce a certain biomechanical strain (for example an increased muscle tone) in the neck region (a). This increased biomechanical strain may, in the long-term, lead to the development of neck pain (b).

Psychosocial load may cause stress (c). Stress may increase the biomechanical strain in the neck region (d), which may in the long term lead to the development of neck pain (b). Psychosocial load may also directly increase the biomechanical strain in the neck region (e). Stress due to psychosocial load may also directly lead to the development of neck pain (f), for instance due to physiological reactions (hormones) or due to different appraisal of the symptoms.
Individual characteristics may directly lead to the development of neck pain (g), for instance due to differences in pain sensitivity and coping styles. Moreover, individual characteristics have a considerable influence on the relationships between physical and psychosocial load and the development of neck pain (h). Finally, physical risk factors, psychosocial risk factors and individual characteristics have a substantial influence on each other (i). Self-reported psychosocial factors, for example, are individual perceptions of the actual psychosocial aspects of the work situation (Figure 1.1). Neck pain may, on its turn, influence physical factors, psychosocial factors and individual characteristics.

There are several hypotheses regarding possible mechanisms underlying the relationship between physical and psychosocial load and the development of neck pain. No conclusive evidence regarding these hypotheses exist, however, there are strong indications for these hypotheses.
Neck pain may be caused by prolonged static loading (sustained muscle contractions) with no opportunities for a rest-break. This causes a reduced local blood circulation and muscle fatigue. Due to increased pressure in the muscle, energy products cannot be delivered to the muscle, and waste products can not be removed from the muscle. The accumulation of waste products in the muscle will activate pain sensors, inducing increased muscle tension. If the blood circulation system in the muscle is disturbed for a prolonged period of time, the pain sensors become over-sensitive, leading to pain, even in situations when the stimulus is relatively small. If the recovery time (rest-breaks) after prolonged static loading is too short, this may lead to permanent damage of the muscle tissue.[22]
Exposure to physical or psychosocial load may initiate the Cinderella-effect. Cinderella woke up very early in the morning and went to bed late at night. The same is true for certain type 1 muscle fibres. Low-threshold type 1 muscle fibres will be continuously activated during low and high muscle loading. Consequently, these type 1 muscle fibres will be activated during almost the entire day, without possible recovery. This kind of very low muscle loading for a prolonged period of time (without rest-breaks) may lead to an overload of the muscle fibres and (permanent) damage of the muscle tissue.[22-25]

Several literature reviews have been carried out to identify physical[26-29] and psychosocial[21,27,30] risk factors for neck pain. However, due to differences in the methodology of these reviews, their conclusions are neither very consistent, nor comparable.

Kuorinka and Forcier identified risk factors for tension neck syndrome in their review.[26] Repetitive work and constrained arm and head posture were concluded to be associated with an increased risk for tension neck syndrome. Bernard found evidence for a relationship between neck disorders and repetitive work, repetitive neck movements, forceful arm movements, and static postures that involve the neck or shoulder muscle.[27] Stock, however, found no evidence for any risk factor in relation to tension neck syndrome.[28] In the review performed by Hagberg and Wegman, several exposures based on job titles were compared.[29] They found an increased risk for tension neck syndrome for keyboard operators.
Bongers *et al.* concluded, on the basis of their review on psychosocial risk factors for musculoskeletal disorders, that a relationship between neck or shoulder symptoms and monotonous work, time pressure, poor work content and high workload seemed likely.[21] On the basis of their review, Hales and Bernard stated that high workload, perceived time pressure, work pressure, high workload variability, poor work content, and monotonous work are probably associated with musculoskeletal complaints of the upper extremities (including the neck).[30] Bernard concluded that intensified workload, monotonous work, and low levels of support were associated with neck and upper extremity disorders.[27]

Study on Musculoskeletal disorders, Absenteeism, Stress and Health

In 1994, a large prospective cohort study in an occupational setting was initiated: SMASH (Study on Musculoskeletal disorders, Absenteeism, Stress and Health). The main objective of SMASH was to identify work-related risk factors for musculoskeletal complaints. There were three important reasons for executing this large-scale project:

1. Earlier research on the relationship between work-related risk factors and musculoskeletal complaints was mostly cross-sectional in design. To study the temporal relationship between risk factors and the occurrence of musculoskeletal complaints, a longitudinal study design is required.
2. Most of the studies on risk factors for musculoskeletal complaints described in the literature, focus on only one or a few risk factors, and do not take both physical and psychosocial risk factors at work and during leisure time into account. This implies that the potential confounding effect of psychosocial load on the relationship between physical factors and musculoskeletal complaints, and, consequently, the potential confounding effect of physical load on the relationship between psychosocial factors and musculoskeletal complaints, cannot be investigated in such studies. In SMASH, work-related physical as well as psychosocial load was assessed simultaneously.
3. In most studies described in the literature, physical load at the workplace is assessed by means of a questionnaire. It is debatable whether the physical load at the workplace can actually be measured by means of self-reported

questionnaires. For SMASH, a more objective direct method (i.e., video-recordings at the workplace) was developed to assess the physical load at the workplace.

Figure 1.2 presents the study design of SMASH. In 1994, the baseline measurements, focusing on three aspects, were carried out. Firstly, the physical load at the workplace was assessed by means of video-recordings and force measurements at the workplace, after which observations were made of the variables of interest from the video-recordings. Secondly, the workers were subjected to a physical examination by a physiotherapist. Based on a standardised protocol, the strength, mobility and functional capacity of the back, neck and shoulder region were assessed. The third aspect of the baseline measurements was a self-administered questionnaire, which contained questions about general working conditions, organisational factors at work, work satisfaction, physical load at work and during leisure time, historical physical load, demographics, lifestyle, stress symptoms, individual characteristics, general health parameters and symptoms of the low back, neck and shoulders.[31]

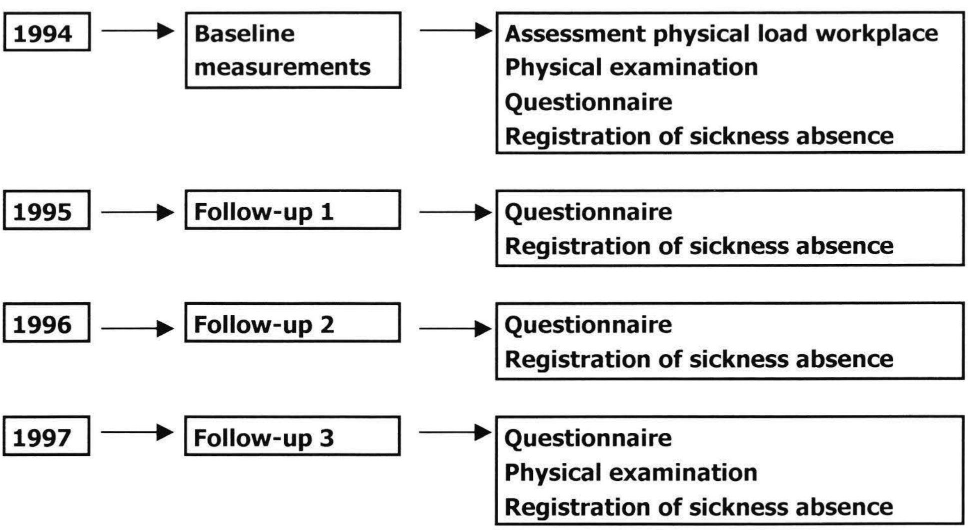

Figure 1.2 Longitudinal study design of SMASH (Study on Musculoskeletal disorders, Absenteeism, Stress and Health), a prospective cohort study in an occupational setting

From 1995 until 1997, three annual follow-up measurements took place. A postal questionnaire, comparable to the one used at baseline, was sent to the workers participating in this study. Moreover, in 1997, at the end of the follow-up, all participants were invited for a second physical examination by a physiotherapist. During the entire study, periods of sickness absence were registered, according to a standardised protocol, by the participating companies, in collaboration with their occupational physician (Figure 1.2).

In 1994, 2,064 workers were invited to participate in SMASH. They were recruited from 34 companies located throughout The Netherlands. The companies

included various industrial and service branches, which resulted in a study population of workers with a wide range of physical and mental workloads. Companies were eligible for participation if they met the following inclusion criteria:
- no major reorganisations or changes in the production process planned within the next three years;
- a turnover rate of the workforce of less than 15%.

Workers were eligible for participation if they met the following inclusion criteria:
- a more or less fixed workplace;
- at least one year of employment in the current job;
- no previous work disability or major workplace adjustments because of musculoskeletal problems.

For 1,845 out of the 2,064 workers who were invited to participate in SMASH, data on at least one of the aspects of the baseline measurements were collected (89.4%).

Objective of this thesis

The main objective of this thesis was to identify work-related physical and psychosocial risk factors for neck pain. Three research questions were formulated:
1. What are the most important work-related physical risk factors for neck pain?
2. What are the most important work-related psychosocial risk factors for neck pain?
3. What are the most important work-related physical and psychosocial variables that are related to sickness absence due to neck pain?

Outline of this thesis

Chapter 2 describes the results of a systematic review of observational studies on physical risk factors for neck pain. The level of evidence for certain work-related and non work-related physical risk factors for neck pain was assessed. In line with Chapter 2, Chapter 3 describes the results of a systematic review of observational studies on psychosocial risk factors for neck pain. Using the same methodology as used in the review described in Chapter 2, the level of evidence for work-related and non-work-related psychosocial risk factors for neck pain was assessed. In Chapter 4, based on data from SMASH, the longitudinal relationship between work-related physical variables (neck flexion, neck rotation and sitting at work) and the occurrence of neck pain is investigated. Chapter 5 presents the results with regard to the longitudinal relationship between work-related psychosocial variables (quantitative job demands, conflicting job demands, decision authority, skill discretion, co-worker support, supervisor support and job security) and the occurrence of neck pain, based on data from SMASH. The longitudinal relationship between work-related physical and psychosocial variables and sickness absence due to neck pain on the basis of data from SMASH is described in Chapter 6. In Chapter 7, a comparison is made between the use of two outcome measures: neck pain and a combination of neck and/or shoulder pain. On the basis of data from SMASH, the relationships between work-related physical and psychosocial variables and these two outcome measures are assessed, and the results of these analyses are compared. Chapter 8 contains a general discussion of the methods and results of the studies presented in Chapters 2 to 7. Chapters 2 to 7 were originally written as separate articles. Therefore, especially in the introduction and methods section of these chapters, there can be some overlap of the information and data presented. Findings and conclusions are summarised, implications of the findings for the prevention of neck pain are discussed and recommendations are made for future research. Finally, this thesis concludes with a summary in both English and Dutch.

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Chapter two

Physical risk factors for neck pain: a systematic review

Summary

To identify physical risk factors for neck pain, a systematic review of the literature was carried out. Based on methodological quality and study design, four levels of evidence were defined to establish the strength of evidence for the relationship between risk factors and neck pain.
Altogether, 22 cross-sectional studies, 2 prospective cohort studies and 1 case-control study were eligible for determining the level of evidence. The results showed some evidence for a positive relationship between neck pain and the duration of sitting and twisting or bending of the trunk. A sensitivity analysis was carried out excluding three items of the quality list, the importance of which seemed doubtful. On the basis of this sensitivity analysis, it was concluded that there is some evidence for a positive relationship between neck pain and the following work-related risk factors: neck flexion, arm force, arm posture, duration of sitting, twisting or bending of the trunk, hand-arm vibration and workplace design.

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

Neck pain is a major problem in modern society. Prevalence data have shown that, in a general population, the one-year prevalence of neck pain was 29% and 40% for males and females, respectively.[1] Prevalence data on occupational settings are even more impressive. For instance, Skov et al. found the one-year prevalence of neck symptoms to be 54% for males and 76% for females in a population of salespeople (N=1,304).[2]

In The Netherlands, the costs of work-related sick leave and medical consumption in 1995 were very high (approximately 12 billion Dutch guilders for that year). Around 40% of these costs were due to musculoskeletal disorders.[3] Although data on the specific costs of neck pain were not available, it is clear that the prevention of musculoskeletal problems, including neck pain, would be of great benefit.

Neck pain is assumed to be a multi-factorial disease, implying that there are several risk factors contributing to its development. Risk factors can be work-related or non-work-related, and they can be divided roughly into three categories (i.e., physical, psychosocial, and individual risk factors). Many studies have been conducted in an attempt to identify the risk factors for neck pain. Most of these studies focus on only one or a few risk factors, or on a single category of risk factors. Several reviews on risk factors for neck pain have also been carried out.[4-7] However, none of these reviews were based on explicitly stated inclusion and exclusion criteria or defined levels of evidence to establish the strength of the relationship between risk factors and neck pain. Borghouts *et al.* did, however, use explicitly stated inclusion and exclusion criteria, but the focus of their systematic review was on the clinical course and prognostic factors related to neck pain.[8]

To identify physical risk factors for neck pain, a systematic review of the literature was carried out. This chapter describes the methods applied in this systematic review and presents the results concerning physical risk factors for neck pain.

Methods

Identification of studies

On-line searches in Medline, Embase, Psychlit and Sportdiscus, HSELINE, CISDOC and NIOSHTIC were carried out for the period 1966 to November 1997 to identify all relevant studies. The following keywords were used (MeSH and text words): neck, neck pain, risk factors, determinants, causality, work, exercise, overuse, physical load, workload, psychosocial factors. Titles and abstracts were screened for potential risk factors for neck pain. The abstracts of all identified studies were read. If an abstract was not available, or, if based on the content of the abstract, it was still not clear whether the article should be included in the review, the entire article was retrieved and read. In order to be included in the review, a study had to meet the following criteria:

1. The population of the study had to be a working population or a community-based population (studies of patient populations were excluded).

2. The design of the study had to be either case-control, cross-sectional, prospective cohort or retrospective cohort with registered data.
3. The assessment of exposure had to concern at least one physical factor at work or during leisure time (studies with exposure solely based on job title were excluded).
4. The outcome had to include one or more syndromes, signs or symptoms related to neck pain. The outcome variable could be either self-reported or a clinical diagnosis, and the outcome must have been separately reported for the neck region.
5. The study had to be a full, peer-reviewed report published in English, Dutch or German.

Reference lists of selected studies were screened for additional relevant studies. To check the selection procedure, a random sample (N=30) of all the articles identified was assessed by a second reviewer to determine whether or not the same articles were eligible for inclusion in the review.

Quality assessment

The methodological quality of all studies included in the review was assessed by means of a methodological quality assessment list. After studying existing quality assessment lists[6,8,9] a criteria list was developed to assess the methodological quality of observational studies in this review. The list consisted of different items in five categories on information, validity and precision (i.e., purpose of the study, study population, exposure measurements, outcome measurements, and analysis and data presentation). Separate quality assessment lists were constructed for cross-sectional, case-control and cohort studies (Table 2.1). As can be seen from Table 2.1, not all the items applied to all three study designs.

For every item on the list, a study was rated 'positive' (+), 'negative' (-), or 'unclear' (?) if a study did or did not meet that item, or if no clear information was stated regarding that item, respectively. For each study, a total quality score was calculated by counting the number of items rated positively for validity or precision. On the basis of this score, the studies were categorised as either high or low in quality. A high-quality study was defined as a study that scored positively on at least 50% of the validity or precision items of the relevant methodological quality list, implying that a minimum score required for a classification as a high quality study was 7 for cross-sectional studies, 9 for case-control studies and 8 for cohort studies. Two reviewers (GA and WvM) scored all the studies independently; the results were compared and differences were discussed during a consensus meeting. If, after discussion, the reviewers could not agree, a third person (PB) made the final decision. Studies rated lowest according to the methodological quality list (i.e., a score of 3 or less) were not included in the analysis for the determination of the level of evidence.

Table 2.1 Description of the different items in the quality assessment lists

Study purpose	
A	Positive if a specific, clearly stated purpose was described (Cr Ca Pr[a])[b]
Study design	
B	Positive if the main features (description of sampling frame, distribution by age and sex) of the study population were stated (Cr Ca Pr)[b]
C	Positive if the participation rate at baseline was at least 80% (Cr Ca Pr)
D	Positive if cases and controls were drawn from the same population and a clear definition of cases and controls was stated. Persons with neck pain in the last 90 days had to be excluded from the control group (Ca)
E	Positive if the response after one year of follow-up was at least 80%, or if the non-response was not selective (Pr)
Exposure measurements	
F	Positive if data on physical load at work were collected and used in the analysis (Cr Ca Pr)
G	Positive if data on physical load at work were collected using standardised methods of acceptable quality[c] (Cr Ca Pr)
H	Positive if data on psychosocial factors at work were collected and used in the analysis (Cr Ca Pr)
I	Positive if data on psychosocial factors at work were collected using standardised methods of acceptable quality[c] (Cr Ca Pr)
J	Positive if data on physical and psychosocial factors during leisure time were collected and used in the analysis (Cr Ca Pr)
K	Positive if data on historical exposure at work were collected and used in the analysis (Cr Ca Pr)
L	Positive if data on history of neck pain, sex and age were collected and used in the analysis (Cr Ca Pr)
M	Positive if the exposure assessment was blinded with respect to disease status (Cr Ca)
N	Positive if exposure was measured in an identical way in cases and controls (Ca)
O	Positive if the exposure was assessed at a time prior to the occurrence of the outcome (Ca)
Outcome measurements	
P	Positive if data on outcome were collected with standardised methods of acceptable quality[d] (Cr Ca Pr)
Q	Positive if incident cases were used (prospective enrollment) (Ca)
R	Positive if data on outcome were collected for at least one year (Pr)
S	Positive if data on outcome were collected at least every three months (Pr)
Analysis and data presentation	
T	Positive if the statistical model used was appropriate for the outcome studied and the measures of association estimated with this model were presented (including confidence intervals) (Cr Ca Pr)
U	Positive if the study controled for confounding (Cr Ca Pr)
V	Positive if the number of cases in the multivariate analysis was at least ten times the number of independent variables in the analysis (Cr Ca Pr)

[a] This item was used in the quality list for cross-sectional (Cr), case-control (Ca) or prospective cohort studies (Pr); [b] This is an information item, and therefore not taken into account when calculating the total quality score; [c] This item was scored positive if one of the following criteria is met: 1) for direct measurements, intraclass correlation coefficient >0.60 or Kappa >0.40; 2) for observational methods, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability; and 3) for self-reported data, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability; [d] This item was scored positive if one of the following criteria is met: 1) for self-reported data, intraclass correlation coefficient >0.60 or Kappa >0.40; 2) for registered data, data must show that registration system is valid and reliable; and 3) for physical examination, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability

Levels of evidence

The strength of evidence for potential risk factors for neck pain was assessed by defining the levels of evidence as follows:

1. Strong evidence: consistent findings in multiple high quality cohort and/or case-control studies.
2. Moderate evidence: consistent findings in multiple cohort and/or case-control studies, of which only one study was of high quality.
3. Some evidence: findings of one cohort or case-control study, or consistent findings in multiple cross-sectional studies, of which at least one study was of high quality.
4. Inconclusive evidence was defined in all other cases (i.e., consistent findings in multiple low quality cross-sectional studies, or inconsistent findings in multiple studies). Moreover, inconclusive evidence was defined as findings of only one cross-sectional study, irrespective of the quality of the study.

A positive effect of a risk factor implied, in line with the hypothesis, an increased risk for the occurrence of neck pain with the presence of this risk factor. A negative effect implied, in contrast to the hypothesis, a decreased risk for the occurrence of neck pain in the presence of this risk factor. Accordingly, no effect of a risk factor implied that the presence of this risk factor was not associated with either an increased or a decreased risk for the occurrence of neck pain.

The focus of this review was on the size and direction of the risk estimate, irrespective of the level of significance. A reported nonsignificant association between a risk factor and neck pain, with no mention of the risk estimate or the direction of the association was disregarded since, in such cases, it was not clear whether the risk estimate was increased or decreased. Reporting a significant association without stating the risk estimate was considered as a finding and thus contributed to the level of evidence. Consistent findings implied that the results of at least 75% of the studies analysing the effect of a certain risk factor should be pointing in the same direction. The measures of effect and the p-values reported by these studies should lead to the same conclusion, i.e., that a risk factor was found to have a positive or negative effect or no effect in relation to neck pain.

Results

Identification of relevant studies

Of the 1,026 studies identified from the various data bases (the data bases overlap, the implication being that the actual number of studies identified was lower), 40 met the criteria for inclusion in the review. The large majority of these studies (N=37) was cross-sectional. One case-control study and two prospective cohort studies were also included. The most important reason for the exclusion of studies was the use of a combined outcome measure[10-16], implying that in these studies no separate results were reported for the neck region.

The two reviewers agreed on inclusion or exclusion for 90% in the studies of the random sample (N=30). After discussion with a third person, consensus was reached on the inclusion or exclusion of all the studies.

Quality assessment

The overall percentage of agreement between the two reviewers on the methodological quality assessment was 84%. Considering the different items on the quality lists separately, the percentage of agreement ranged between 48% and 98%. The item concerning the use of an appropriate statistical model and the presentation of measures of effect (item T in Table 2.1) had the lowest level of agreement. This result was due to an initial difference in interpretation of the item by the two reviewers.
During a consensus meeting, all disagreements between the two reviewers were resolved and the final scores per item on the quality assessment lists are presented in the table in the appendix at the end of this chapter. In the last column of this table, the total quality score is presented for each study.

Of the 37 cross-sectional studies, only 4 scored positively on more than 50% of the validity/precision items on the quality list and were rated as high quality studies.[17-20] Of the validity/precision items, the item concerning the measurement and analysis of physical factors at work (item F) was the most often scored positively. This outcome was not very surprising, since most literature on physical risk factors for neck pain concentrates on work-related risk factors. The items that were the most often scored as negative or unclear were those concerning the use of standardised measures of acceptable quality (items G, I, and P). Only one study provided satisfactory information on the standardisation and quality of their exposure measures.[20] Two studies provided this information for the outcome measures.[20,21]
Only one of the three longitudinal studies scored positively on more than 50% of the validity/precision items and was defined as a high quality study.[22] The case-control study only investigated physical factors during leisure time as risk factors for neck pain.[23] Consequently, many items on the quality list were scored negatively. None of the prospective cohort studies gave satisfactory information on the standardisation and reliability of the exposure and outcome measures (items G, I, and P), the collection and analysis of data on history of neck pain, age and sex (item L), or the collection of data at least every three months (item S).

Of the total of 40 studies in this review, 36 studies collected and analysed data concerning physical factors at work (item F). Data concerning physical load during leisure time (item J) were collected and analysed in 11 studies. Of the 40 studies, 15 cross-sectional studies with a total quality score of 3 or less were excluded from determination of the level of evidence.[24-38] Consequently, the final number of studies included in the level of evidence synthesis was 25 (i.e., 2 prospective cohort studies[22,39], 1 case-control study[23], and 22 cross-sectional studies[2,17-21,40-55]). Table 2.2 gives a brief description of these studies.

The prospective study carried out by Rundcrantz *et al.* focussed on occupational disorders among dentists.[39] The exposure measures used in this study were very job-specific ergonomic factors, which were not comparable with the exposure measures used in any other study and were not related to self-reported neck symptoms. As a consequence, this study was not included in the determination of the level of evidence of any risk factor.

Level of evidence

Eight sets of risk factors were identified, for which the level of evidence was determined. First, several neck postures were considered, i.e., neck flexion, neck extension and neck rotation. The second set of risk factors involved factors related to the arm, i.e., arm force and arm posture. The third, fourth and fifth set of risk factors concerned sedentary working postures, twisting and/or bending of the trunk, and hand-arm vibration. The sixth work-related set of risk factors concerned work-place design. Finally, two sets of non-work-related risk factors were identified, i.e., driving a vehicle and sports and exercise.

Table 2.2 Descriptive information of studies used in this review with a total quality score of 4 or more

Reference Design, MQS[a]	Study population	Outcome measure(s)	Physical risk factor(s) and strength of association
Andersen & Gaardboe[40] Cr[b], 5	Female sewing machine operators (N=424) Response of total cohort 78.2% (N=896)	Self-reported chronic neck pain	*Non-work-related factors* Leisure time exercise (OR=0.89, 0.63-1.25)[c]
Bergqvist *et al.*[41] Cr, 6	Office workers (N=353) Response Q[d] 92% Response PE[e] 91% Response WA[f] 82%	Tension neck syndrome	*Work-related factors* Keyboard placed too high (OR=4.4, 1.1-17.6)
Bernard *et al.*[17] Cr, 7	Newspaper employees using video display terminals Response at baseline 93% (N=973)	Self-reported neck symptoms	*Work-related factors* Time spent on telephone (OR=1.4, 1.0-1.8); Number of times arising from chair (ns[g]); Number of breaks (ns)
Bru *et al.*[21] Cr, 5	Female hospital staff Response at baseline 85% (N=586)	Neck pain index (based on self-reported data)	*Work-related factors* Perceived ergonomic load (ns)

Table 2.2 Continued

Reference Design, MQS[a]	**Study population**	**Outcome measure(s)**	**Physical risk factor(s) and strength of association**
Bovenzi *et al.*[42] Cr, 6	Male forestry workers using chain-saws (N=65) and male workers who performed maintenance activities in a hospital and were not exposed to vibration (controls, N=31)	Self-reported persisting neck pain Tension neck syndrome Cervical syndrome	*Work-related factors* Vibration >7.5 m/s^2 (OR=3.8, p=0.03)[h]; Vibration <7.5 m/s^2 (OR=0.9, ns) Vibration >7.5 m/s^2 (OR=3.8, p=0.03); Vibration <7.5 m/s^2 (OR=0.9, ns) Vibration >7.5 m/s^2 (OR=10.7, p<0.005); Vibration <7.5 m/s^2 (OR=2.8, ns)
Dartigues *et al.*[43] Cr, 5	A working population (N=990)	Self-reported recurrent cervical pain syndrome	*Work-related factors* Sitting posture (ns); Cervical spine rotation (OR=2.4, 1.5-3.8); Cervical spine flexion (OR=1.7, 1.0-3.0); Cervical spine extension (OR=2.3, 1.5-3.7); Permanent posture (ns); Strenuous muscular activity (ns) *Non-work-related factors* Strenuous muscular activity in leisure time (OR=0.4, 0.2-0.7)
Dimberg *et al.*[44] Cr, 5	Employees from Volvo Flygmotor N=2,933	Self-reported neck symptoms	*Work-related factors* Using vibrating tools (p<0.001) *Non-work-related factors* Playing more racquet sports (p<0.001)
Hales *et al.*[18] Cr, 7	Telecommunication employees utilising video display terminals for at least 6 hours/day Response at baseline 96% (N=512)	Self-reported neck disorders	*Non-work-related factors* Hours per week spent on recreational activities or hobbies (ns)
Ignatius *et al.*[45] Cr, 6	Female typists working in the Government Housing Department Response at baseline 52% (N=170)	Self-reported neck pain	*Work-related factors* Mismatch of the desk and chair heights (OR=3.0, p=.021; OR=2.98)[i]; Bending the neck at work (OR=3.4, p=.012; OR=2.62); Daily typing hours (ns); Bent back at work (ns)
Kamwendo *et al.*[19] Cr, 7	Female medical secretaries and office personnel Response at baseline 96% (N=420)	Self-reported neck pain	*Work-related factors* Sitting 5 hours or more a day (OR=1.49, 0.86-2.61); Work with office machines more than 5 hours a day (OR=1.65, 1.02-2.67)

Table 2.2 Continued

Reference Design, MQS[a]	**Study population**	**Outcome measure(s)**	**Physical risk factor(s) and strength of association**
Johansson & Rubenowitz[46] Cr, 5	Blue and white collar workers from 8 large metal industry companies Response at baseline 90% (N=450)	Self-reported neck symptoms	*Work-related factors (bc[j] workers)* Heavy material handling (ns); Extreme work posture (ns); Light bent work posture (ns); Monotonous working movements (ns) *Work-related factors (wc[k] workers)* Bent work postures (p<0.01); Monotonous working movements (p<0.001); Twisted work postures (p<0.01)
		Self-reported neck symptoms, symptoms must be work-related	*Work-related factors (bc workers)* Heavy material handling (ns); Extreme work posture (ns); Light bent work posture (ns); Monotonous working movements (ns) *Work-related factors (wc workers)* Bent work postures (p<0.05); Monotonous working movements (p<0.001); Twisted work postures (p<0.01)
Linton[50] Cr, 6	Full-time employees working daytimes (N=22,180)	Self-reported neck pain	*Work-related factors* Heavy lifting (OR=1.41-1.83)[l]; Monotonous work (OR=2.25-2.95); Sitting (OR=0.94-1.33); Uncomfortable posture (OR=1.59-2.42) *Non-work-related factors* Exercise (OR=0.91-1.06)
Johansson[47] Cr, 6	Home care workers (N=305)	Self-reported neck symptoms	*Work-related factors* Lifting heavy loads (RR=1.21, 0.92-1.59)[m]; Monotonous movements (RR=1.33, 1.04-1.69); Twisted postures (RR=1.26, 0.97-1.63); Deep forward flexed trunk (RR=1.33, 1.06-1.68; p<0.15); Hands above shoulder level (RR=1.17, 0.96-1.44)
		Self-reported work-related neck symptoms	*Work-related factors* Lifting heavy loads (RR=1.74, 1.09-2.77); Monotonous movements (RR=1.73, 1.22-2.47); Twisted postures (RR=1.69, 1.09-2.63; p<0.15); Deep forward flexed trunk (RR=1.68, 1.20-2.34; p<0.01); Hands above shoulder level (RR=1.38, 1.03-1.84)

Table 2.2 Continued

Reference Design, MQS[a]	Study population	Outcome measure(s)	Physical risk factor(s) and strength of association
Kilbom *et al.*[48] Cr, 5	Female assembly line workers of two electronic manufacturing companies Response at baseline 77% (N=106)	Severity of self-reported neck symptoms	*Work-related factors* Increased average time per work cycle in neck flexion ($p<0.01$); Increased average time per work cycle upper arm 0-30º abducted ($p<0.05$) *Non-work-related factors* Leisure physical activity (ns)
Lau *et al.*[49] Cr, 5	All adults >30 years living in two housing blocks in Shatin, Hong Kong	Self-reported neck pain	*Non-work-related factors* Sports activity (ns)
Mäkelä *et al.*[20] Cr, 9	Finnish adults drawn from the population register, representing the Finnish adult population of 30 years and older Response at baseline 90% (N=7,217)	Chronic neck syndrome	*Work-related factors (30-64 year)* Physical stress at work (OR=1.35, 1.27-1.42; OR=1.26, 1.18-1.33) *Work-related factors (>64 years)* Physical stress at work (OR=1.21, 1.08-1.34; OR=1.12, 1.00-1.26)
Mundt *et al.*[23] Ca[n], 6	Cases: patients with cervical disc herniation (N=68) Controls: persons free of disc herniation (N=63) N=63 cases were matched to a control (93%)	Herniated cervical disc	*Non-work-related factors* Baseball (RR=1.05, 0.40-2.75); Golf (RR=0.59, 0.21-2.61); Bowling (RR=1.63, 0.70-3.83); Swimming (RR=0.71, 0.31-1.63); Diving (RR=0.96, 0.36-2.52); Jogging (RR=0.86, 0.41-1.81); Aerobics (RR=0.94, 0.39-2.29); Racket sports (RR=1.14, 0.50-2.60); Playing any of these sports (RR=0.39, 0.12-1.30); Use of free weights (RR=1.87, 0.74-4.74); Weight lifting (RR=0.75, 0.31-1.78)
Musson *et al.*[51] Cr, 4	Workers using various types of impact tools (N=445) Response at baseline 38% (N=169)	Self-reported regularly pain or stiffness in the neck	*Work-related factors* Vibration ($\beta=0.044$, $p=.01$); Lifting heavy loads while handling impact tool (ns); Turning neck while handling impact tool (ns); Bending forward while handling impact tool (ns); Bending aside while handling impact tool (ns)
Wells *et al.*[54] Cr, 4	Male letter carriers, meter readers and postal clerks	Self-reported current symptoms of neck pain	*Work-related factors* Weight carrying (ns)

Table 2.2 Continued

Reference **Design, MQS**[a]	**Study population**	**Outcome measure(s)**	**Physical risk factor(s) and strength of association**
Rundcrantz *et al.*[39] Pr[o], 5	Official dentists in Malmö Response at baseline 90% (N=359) Response at follow-up 92% (N=315)	Self-reported neck symptoms	*Work-related factors* Changing own position to the patient to obtain a direct view (ns); Alter the position of the patient to obtain a direct view (ns)
Schibye *et al.*[52] Cr, 5	Female sewing machine operators Response at baseline 94% (N=306)	Self-reported neck symptoms	*Work-related factors* Individual adjustment of table and chair (ns)
Skov *et al.*[2] Cr, 6	Random 8% sample of the members of the association Danish Active Salespeople Response at baseline 66% (N=1,306)	Self-reported neck symptoms	*Work-related factors* One quarter of work time sitting (OR=2.68, 1.31-5.49); Half of work time sitting (OR=1.92, 0.98-3.79); Three quarters of work time sitting (OR=2.18, 1.11-4.29); All of work time sitting (OR=2.80, 1.40-5.59); Lifting heavy loads (ns) *Non-work-related factors* Annual driving distance 5-10,000 km (OR=0.99, 0.45-1.76); Annual driving distance 10-15,000 km (OR=1.48, 0.75-2.93); Annual driving distance 15-30,000 km (OR=1.74, 1.01-2.99); Annual driving distance 30-50,000 km (OR=2.10, 1.24-3.54); Annual driving distance >50,000 km (OR=2.43, 1.36-4.34); Time spent in the car (ns); Leisure time sports activities (ns)
Tharr[53] Cr, 6	Teleservice representatives from 2 teleservice centres Response at baseline 95% (N=108)	Self-reported neck symptoms	*Work-related factors* Chair discomfort (OR=3.5, 1.4-8.9); Hours spent typing at VDT work station (ns); Number of hours spent on the telephone (ns); Length of time continuously sitting on a chair (ns)

Table 2.2 Continued

Reference Design, MQS[a]	**Study population**	**Outcome measure(s)**	**Physical risk factor(s) and strength of association**
Viikari-Juntura *et al.*[22]	Male machine operators, carpenters and office workers	Self-reported neck pain, change from 1984 to 1987:	
Pr, 9		- none to moderate	*Work-related factors*
	Response at baseline 69% (N=2,222)		Rather or very much twisting or bending at work (OR=1.8; 1.2-2.7)
	Response at follow-up 82% (N=1,832)		*Non-work-related factors* Physical exercise (ns); Annual car driving (ns)
		- none to severe	*Work-related factors* Rather or very much twisting or bending at work (OR=1.9; 1.2-3.2) *Non-work-related factors* Physical exercise (ns); Annual car driving (ns)
		- persistent severe	*Work-related factors* Twisting or bending at work (ns) *Non-work-related factors* Physical exercise (ns); Annual car driving (ns)
Yu & Wong[55] Cr, 4	Video display unit workers in a Hong Kong bank Response at baseline 80% (N=121)	Self-reported neck discomfort or ache during work after starting their job	*Work-related factors* Longer daily video display use working hours (p=0.013); Bending back at work (p<0.001); Inclining neck at work (p<0.001; 787.400, 33.280-18630); Incorrect height of chair (p=0.010); Repetitive movements (p=0.232); Fixed keyboard distance (p=0.549); Fixed keyboard height (p=0.005; 90.060, 7.684-1056); Fixed keyboard tilt (p=0.341); Fixed screen distance (p=1.000); Fixed screen height (p=0.061); Fixed screen tilt (p=0.571)

[a] Methodological quality score; [b] Cross-sectional study design; [c] Odds ratio and 95% confidence interval; [d] Questionnaire; [e] Physical examination; [f] Work place assessment; [g] Not significant; [h] Odds ratio and p-value; [i] If two analysis were carried out for a specific exposure and outcome, both results are presented; [j] Blue collar; [k] White collar; [l] Several age-specific odds ratios ranging from 1.41 till 1.83 are presented in this study; [m] Rate ratio and 95% confidence interval; [n] Case-control study design; [o] Prospective study design

Neck postures (flexion, extension and rotation)

Four low quality cross-sectional studies reported a relationship between neck pain and neck flexion as a risk factor.[43,45,48,55] All four studies indicated a positive effect of neck flexion on the occurrence of neck pain. Dartigues *et al.* presented an odds ratio of 1.7 for cervical spine flexion in relation to self-reported neck symptoms.[43] Kilbom *et al.* found a significant positive association between neck flexion and self-reported neck symptoms ($p<0.01$) in a multiple regression analysis.[48] Odds ratios of 3.4 (univariate analysis) and 2.6 (multivariate analysis) were reported by Ignatius *et al.*[45], and a very high and unstable odds ratio (787) was reported by Yu and Wong.[55] Based on the availability of only four cross-sectional studies with a low quality score, the conclusion was reached that there is inconclusive evidence for a relationship between neck flexion and neck pain, even though the results of these studies all indicated a positive effect.

One study investigated neck extension in relation to neck symptoms.[43] The authors found that neck extension was positively associated with self-reported neck symptoms, with an odds ratio of 2.3 in an univariate analysis. In their multivariate analysis they also found a significant association between neck extension and neck symptoms. Since there was only one cross-sectional study with a low quality score reporting on neck extension as a risk factor for neck pain, inconclusive evidence was found for a relationship between this measure of exposure and the outcome under study.

Two cross-sectional studies with a low quality score reported on the relationship between neck rotation and neck symptoms.[43,51] Dartiques *et al.* reported a positive effect (OR=2.4) of cervical spine rotation on self-reported neck symptoms.[43] Musson *et al.* only stated that neck rotation was not significantly associated with neck symptoms, without reporting a measure of effect.[51] On the basis of one low-quality cross-sectional study, it can be concluded that the evidence is inconclusive for a relationship between neck rotation and neck pain.

Arm force and arm posture

Arm force was studied as a potential risk factor for neck pain in six low-quality cross-sectional studies.[2,46,47,50,51,54] Different definitions and different methods of measuring arm force were used. Four of these studies only reported that arm force was not significantly associated with neck symptoms, but they did not report a measure of effect.[2,46,51,54] Linton studied the relationship between heavy lifting and self-reported neck symptoms in specific age groups, the result being odds ratios varying between 1.41 and 1.83, indicating a positive effect of heavy lifting on the occurrence of neck symptoms.[50] Johansson reported an age-stratified rate ratio of 1.21 for the relationship between heavy lifting and self-reported neck symptoms.[47] If the outcome measure was defined as self-reported work-related neck symptoms, the rate ratio was 1.74.

In summary, the level of evidence for arm force is based on the results of two cross-sectional studies, both with a low quality score.[47,50] The results of both studies point in the same direction, i.e., that there is a positive effect of arm force on the occurrence of neck pain. However, due to the low quality of the studies, it can be concluded that there is inconclusive evidence for a relationship between arm force and neck pain.

Several low quality cross-sectional studies reported on the relationship between arm posture and neck pain.[46-50,55] As described earlier for arm force, arm posture was also operationalised in different ways in these studies, for example, as static arm posture, as repetitive movements of the arms, or as non-neutral positions of the upper arm. Yu and Wong only stated that the relationship between repetitive movements and self-reported neck symptoms was not significant, not mentioning any measure of effect.[55] In their study, Johansson and Rubenowitz found a significant positive correlation coefficient ($p<0.001$) between monotonous work movements and self-reported neck symptoms among white collar workers[46], and Kilbom *et al.* found a significant positive relationship ($p<0.05$) between the time spent in upper arm abduction and self-reported neck symptoms.[49] Moreover, two studies reported positive measures of effect for arm load on the occurrence of neck symptoms.[47,50] Linton reported odds ratios varying for specific age-groups from 2.25 to 2.95.[50] Johansson found a rate ratio of 1.33 for monotonous movements and a rate ratio of 1.17 for work with the hands above shoulder level in relation to neck symptoms.[47] In relation to work-related neck symptoms, Johansson found rate ratios of 1.73 and 1.38 for monotonous work and work with the hands above shoulder level, respectively. Again, in spite of the many positive associations reported, it can be concluded that there is inconclusive evidence for a relationship between arm load and neck pain because no high-quality study reported this relationship.

Duration of (fixed) sedentary work postures

A total of eight cross-sectional studies investigated the duration of sitting as a risk factor for neck pain.[2,17,19,43,45,50,53,55] Two of these studies were rated as high in quality.[17,19] All of them used different methods to measure the sitting posture of the worker. For example, Bernard *et al.*[17] measured 'the time spent on the telephone' and Kamwendo *et al.*[19] studied 'the time spent working with office machines' and 'sitting for more than 5 hours a day' as potential risk factors for neck pain. Three studies only reported that the association between sitting and neck pain was not significant, but they did not describe a measure of effect.[43,45,53] Kamwendo *et al.* reported an odds ratio of 1.49 for sitting more than 5 hours a day in relation to self-reported neck symptoms.[19] Furthermore, they reported an odds ratio of 1.65 for the relationship between working with office machines for more than 5 hours a day and self-reported neck symptoms. Bernard *et al.* reported an odds ratio of 1.4 in a multivariate analysis for the relationship between increased time spent on the telephone and self-reported neck symptoms.[17] In the study carried out by Skov *et al.* the values of the odds ratios for sitting in relation to self-reported neck symptoms were slightly higher.[2] In a multivariate analysis, four categories of 'sitting time' were found to be related to neck symptoms. The odds ratios ranged from 1.92 to 2.80, the odds ratios increasing for increased 'sitting time'. Finally, Yu and Wong also reported

a significant association (p=0.013) between increased hours of video display terminal (VDT) work and self-reported neck discomfort.[55] Linton reported 4 odds ratios for specific age-groups (0.94, 1.00, 1.12 and 1.33) for the relationship between sedentary posture and self-reported neck pain.[50] From this study it is not clear whether there was a positive effect or no effect of sedentary postures on neck pain.
In summary, four cross-sectional studies, two of which were of high quality, reported a positive effect of sitting posture on the occurrence of neck pain, the conclusion therefore being that there is some evidence for a relationship between sitting posture and neck pain.

Twisting or bending of the trunk

Six studies reported on twisting or bending of the trunk as a risk factor for neck pain. One was a high-quality prospective cohort study[22], and the other five studies were of cross-sectional design and low in quality.[45-47,51,55] In the high-quality prospective cohort study carried out by Viikari-Juntura *et al.*, an odds ratio of 1.8 was reported for 'rather' or 'very much' bending or twisting and the development of self-reported neck trouble during follow-up.[22] An odds ratio of 1.9 was found for 'rather' or 'very much' twisting or bending in relation to the development of self-reported severe neck trouble during follow-up. Two low quality cross-sectional studies reported a nonsignificant relationship between bending and neck symptoms, without mentioning any measure of effect.[45,51] The results of the remaining three low quality cross-sectional studies all point in the same direction as the results of the prospective cohort study.[46,47,55]
Based on the prospective findings of Viikari-Juntura *et al.*[22], it can be concluded that there is some evidence for a positive relationship between twisting or bending of the trunk and neck pain.

Hand-arm vibration

Hand-arm vibration was studied in three cross-sectional studies with a low quality score.[42,44,51] Dimberg *et al.* found a positive significant relationship ($p<0.001$) between hand-arm vibration and neck symptoms.[44] Bovenzi *et al.* reported several odds ratios for different outcome measures for two categories of vibration, compared with no vibration, the results indicating a positive effect of vibration on neck pain.[42] For self-reported neck pain the odds ratios were 0.9 for the low category and 3.8 for the high category, compared with no vibration. For the outcome measure tension neck syndrome the same odds ratios were found. For the outcome measure cervical syndrome, an odds ratio of 2.8 was reported for the low category and that of 10.7 for the high category, compared with no vibration. Musson *et al.* reported a beta of 0.044 with a p-value of 0.01 for the relationship between hand-arm vibration and self-reported neck pain.[51] In spite of the consistent positive findings of these three studies, it is concluded that there is inconclusive evidence for a relationship between hand-arm vibration and neck pain, due to the low quality of the studies.

Workplace design

A total of five low quality cross-sectional studies investigated the relationship between workplace design and neck pain.[41,45,52,53,55] Schibye *et al.* studied the lack of individual adjustment for a table and chair as a risk factor for self-reported neck symptoms, but found no significant relationship between the two factors and no measure of effect was reported.[52] Ignatius *et al.* reported odds ratios of 3.0 (univariate analysis) and 2.98 (multivariate analysis) for the relationship between a mismatch of table and chair height and self-reported neck pain.[45] Tharr reported an odds ratio of 3.5 for the relationship between chair discomfort and self-reported neck symptoms.[53] Yu and Wong studied many workplace design factors, all concerning the chair and the VDT.[55] They reported a positive significant relationship ($p=0.01$) between incorrect chair height and self-reported neck symptoms. For the factors concerning the VDT they reported a significant positive association between a fixed keyboard height and self-reported neck symptoms ($p=0.005$). The odds ratio in the multivariate analysis for this relationship was 90, which is extremely high and therefore probably unstable. For all other factors, concerning the VDT, Yu and Wong only reported that the relationships between these factors and neck symptoms were not significant, without mentioning any measure of effect. Bergqvist *et al.* reported a significant association between insufficient table space and tension neck syndrome without mentioning the p-value.[41] Furthermore, they reported an odds ratio of 4.4 for a keyboard which was placed too high in relation to tension neck syndrome.
Based on four low quality cross-sectional studies, the conclusion is that there is inconclusive evidence for a relationship between workplace design factors and neck pain.

Driving a vehicle

Driving a vehicle as a risk factor for neck pain was assessed in two studies. One was a low quality cross-sectional study[2], and the other was a high quality prospective cohort study.[22] Skov *et al.* studied annual driving distance in relation to neck pain.[2] Six distance categories were distinguished (<5000 km, 5000-10000 km, 10000-15000 km, 15000-30000 km, 30000-50000 km, and >50000 km) as risk factors for self-reported neck pain. They found odds ratios ranging from 0.99 to 2.43 (multivariate analysis) for the different categories, with increasing values for the odds ratio with increasing distance, implying a positive effect of annual driving distance on neck pain. In their prospective cohort study, Viikari-Juntura *et al.* found that the relationship between annual car driving and neck pain was not significant, without mentioning a measure of effect.[22] Based on one low-quality cross-sectional study it can be concluded that there is inconclusive evidence for a relationship between driving a vehicle and neck pain.

Sports and exercise

Sports and exercise during leisure time were investigated in eight studies, six of which were low-quality and cross-sectional in nature[2,40,44,48-50], one was a low-

quality case-control study[23], and one was a high quality prospective cohort study.[22] Some of the studies hypothesised a favourable effect of participation in sports on neck pain, while others considered participation in sports to be a risk factor for neck pain. In their high-quality prospective study, Viikari-Juntura *et al.* found that the relationship between physical exercise during leisure time and self-reported neck trouble was not significant, but they reported no measure of effect.[22]
Mundt *et al.* studied the relationship between participation in sports and herniated cervical disc in a low quality case-control study, finding positive, negative and no effects for the various sports studied.[23] They calculated rate ratios for participation in various types of sports at least ten times in the two years prior to the occurrence of cervical herniated disc: baseball (RR=1.05), golf (RR=0.59), bowling (RR=0.63), swimming (RR=0.71), diving (RR=0.96), jogging (RR=0.86), aerobics (RR=0.94), racket sports (RR=1.14). The rate ratio for participation in any of these sports at least ten times in the two years prior to the occurrence of cervical disc herniation was 0.39. The rate ratio for the use of free weights was 1.87 and the rate ratio for weight lifting was 0.75. On the basis of these inconsistent results, it is concluded that there is inconclusive evidence for a relationship between sports and exercise and neck pain.
There were also several low-quality cross-sectional studies in which the relationship between leisure time exercise and neck pain was investigated. Three studies found that the relationship between exercise and neck pain was not significant, but they did not report any measure of effect.[2,48,49] Linton and Andersen and Gaardboe reported odds ratios for the relationship between exercise and neck pain, but neither study indicated an effect.[40,50] Linton reported odds ratios ranging for different age-groups from 0.91 to 1.06 (50), and Andersen and Gaardboe found an odds ratio of 0.89.[40]
Dimberg *et al.* more specifically studied the relationship between participating in racket sports and self-reported neck symptoms.[44] The results of their multivariate analysis showed that increased participation in racket sports was significantly associated with fewer neck symptoms ($p<0.001$). Based on the hypothesis that sports and exercise induce neck pain, this finding should be interpreted as a negative effect.
On the basis of the case-control study of Mundt *et al.*[23], it is concluded that there is inconclusive evidence for a relationship between sports and exercise and neck pain.

Discussion

To identify physical risk factors for neck pain, a systematic review of the literature was carried out. The results showed some evidence for a positive relationship between the duration of (fixed) sedentary work posture, and twisting and/or bending of the trunk, and the occurrence of neck pain. Inconclusive evidence was found for the other physical risk factors studied, i.e., neck flexion, neck extension, neck rotation, arm force and posture, hand-arm vibration, workplace design, driving a vehicle, and sports and exercise.

Kuorinka and Forcier identified risk factors for tension neck syndrome in their review.[4] Repetitive work and constrained arm and head posture appeared to be associated with an increased risk for tension neck syndrome among working populations. In the present review neither of these factors were found to be related to neck pain. In his review, Bernard found evidence for a relationship between neck disorders and repetitive work (continuous arm or hand movements that generate load to the neck/shoulder area), repetitive neck movements, forceful arm movements, and static postures involving the neck/shoulder muscles.[5] These results are similar to the results found by Kuorinka and Forcier[4], although they differ from the results reported in the present review. Stock did not find any evidence for risk factors related to tension neck syndrome[6], possibly due to the very strict inclusion criteria which were applied, resulting in the inclusion of only three studies. Stock excluded studies using self-reported neck symptoms as an outcome measure. Most studies included in the present review actually used self-reported neck symptoms as an outcome measure. Consequently, the results of these reviews are barely comparable. In the review carried out by Hagberg and Wegman, several exposures based on job titles were compared. For keyboard operators, an increased odds ratio was found for tension neck syndrome.[7] In the present review, studies assessing exposure based on job titles were excluded. Consequently, it is difficult to make a comparison between the results of this review and the results reported by Hagberg and Wegman.

Selection of studies

For this review several data bases were systematically searched to identify all relevant studies. Many studies on risk factors do not focus on one single outcome measure, but report on several separate outcome measures, of which neck pain is one. If, in these studies, the main focus is not on neck pain but, for example, on low back pain, key words could have been used which only relate to low back pain and not to neck pain. Consequently these studies may have been missed during the literature search. Furthermore, no effort was made to identify unpublished studies concerning risk factors for neck pain. These two facts may have introduced bias in the identification of studies for this review.

The most important reason for exclusion was the fact that the results of a study were not reported for the neck region separately. Many studies did not use neck pain as an outcome measure, but used a combination of neck and/or shoulder pain as an outcome measure.[10-16] Since the objective of this review was to identify risk factors for neck pain, it was decided to exclude these studies. Moreover, in the excluded studies, it was often unclear what was meant by neck and/or shoulder pain. Pain in the proximal part of the upper arm may have been included in these studies. Since it is possible that other risk factors may be of influence in determining the existence of pain in the neck and/or shoulder region, these studies were not included in the review. However, this procedure may have led to the exclusion of some studies that actually did investigate the neck region.

Most of the studies identified were of cross-sectional design. Only one case-control study[23] and two prospective cohort studies[22,39] were identified. In cross-sectional research the temporal relationship between exposure and outcome, and thus causality, cannot be firmly established. The reason cross-sectional studies were included in this review, despite this disadvantage, was that most of the research on risk factors for neck pain was actually based on a cross-sectional design. It would not have been acceptable to neglect the vast amount of information obtained from cross-sectional research. However, the fact that the majority of studies evaluated were cross-sectional does imply that only some evidence could be established in this review.

The studies included in the review were very heterogeneous with regard to both the exposure measures and the outcome measures. Most of the studies used a self-reported outcome measure, but four used clinical diagnosis as the outcome measure.[20,23,41,42] Some studies presented extensive definitions of the outcome measures with regard to the intensity and duration of neck symptoms, while other studies only used the occurrence of neck symptoms during the previous 12 months as an outcome measure, irrespective of the intensity and duration of symptoms. One of the inclusion criteria for this review was that studies either reported on specific or nonspecific neck symptoms. This criterion resulted in the inclusion of only one study that used a specific neck outcome (cervical herniated disc).[23] Although the outcome used in this study, carried out by Mundt *et al.*, may be essentially different in comparison to the outcomes used in the other studies included in the review, it was combined with all other studies for the determination of the level of evidence for the risk factor 'sports and exercise'. Inconclusive evidence was found for a relationship between sports and exercise and neck pain, due to the inconsistent findings reported by Mundt *et al.*, but, even if these findings were ignored, the results regarding the level of evidence for the risk factor 'sports and exercise' would not have been influenced. On the basis of three low quality cross-sectional studies reporting mixed results, it can be concluded that there is inconclusive evidence for a relationship between sports and exercise and neck pain.

Some studies used very general exposure measures for the assessment of the physical load. For example, Dartigues *et al.* used self-reported 'strenuous muscular activity at work' as a general measure of exposure[43], and Mäkelä *et al.* used self-reported 'physical stress at work' as the only physical exposure measure in their high quality cross-sectional study.[20] In the same way, general measures were used for activities during leisure time and for entire body postures. No level of evidence was determined for these general measures because the focus of this review was on neck-specific risk factors, such as neck postures and neck movements. Although at first sight the risk factors sedentary working posture, twisting or bending of the

trunk, workplace design, and driving a vehicle may also not be classified as neck-specific risk factors, the level of evidence for these factors was determined. The reason for this approach was that they are surrogate factors for awkward neck postures or neck movements.
Little is known about the mechanisms leading from physical exposure to musculoskeletal disorders. Winkel and Mathiassen suggest the following three main dimensions to quantify physical exposure: the level (the magnitude of the mechanical force), repetitiveness (the frequency of shifts between force levels), and the duration (the time period) of exposure.[56] In most studies in the review little quantitative information on the level, time pattern or duration of the exposure to the risk factor under study was reported. In future epidemiologic studies, all three dimensions should be considered in the assessment of physical exposure in relation to musculoskeletal disorders.

Methodological quality and levels of evidence

A quality list was constructed to assess the methodological quality of the studies in this review. This list consisted of several items concerning information, validity and precision in different categories. A total quality score was calculated by counting the number of validity and precision items that were scored positively on the criteria list. Based on the total quality score, studies were defined as high or low in quality. Four levels of evidence were defined to establish the strength of evidence for a relationship between a risk factor and neck pain. These levels were based on the consistency of results, study design, and methodological quality. The procedure and rating of the methodological quality had a considerable influence on the establishment of the level of evidence, indicating that changes in this procedure may have a large impact on the results.
All items on the methodological quality list were given the same weighting factor, on the assumption that all items were equally important. One disadvantage of this method is that a single critical mistake in a study will lead to a negative score on this one critical quality item. If that same study scores positively on all other items, this critical flaw in the study has little or no influence on the total quality score.
Of the 37 cross-sectional studies that investigated physical risk factors for neck pain, only four were rated as high-quality studies.[17-20] The mean total quality score for the cross-sectional studies was 4.3. Compared with the cut-off value of at least 7 for classification as a high-quality study, this value is low. The items on standardisation of the exposure and outcome measures were given the lowest scores. Only one study[20] presented data on the standardisation of the exposure measures, and only two studies presented such data for the outcome measures.[20,21] Many studies reported that they used standardised questionnaires, but presented no data to confirm this. It is clear that the three items concerning the standardisation of exposure and outcome measures did not discriminate between high- or low-quality studies, since hardly any of the studies scored positively on these items. This outcome is not surprising, because it were very strict items. Not only should

exposure and outcome assessment be standardised, but data to confirm the standardisation should also be presented. When these three standardisation items on the methodological quality list were not taken into account, the number of high-quality studies increased from 5 to 13.[2,17-20,22,41,42,45,47,50,52,53] Two of the three longitudinal studies were classified as high-quality studies.[2,22] The results of this sensitivity analysis lead to the conclusion that there is some evidence that neck flexion, arm force, arm posture, duration of (fixed) sedentary working posture, twisting or bending of the trunk, hand-arm vibration and workplace design factors are risk factors for neck pain. Inconclusive evidence was found for neck extension, neck rotation, driving a vehicle and sports and exercise. These results are more in line with the results of the reviews carried out by Kuorinka and Forcier[4] and Bernard.[5]

Conclusions

According to this systematic review, there is some evidence for a positive relationship between the duration of (fixed) sedentary posture at work and neck pain, and there is some evidence for a positive relationship between twisting or bending of the trunk at work and neck pain. It is clear that the low methodological quality of most of the studies described in this review was the main reason behind inconclusive evidence for risk factors that would be expected to be related to neck pain. A sensitivity analysis showed that a change in the quality assessment list resulted in a different conclusion, namely, that there is some evidence for a positive relationship between neck pain and neck flexion, arm force, arm posture, duration of (fixed) sedentary posture, twisting or bending of the trunk, hand-arm vibration and workplace design factors.

In contrast to reviews on the effectiveness of different types of interventions, methodological guidelines on the systematic review of observational studies are not available. The systematic review of observational studies on risk factors for musculoskeletal disorders is still in a very experimental stage. It is challenging to capture the wide range of possible biases that threaten the validity of the results of observational studies. However, there is much to gain from a systematic transparent method for the review process of observational epidemiologic studies.

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APPENDIX Methodological quality scores

Scores for items of quality assessment for all the studies in this review. The column headings correspond with the letters in front of the item definitions in Table 2.1. As can be seen in this table, not all the items were used in all three of the methodological quality assessment lists.

Reference	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	tot[a]
Andersen & Gaarboe[40]	+	+	-	.	.	-	-	-	-	+	+	-	-	.	.	?	.	.	.	+	+	+	5
Bergqvist *et al.*[41]	+	?	+	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	+	+	+	6
Bernard *et al.*[17]	+	+	+	.	.	+	?	+	?	-	+	-	+	.	.	?	.	.	.	+	+	?	7
Bovenzi *et al.*[42]	+	+	?	.	.	+	?	-	-	-	+	-	+	.	.	?	.	.	.	+	+	+	6
Bru *et al.*[21]	+	+	+	.	.	+	?	+	?	-	-	-	-	.	.	+	.	.	.	-	+	?	5
Chang *et al.*[24]	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Dartigues *et al.*[43]	+	+	?	.	.	+	?	+	?	+	-	?	-	.	.	?	.	.	.	+	+	?	5
Dimberg *et al.*[44]	+	-	+	.	.	+	?	?	?	+	+	-	-	.	.	?	.	.	.	-	+	?	5
Hales *et al.*[18]	+	+	+	.	.	+	?	+	?	+	+	-	-	.	.	?	.	.	.	+	+	-	7
Hünting *et al.*[34]	+	+	?	.	.	+	?	-	-	-	-	-	?	.	.	?	.	.	.	-	-	-	1
Hünting *et al.*[25]	-	+	?	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	1
Ignatius *et al.*[45]	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	6
Ingelgård *et al.*[26]	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Jacobsson *et al.*[27]	+	+	?	.	.	+	-	-	-	-	-	-	-	.	.	?	.	.	.	+	+	-	3
Johansson *et al.*[37]	+	+	?	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Johansson[38]	+	+	?	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Johansson, Rubenowitz[46]	+	-	+	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	+	+	5
Johansson[47]	+	+	-	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	6
Kajland *et al.*[35]	+	+	+	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Kamwendo *et al.*[19]	+	+	+	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	+	7
Kilbom *et al.*[48]	+	+	-	.	.	+	?	+	?	+	+	-	-	.	.	?	.	.	.	-	+	?	5
Lau *et al.*[49]	+	+	-	.	.	-	-	-	-	+	-	+	-	.	.	?	.	.	.	+	+	+	5
Linton[50]	+	+	?	.	.	+	?	+	?	+	-	-	-	.	.	?	.	.	.	+	+	+	6
MacKay Rossignol *et al.*[33]	+	+	+	.	.	+	?	-	-	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Mäkelä *et al.*[20]	+	+	+	.	.	+	+	+	+	-	-	?	-	.	.	+	.	.	.	+	+	+	9
Mundt *et al.*[23]	+	+	?	+	.	-	-	-	-	+	-	-	-	+	-	?	-	.	.	+	+	+	6
Musson *et al.*[51]	+	-	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	+	+	-	4
Ohlsson *et al.*[28]	+	+	?	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	?	3
Pocekay *et al.*[29]	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	+	?	3
Rosecrance *et al.*[30]	+	+	-	.	.	+	?	+	?	-	-	-	-	.	.	?	.	.	.	-	-	-	2
Rundcrantz *et al.*[36]	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	-	-	3
Rundcrantz *et al.*[39]	+	+	+	.	+	+	?	-	-	-	+	-	.	.	.	?	.	+	-	-	-	-	5
Schibye *et al.*[52]	+	+	+	.	.	+	-	-	-	-	+	-	?	.	.	?	.	.	.	+	+	?	5
Skov *et al.*[2]	+	+	-	.	.	+	?	+	?	+	-	-	-	.	.	?	.	.	.	+	+	+	6
Starr *et al.*[32]	+	+	?	.	.	+	?	-	-	-	-	-	?	.	.	?	.	.	.	-	-	-	1
Tharr[53]	+	+	+	.	.	+	?	+	?	-	+	-	-	.	.	?	.	.	.	+	+	?	6
Viikari-Juntura *et al.*[22]	+	+	-	.	+	+	?	+	?	+	+	?		.	.	?	.	+	-	+	+	+	9
Wells *et al.*[54]	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	-	4
Westgaard & Jansen[31]	+	-	?	.	.	-	-	-	-	+	-	+	-	.	.	?	.	.	.	-	+	?	3
Yu & Wong[55]	+	+	+	.	.	+	?	-	-	-	+	-	-	.	.	?	.	.	.	-	+	-	4

[a] Total score calculated by counting the number of positive validity/precision items

Chapter three

Psychosocial risk factors for neck pain: a systematic review

Summary

In order to identify the most important psychosocial risk factors for neck pain, a systematic review of the literature was carried out. The methodological quality of all studies in the review was assessed. Four levels of evidence were defined to assess the strength of evidence for potential risk factors for neck pain (strong, moderate, some or inconclusive evidence).

Some evidence was found for a positive relationship between neck pain and high quantitative job demands, low social (co-worker) support, low job control, high and low skill discretion and low job satisfaction. Inconclusive evidence was found for high job strain, low supervisor support, conflicts at work, low job security and limited rest-break opportunities.

The procedure of the assessment of the methodological quality and the rating system applied to distinguish between high-score and low-score studies, had a considerable influence on the level of evidence, indicating that changes in this procedure may have a major impact on the overall conclusions of this review.

Ariëns GAM, Mechelen W van, Bongers PM, Bouter LM, Wal G van der. Psychosocial risk factors for neck pain: a sysytematic review. Am J Ind Med 2001;39:180-193.

Musculoskeletal problems are a major problem in modern society. In the Netherlands, the costs of work-related sick leave and medical consumption are very high (US$ 4.8 billion a year). Around 40% of these total costs is due to musculoskeletal disorders.[1] Neck pain may not be the biggest musculoskeletal problem, but it still is substantial. Recent prevalence data showed that in a general population the one-year prevalence of neck pain was 15% and 17% for males and females, respectively.[2] Prevalence data in occupational settings are even more impressive. Skov *et al.* reported one-year prevalences of neck pain of 54% for males and 76% for females in a population of sales people (n=1,304).[3]

Neck pain is assumed to be a multi-factorial disease, implying that there are a number of risk factors contributing to the development of neck pain. Risk factors can be work-related or non-work-related. Furthermore, risk factors can be divided roughly in three groups, i.e., physical risk factors, psychosocial risk factors and individual-related risk factors. Many studies have been conducted to identify the most important risk factors for neck pain. Most studies focus on only one or a few risk factors, or on one particular category of risk factors. While most attention has always been given to physical risk factors for neck pain, psychosocial risk factors also seem to play a major role in the development of neck pain.

To identify the most important psychosocial risk factors for neck pain, a systematic review of the literature was carried out. This review deals with psychosocial risk factors at work and in leisure time, such as demands and control over work, work organisation factors, work satisfaction, and social support at work and in leisure time. Individual-related psychological factors such as coping behaviour are not within the scope of this review. A complementary systematic review concerning physical risk factors for neck pain has been published elsewhere.[4]

Methods

On-line searches in Medline, Embase, Psychlit, Sportdiscus, HSELINE, CISDOC and NIOSHTIC were carried out to identify all relevant studies. The search concerned the time period January 1966 to November 1997, using the following keywords (MeSH and text words): neck, neck pain, risk factors, determinants, causality, work, exercise, overuse, physical load, workload, psychosocial factors. Abstracts of all studies identified were read. If no abstract was available, or if, based on the abstract, it was unclear whether a study should enter this systematic review, the whole article was retrieved and read. In order to be included, a study had to meet the following criteria:

1. The study population must be a working population or a community-based population. Studies of patient populations were excluded.
2. The study design must either be case-control, cross-sectional, or cohort.
3. The assessment of exposure should at least concern one psychosocial factor at work or during leisure time.
4. The assessment of exposure may not be based just on job-titles.

5. The outcome can include one or more syndromes, signs or symptoms of the neck. The outcome can be a self-reported variable, as well as a clinical diagnosis. The outcome must be reported for the neck-region separately.
6. The study must be a full, peer-reviewed report published in the English, Dutch or German language.

Reference lists of included studies were checked for additional references. To check the selection procedure, a random sample of 30 studies was judged by a second reviewer to determine whether or not a study should be included in the review.

The methodological quality of all studies that entered the review was assessed by means of a methodological quality assessment list. After critically reviewing existing quality lists[5-7], a criteria list was developed to assess the methodological quality of observational studies. The criteria list contained various items on information and validity and/or precision in 5 categories: study purpose, study design, exposure measurements, outcome measurements, and analysis and data presentation. Separate quality assessment lists were constructed for cross-sectional, case-control and cohort studies. In Table 3.1 the items of the methodological quality assessment lists are presented. The first two items of the quality assessment list (items A and B) provide descriptive information only, while all other items of the list concern the validity and/or precision of the study.
For every item in the quality list, two independent reviewers (GA and WvM) rated each study either 'positive' (+), 'negative' (-), or 'unclear' (?) if a study did or did not meet an item, or if no clear information was stated regarding that item, respectively. Results of these two independent reviewers were compared and, if differing, in a meeting consensus upon each item was reached. For each study, a total quality score was calculated by counting the number of validity/precision items that were rated positively. Based on this total score, a study was either categorised as a high-score or low-score study. A high-score study was arbitrarily defined as a study that scored positively on at least 50% of the validity/precision items of the methodological quality list concerned. Low-score studies scored positively on less than 50% of the validity/precision items. The strength of evidence for potential risk factors was assessed by defining four levels of evidence as follows:

1. Strong evidence: consistent findings in multiple high-score cohort and/or case-control studies.
2. Moderate evidence: consistent findings in multiple cohort and/or case-control studies, of which only one study is a high-score study.
3. Some evidence: findings of one cohort or case-control study, or consistent findings in multiple cross-sectional studies of which at least one study is a high-score study.
4. Inconclusive evidence concerns all other cases, i.e., consistent findings in multiple low-score cross-sectional studies, or inconsistent findings in multiple studies. Moreover, the evidence is considered to be inconclusive if only one cross-sectional study is available, irrespective of the quality of this study.

Table 3.1 Description of the different items in the quality assessment lists

Study purpose	
A	Positive if a specific, clearly stated purpose was described (Cr Ca Pr[a])[b]
Study design	
B	Positive if the main features (description of sampling frame, distribution by age and sex) of the study population were stated (Cr Ca Pr)[b]
C	Positive if the participation rate at baseline was at least 80% (Cr Ca Pr)
D	Positive if cases and controls were drawn from the same population and a clear definition of cases and controls was stated. Persons with neck pain in the last 90 days had to be excluded from the control group (Ca)
E	Positive if the response after one year of follow-up was at least 80%, or if the non-response was not selective (Pr)
Exposure measurements	
F	Positive if data on physical load at work were collected and used in the analysis (Cr Ca Pr)
G	Positive if data on physical load at work were collected using standardised methods of acceptable quality[c] (Cr Ca Pr)
H	Positive if data on psychosocial factors at work were collected and used in the analysis (Cr Ca Pr)
I	Positive if data on psychosocial factors at work were collected using standardised methods of acceptable quality[c] (Cr Ca Pr)
J	Positive if data on physical and psychosocial factors during leisure time were collected and used in the analysis (Cr Ca Pr)
K	Positive if data on historical exposure at work were collected and used in the analysis (Cr Ca Pr)
L	Positive if data on history of neck pain, sex and age were collected and used in the analysis (Cr Ca Pr)
M	Positive if the exposure assessment was blinded with respect to disease status (Cr Ca)
N	Positive if exposure was measured in an identical way in cases and controls (Ca)
O	Positive if the exposure was assessed at a time prior to the occurrence of the outcome (Ca)
Outcome measurements	
P	Positive if data on outcome were collected with standardised methods of acceptable quality[d] (Cr Ca Pr)
Q	Positive if incident cases were used (prospective enrollment) (Ca)
R	Positive if data on outcome were collected for at least one year (Pr)
S	Positive if data on outcome were collected at least every three months (Pr)
Analysis and data presentation	
T	Positive if the statistical model used was appropriate for the outcome studied and the measures of association estimated with this model were presented (including confidence intervals) (Cr Ca Pr)
U	Positive if the study controled for confounding (Cr Ca Pr)
V	Positive if the number of cases in the multivariate analysis was at least ten times the number of independent variables in the analysis (Cr Ca Pr)

[a] This item was used in the quality list for cross-sectional (Cr), case-control (Ca) or prospective cohort studies (Pr); [b] This is an information item, and therefore not taken into account when calculating the total quality score; [c] This item was scored positive if one of the following criteria is met: 1) for direct measurements, intraclass correlation coefficient >0.60 or Kappa >0.40; 2) for observational methods, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability; and 3) for self-reported data, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability; [d] This item was scored positive if one of the following criteria is met: 1) for self-reported data, intraclass correlation coefficient >0.60 or Kappa >0.40; 2) for registered data, data must show that registration system is valid and reliable; and 3) for physical examination, intraclass correlation coefficient >0.60 or Kappa >0.40 for the inter- or intraobserver reliability

Cross-sectional studies that were rated lowest for quality according to the methodological quality list (score of 3 or less) were excluded from the analysis for the determination of the strength of evidence.
A positive, a negative or no effect of a risk factor can be found in the publications reviewed. A positive effect is defined as an increased risk for the occurrence of neck pain due to the presence of a risk factor. In contrast, a decreased risk for the occurrence of neck pain due to the presence of a risk factor was defined as a negative effect. No effect implied that the presence of a risk factor was neither associated with an increased nor with a decreased risk for the occurrence of neck pain. The focus of this review was on the size and direction of the risk estimate, irrespective of the level of significance. A study that reported a nonsignificant association between a risk factor and neck pain, with no mention of the risk estimate was eliminated from the determination of the level of evidence. This ignorance of statistical significance and exclusion of nonsignificant study results (without the mention of a risk estimate), was based on the fact that in most studies no sufficient information is presented on the possible reason for finding nonsignificant results: either there was no association or there was a lack of statistical power due to, for example, a small study population.[8]
Reporting a significant association without stating the risk estimate was considered as a finding and thus contributed to the level of evidence.
Consistent findings implied that the results of at least 75% of the studies investigating the effect of a certain risk factor pointed in the same direction. The risk estimates and p-values reported by these studies should lead to the same conclusion, i.e., that a positive, negative or no effect was found in relation to neck pain.
The same methods have been used in our systematic review on physical risk factors for neck pain.[4]

Results

Identification of studies and quality assessment

Out of 1026 studies identified, 29 studies were included in this review. All studies included but one, a prospective cohort study of Viikari-Juntura *et al.*[9], had a cross-sectional design. The most important reason to be excluded from this review was the use of a combined outcome measure[10-16], meaning that these studies did not report their results separately for the neck region, but combined the neck region with another body region (most often the shoulder region). The two independent reviewers agreed on inclusion or exclusion for 90% of the studies in the random sample. After discussion with a third person, consensus was reached on inclusion or exclusion of all studies.

In the Appendix at the end of this chapter the results of the assessment of the methodological quality of all studies included in this review are presented. The percentage of agreement between the two independent reviewers on the

methodological quality assessment was 86,3%. All disagreements between the two reviewers were discussed and resolved in a consensus meeting, and for each study, a final score was given on every item.
Twenty-eight studies collected and analysed data concerning psychosocial factors at work. One additional study did not collect data on psychosocial factors at work. However, in this study, data on psychosocial factors during leisure time were collected.[17] The items in the quality list that were most often scored negative, were those concerning the use of standardised exposure measurements of acceptable quality (items G and I) and item L, the item that was scored positive if data on a history of neck disorders, sex and age were collected and used in the analysis. Only once, these items were scored positive. The items on blinding of the exposure assessment and on the use of standardised methods for the outcome measures (items M and P) were scored positive only twice. Confounding was controlled for by 23 out of 29 studies (item U) and 22 studies had also collected data on physical exposure at work. Nine cross-sectional studies scored 3 or less points on the quality list.[17-25] They were excluded from the determination of the level of evidence. The final number of studies to be used for the level of evidence synthesis is therefore 20. Of these 20 studies, 5 scored positive on more than 50% of the validity/precision items of the methodological quality list, and were defined as being high-score studies. Table 3.2 gives a brief description of the studies that have been used for the determination of the level of evidence.

Table 3.2 Descriptive information of all studies included in this review that had a total quality score of 4 or more

Reference **Design, MCS**[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Kilbom *et al.*[26] Cr[b], 5	Female assembly line workers of 2 electronic manufacturing companies Response at baseline 77% (n=106)	Severity of self-reported neck symptoms	*Work-related factors* Overtime work (ns)[c]; Perceived psychological stress at work (ns); Work satisfaction (ns); Number of breaks and rest pauses at work (ns)
Dartigues *et al.*[39] Cr, 5	A working population (n=990)	Self-reported recurrent cervical pain syndrome	*Work-related risk factors* Conflict related to work (OR=3.1, 2.0-4.8)[d] *None-work-related risk factors* Conflict related to family (OR=1.8, 1.1-3.0)
Musson[27] Cr, 4	Workers using various types of impact tools (n=445) Response at baseline 38% (n=169)	Self-reported regularly pain or stiffness in the neck	*Work-related factors* Time pressure (ns)

Table 3.2 Continued

Reference **Design, MCS**[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Linton[28] Cr, 6	Full-time employees working daytimes (n=22,180)	Self-reported neck pain	*Work-related risk factors* Monotonous work (OR=2.25-2.95)[e]; Overall psychosocial score (OR=1.89-2.57); Poor work content (OR=1.94-2.47); Low social support (OR=1.38-2.57); High psychosocial work load (OR=1.24-1.49)
Kamwendo *et al.*[29] Cr, 7	Female medical secretaries and office personnel Response at baseline 96% (n=420)	Self-reported neck pain	*Work-related risk factors* Poorly experienced psychosocial work environment (p=0.004)[f]; Interesting and stimulating work (ns); Work variation (ns); Friendly spirit of co-operation with fellow workers (p=0.013); Help and support if you run into difficulties in your work (ns); Ability to influence working conditions (p=0.001); Too much to do (p=0.010); Good contact and co-operation with superiors (ns); Demands of your work too great (ns); Anxiety feelings about possible reorganisation or new techniques in your work (ns)
Bernard *et al.*[30] Cr, 9	Newspaper employees using video display terminals Response at baseline 93% (n=973)	Self-reported neck symptoms	*Work-related risk factors* Number of hours spent under a deadline per week (OR=1.7, 1.4-3.0); Work variance (OR=1.7, 1.2-2.5); Number of breaks (ns); Job control (ns); Job security (ns); Interaction with co-workers or customers (ns); Group conflict (ns) *Non-work-related risk factors* Lack of social support from spouses and friends (ns)
Mäkelä *et al.*[43] Cr, 9	Finnish adults drawn from the population register, representing the Finnish adult population of 30 years and older Response at baseline 90% (n=7,217)	Chronic neck syndrome	*Work-related factors (30-64 year)* Mental stress at work (OR=1.20, 1.12-1.28) *Work-related factors (>64 years)* Mental stress at work (OR=1.27, 1.11-1.46)

Table 3.2 Continued

Reference Design, MCS[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Hales *et al.*[31] Cr, 7	Telecommunication employees using video display terminals for at least six hours per day Response at baseline 96% (n=512)	Self-reported neck disorders	*Work-related risk factors* Routine work lacking decision making opportunities (OR=4.2, 2.1-8.6); Lack of productivity standard (OR=3.5, 1.5-8.3); Fear of being replaced by computers (OR=3.0, 1.5-6.1); High information processing demands (OR=3.0, 1.4-6.2); Job requires a variety of tasks (OR=2.9, 1.5-5.8); Increasing work pressure (OR=2.4, 1.1-5.5)
Ignatius *et al.*[41] Cr, 6	Female typists working in the Government Housing Department Response at baseline 52% (n=170)	Self-reported neck pain	*Work-related factors* No rest other than lunch breaks (ns)
Johansson and Rubenowitz[32] Cr, 5	Blue and white collar workers from 8 large metal industry companies Response at baseline 90% (n=450)	Self-reported neck symptoms	*Work-related factors (bc[g] workers)* Low influence on and control over work (ns); Poor supervisor climate ($p<0.05$); Low stimulus from the work (ns); Poor relations with fellow workers (ns); High psychological work load ($p<0.001$) *Work-related factors (wc[h] workers)* Low influence on and control over work (ns); Poor supervisor climate (ns); Low stimulus from the work (ns); Poor relations with fellow workers (ns); High psychological work load (ns)
		Self-reported neck symptoms, symptoms must be work-related	*Work-related factors (bc workers)* Low influence on and control over work (ns); Poor supervisor climate ($p<0.05$); Low stimulus from the work ($p<0.05$); Poor relations with fellow workers (ns); High psychological work load ($p<0.001$); *Work-related factors (wc workers)* Low influence on and control over work ($p<0.05$); Poor supervisor climate (ns); Low stimulus from the work (ns); Poor relations with fellow workers (ns); High psychological work load ($p<0.01$)

Table 3.2 Continued

Reference Design, MCS[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Viikari-Juntura *et al.*[9] Pr[i], 9	Male machine operators, carpenters and office workers Response at baseline 69% (n=2,222) Response at follow-up 82% (n=1,832)	Self-reported neck pain, change from 1984-1987: - none to moderate - none to severe - persistent severe	 *Work-related factors* Job satisfaction (ns) *Work-related factors* Job satisfaction (OR=1.7, 1.1-2.6) *Work-related factors* Job satisfaction (ns)
Ahlberg-Hultén *et al.*[34] Cr, 5	Female nurses and nurse's aides Participation rate 79% (n=90)	Self-reported pain in the neck	*Work-related factors* Feeling of isolation (0.01, p=0.92)[j]; Poor relations with superiors (-0.14, p=0.40); Conflicts (0.11, p=0.52); Stress (0.08, p=0.72); Intensity of authority over decisions (0.05, p=0.71); High psychological demands (0.00, p=0.97); Low skill utilisation (-0.03, p=0.73); High job strain (-0.43, p=.67; 0.59, p=0.62)[k]
Bergqvist *et al.*[42] Cr, 6	Office workers (n=353) Response Q[l] 92% Response PE[m] 91% Response WA[n] 82%	Tension neck syndrome	*Work-related factors* Limited rest-break opportunities (OR=7.4, 3.1-17.4)
Johansson[33] Cr, 6	Home care workers (n=305)	Self-reported neck symptoms Self-reported work-related neck symptoms	*Work-related factors* Low influence and control over work (RR=1.27, 1.00-1.62)[o]; Poor supervisor climate (RR=1.23, 0.99-1.53); Low stimulus from the work itself (RR=1.33, 1.05-1.67); Poor relationships with fellow workers (RR=1.19, 0.94-1.50); High psychological work load (RR=1.52, 1.20-1.94; p<0.001) *Work-related factors* Low influence and control over work (RR=1.30, 0.93-1.81); Poor supervisor climate (RR=1.29, 0.93-1.79); Low stimulus from the work itself (RR=1.52, 1.10-2.11); Poor relationships with fellow workers (RR=1.20, 0.87-1.65); High psychological work load (RR=1.83, 1.28-2.61; p<0.001)

Table 3.2 Continued

Reference Design, MCS[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Lagerström *et al.*[35] Cr, 5	Female nursing personnel of a hospital Response at baseline 84% (n=688)	Self-reported ongoing neck symptoms	*Work-related factors* Low work commitment (OR=1.67, 1.10-2.60; OR=1.65, 1.07-2.54); Low support from superiors (OR=2.08, 1.32-3.26; OR=2.03, 1.28-3.16); High work demand (ns); Lack of stimulation (ns); Low work control (ns)
		Self-reported severe ongoing neck symptoms (>6 on a 10-point scale from 'not at all' to 'very much')	*Work-related factors* Low work commitment (ns); Low support from superiors (ns); High work demand (OR=1.82, 1.14-2.92; OR=1.82, 1.14-2.92); Lack of stimulation (ns); Low work control (ns)
Tharr[40] Cr, 6	Teleservice representatives drawn from 2 teleservice centres Response at baseline 95% (n=108)	Self-reported neck symptoms	*Work-related factors* High workload variability (OR=1.2, 1.0-1.4)
Bru *et al.*[36] Cr, 5	Female hospital staff Response at baseline 85% (n=586)	Neck pain index (based on self-reported data)	*Work-related factors* Work overload (p=0.004); Poor social relations (p=0.005); Poor work content (p=0.03)
Skov *et al.*[3] Cr, 6	Random 8% sample of the members of the association of Danish Active Salespeople Response at baseline 66% (n=1,306)	Self-reported neck symptoms	*Work-related factors* High demands in the work (ns); Variation in the work (highest quartile is reference value), next to highest quartile (OR=1.78, 1.16-2.73), next to lowest quartile (ns), lowest quartile (OR=1.82, 1.23-2.69); Control over time, low compared to high control (OR=1.44, 1.07-1.93), medium compared to high control (ns); Perceived competition, high compared to low competition (OR=1.44, 1.08-1.91), medium compared to low perceived competition (ns)

Table 3.2 Continued

Reference Design, MCS[a]	**Study population**	**Outcome measure(s)**	**Psychosocial risk factor(s) and strength of association**
Toomingas *et al.*[37] Cr, 4	Male furniture movers, female medical secretaries and males and females of the working population	Self-reported neck symptoms in past 12 months	*Work-related factors* High psychological demands (PR=1.5, 1.1-2.0)[p]; High decision latitude (ns); High social support (PR=1.6, 1.1-2.3); High job strain (PR=1.6, 1.1-2.2)
	Response at baseline 71% (n=358)	Neck sign: neck tenderness	*Work-related factors* High psychological demands (PR=2.0, 1.1-3.7); High decision latitude (ns); High social support (ns); High job strain (PR=2.1, 1.2-3.7)
		Neck sign: neck movement restriction	*Work-related factors* High decision latitude (ns); High job strain (ns)
		Neck syndrome: neck tension syndrome	*Work-related factors* High psychological demands (ns); High decision latitude (ns); High social support (PR=2.7, 1.1-6.7); High job strain (ns)
Zettenberg *et al.*[38] Cr, 6	Car assembly workers (N=564)	Self-reported neck complaints	*Work-related factors* Good relation with workmates or foreman (p<0.01; p<0.01); Low work satisfaction (p<0.04); Stress at work (p<0.001)
		Neck myalgia	*Work-related factors* Good relation with workmates or foreman (ns); Work satisfaction (ns); Stress at work (p<0.005)

[a] Methodological quality score; [b] Cross-sectional study; [c] Not significant; [d] Odds ratio and 95% confidence interval; [e] Several odds ratios are presented within this range for different age groups; [f] P-value; [g] Blue collar; [h] White collar; [i] Prospective cohort study; [j] Coefficient and corresponding p-value; [k] If two analysis are carried out, results of both analysis are presented; [l] Questionnaire; [m] Physical examination; [n] Work place assessment; [o] Rate ratio and 95% confidence interval; [p] Prevalence ratio and 95% confidence interval

Levels of evidence

As can be seen in Table 3.2, various psychosocial factors were examined. All these factors were grouped into 9 categories of psychosocial factors. The results concerning the determination of the level of evidence for these 9 categories are described below and summarised in Table 3.3.

Table 3.3 Summary of the results concerning the level of evidence synthesis

Risk factor	Direction of the association	Number of high-score and low-score studies[a]	Number of studies with positive effect[b]	Level of evidence
Quantitative job demands	- high	High: 3 Low: 7	High: 3 Low: 6	Some
Social support at work	- low	High: 1 Low: 8	High: 1 Low: 7	Some
- supervisor support	- low	High: 0 Low: 4	High: 0 Low: 3	Inconclusive
- co-worker support	- low	High: 1 Low: 1	High: 1 Low: 1	Some
Conflicts at work	- yes	High: 0 Low: 2	High: 0 Low: 1	Inconclusive
Conflicts in leisure time	- yes	High: 0 Low: 1	High: 0 Low: 1	Inconclusive
Job control	- low	High: 2 Low: 4	High: 2 Low: 3	Some
Skill discretion	- low	High: 1 Low: 6	High: 1 Low: 5	Some
	- high	High: 1 Low: 1	High: 1 Low: 1	Some
Job strain	- high	High: 0 Low: 3	High: 0 Low: 2	Inconclusive
Job satisfaction	- low	High: 1 Low: 3	High: 1 Low: 3	Some
Job security	- low	High: 1 Low: 0	High: 1 Low: 0	Inconclusive
Rest-break opportunities	- limited	High: 0 Low: 1	High: 0 Low: 1	Inconclusive

[a] Number of high-score (High) and low-score (Low) studies that are used for the determination of the level of evidence; [b] Number of high-score (High) and low-score (Low) studies that reported a positive effect of a risk factor, i.e., an increased risk for the occurrence of neck pain

Quantitative job demands

A total of 13 cross-sectional studies investigated the effect of high quantitative job demands in relation to neck pain.[3,26-37] Three of these studies were rated as high-score studies.[29-31] Three studies have not been taken into account for the determination of the level of evidence, because they reported a nonsignificant relationship between psychosocial workload and neck pain without mentioning a risk estimate.[3,26,27] In their high-score study, Hales *et al.* reported an odds ratio of 2.4 for the relationship between increasing work pressure and self-reported neck pain.[31] The high-score study of Bernard *et al.* reported an odds ratio of 1.7 for the relationship between neck pain and an increased number of hours spent working under a deadline.[30] Kamwendo *et al.* showed a p-value of 0.01 for the relationship between neck pain and the following statement: 'I have too much to do'.[29] Several low-score cross-sectional studies, investigating the relationship between high quantitative job demands and neck pain, confirmed the results found in the high-score studies.[28,32,33,35-37] One low-score study could not detect a relationship between high quantitative job demands and neck pain.[34] Based on the results described above, it is concluded that some evidence is found for a positive relationship between high quantitative job demands and neck pain.

Social support

Ten cross-sectional studies investigated the relationship between work-related social support and neck pain.[28-30,32-38] Two of these studies were classified as being high-score studies.[29,30] One of these high-score studies was not taken into account for the determination of the level of evidence, since this study only reported that the relationship between low social support and neck pain was not significant, without mentioning a risk estimate.[30] Kamwendo *et al.* reported a p-value of 0.013 for the relationship between neck pain and 'a poor spirit and co-operation with fellow workers' in their high-score study.[29] Seven out of eight low-score cross-sectional studies[28,32,33,35-38] confirm the results of Kamwendo *et al.*[29], leading to the conclusion that there is some evidence of a positive relationship between poor social support at work and neck pain.

With respect to work-related social support, supervisor support and co-worker support can be distinguished. The relationship between supervisor support and neck pain was investigated by 5 cross-sectional studies[29,32-35], one of which was a high-score study.[29] Despite the high score of the study of Kamwendo *et al.*[29], a nonsignificant relationship was reported, without the mention of a risk estimate. Three out of the remaining 4 low-score cross-sectional studies suggested a positive relationship between poor supervisor support and neck pain. However, due to the low score of these cross-sectional studies, it is concluded that there is inconclusive evidence for the relationship between low supervisor support and neck pain.

Results regarding the relationship between co-worker support and neck pain are reported by 3 cross-sectional studies.[29,32,33] One study was not included in the determination of the level of evidence, since only a nonsignificant relationship without a risk estimate was mentioned.[32] In their high-score study, Kamwendo *et al.* reported a p-value of 0.013 for the relationship between poor co-worker support and neck pain.[29] In the low-score study of Johansson this result was confirmed[33], leading to the conclusion that there is some evidence for a positive relationship between poor co-worker support and neck pain.

Finally, as the only study in this review, the high-score study of Bernard *et al.* studied the relationship between neck pain and the lack of social support by friends and family.[30] However, they reported a nonsignificant association and no risk estimate was mentioned. This leads to the conclusion that there is inconclusive evidence for such a relationship.

Conflicts

Three cross-sectional studies investigated the relationship between conflicts at work and neck pain.[30,34,39] The study of Bernard *et al.* was a high-score study, however, reported that the relationship between neck pain and conflicts at work was not significant, without reporting a risk estimate.[30] The other two studies, the studies of Ahlberg-Hultén *et al.* and Dartiques *et al.* were low-score cross-sectional studies.[34,39] Due to the low score of these two studies, it is concluded that there is inconclusive evidence for a relationship between conflicts at work and neck pain.
One study also investigated the effect of non-work-related conflicts on the occurrence of neck pain.[39] An odds ratio of 1.8 was reported for this relationship. Due to the fact that no other studies in this review investigated this relationship, inconclusive evidence was found for the relationship between non-work-related conflicts and neck pain.

Job control

Nine cross-sectional studies studied the risk factor job control in relation to neck pain.[3,29-35,37] Three of these studies were not taken into account because they stated that the relationship between job control and neck pain was not significant without the report of a risk estimate.[30,35,37] Of the remaining six studies, two were qualified as high-score studies.[29,31] Both these studies reported results suggesting a positive relationship between low job control and neck pain. Firstly, Hales *et al.* reported an odds ratio of 4.2 for the relationship between neck pain and routine work lacking decision making opportunities.[31] Secondly, Kamwendo *et al.* showed a p-value of 0.001 for the relationship between low ability to influence working conditions and neck pain.[29] Three low-score cross-sectional studies confirmed the results of the high-score studies.[3,32,33] One low-score cross-sectional study could not identify a relationship between job control and neck pain.[34] Based on the results of 6 cross-sectional studies, of which two were high-score studies, it is concluded that there is some evidence for a positive relationship between low job control and neck pain.

Skill discretion

Nine cross-sectional studies reported results on the relationship between low skill discretion and neck pain. Two studies were high-score studies[29,30], seven studies were classified as low-score studies.[3,28,32-36] One low-score and one high-score study reported that the relationship between skill discretion and neck pain was not significant without reporting a risk estimate.[29,35] In their high-score study, Bernard *et al.* reported an odds ratio of 1.7 for the relationship between neck pain and low work variance.[30] Five low-score cross-sectional studies confirmed the results of Bernard *et al.*, all suggesting a positive relationship between low skill discretion and neck pain.[3,28,32,33,36] One low-score cross-sectional study could not identify a relationship between skill discretion and neck pain.[34] Based on the results of the 6 studies that were used for the determination of the level of evidence, it is concluded that there is some evidence for a positive relationship between low skill discretion and neck pain. On the contrary, two studies investigated the effect of high skill discretion on neck pain.[31,40] In their high-score study, Hales *et al.* reported an odds ratio of 2.9 for the relationship between neck pain and a variety of job tasks.[31] Tharr reported an odds ratio of 1.2 for high work load variability in relation to neck pain.[40] Based on the finding of these two cross-sectional studies, of which one is a high-score study, it is concluded that there is some evidence for a positive effect of high skill discretion in relation to neck pain.

Job strain

A total of 4 cross-sectional studies investigated the relationship between high job strain and neck pain.[26,34,37,38] One of these studies reported a nonsignificant relationship between perceived psychological stress at work and neck pain, but did not mention a risk estimate.[26] Three studies remained for the determination of the level of evidence. Due to the low score of these studies, and irrespective of their results, it is concluded that there is inconclusive evidence for a relationship between high job strain and neck pain.

Job satisfaction

Three low-score cross-sectional studies[26,36,38] and one high-score prospective study[9] investigated the relationship between job satisfaction and neck pain. Viikari-Juntura *et al.* reported an odds ratio of 1.7 for the relationship between low job satisfaction and the change in neck pain from no neck pain at baseline till severe neck pain at follow up.[9] This result suggested a positive relationship between low job satisfaction and the development of neck pain. Zettenberg *et al.* and Bru *et al.* reported p-values of 0.04 and 0.03 respectively, for the relationship between low job satisfaction and neck pain.[36,38] Kilbom *et al.* reported that this relationship was not significant, without mentioning a risk estimate.[26] Based on the results of one high-score prospective study of Viikari-Juntura *et al.* and two low-score cross-sectional studies of Zettenberg *et al.* and Bru *et al.*, it is concluded that there is some evidence for a positive relationship between low job satisfaction and neck pain. One additional study investigated the relationship between neck pain and low work commitment.[35] If 'low work commitment' is considered to represent low job satisfaction, the study of Lagerström *et al.*[35] should also be taken into account for the determination of the level of evidence. The conclusion, that there is some evidence for a positive relationship between low job satisfaction and neck pain, will not change if this additional study is added.

Job security

A total of 3 cross-sectional studies, all defined as high-score studies, reported results concerning the relationship between low job security and neck pain.[29-31] Two of these studies reported a nonsignificant relationship between job security and neck pain, without mentioning a risk estimate.[29,30] Hales *et al.* reported an odds ratio of 3.0 for the relationship between 'the fear of being replaced by a computer' and neck pain in their high-score study.[31] Since only one study reported results to determine the level of evidence, it is concluded that there is inconclusive evidence for the relationship between low job security and neck pain.

Rest-break opportunities

Of the four cross-sectional studies that reported results on the relationship between neck pain and rest-break opportunities, three studies stated that this relationship was not significant. No risk estimate was presented.[26,30,41] Bergqvist *et al.* reported an odds ratio of 7.4 for the relationship between 'limited rest-break opportunities' and neck pain.[42] Based on only one low-score cross-sectional study, it is concluded that there is inconclusive evidence for the relationship between rest-break opportunities and neck pain.

Discussion

In order to identify psychosocial risk factors for neck pain, a systematic review of the literature was carried out. The results showed some evidence for a positive relationship between neck pain and high quantitative job demands, poor social (co-worker) support, low job control, low skill discretion, and low job satisfaction. Inconclusive evidence was found for the relationship between neck pain and poor supervisor support, conflicts at work, low job security, high job strain and limited rest-break opportunities (Table 3.3). Other factors, such as feelings of isolation and lack of productivity standards were taken into consideration by some of the studies in this review, although these factors were not used in the determination of the level of evidence. The reason for this was that it was difficult to place these factors within any of the nine categories of risk factors identified in this review. Furthermore, in three studies very general measures for psychosocial exposure at work were used, such as 'mental stress at work' or 'overall psychosocial score'.[28,29,43] Since the focus of this review was on specific aspects of the psychosocial exposure, these general measures were not discussed.

The risk factor 'skill discretion' was studied in different ways. Eight studies investigated the effect of low skill discretion on the occurrence of neck pain, while two studies looked at the effect of high skill discretion in relation to neck pain. For both high and low skill discretion it was concluded that there is some evidence for a relationship with neck pain, suggesting an U-shaped relationship between skill discretion and neck pain.

Several investigators suggest three mechanisms that account for possible associations between psychosocial factors and musculoskeletal disorders.[44-46] Firstly, they suggest that psychosocial demands can exceed an individual's coping capabilities, resulting in a stress response, which, in turn, can produce muscle tension or static loading of the muscles or generate other physiological responses that may result in neck pain. As a second mechanism, they suggest that psychosocial demands may affect the awareness and reporting of musculoskeletal disorders, or increase its attribution to the work environment. As a third possible mechanism, it is stated that, in a certain situation, psychosocial demands may be highly correlated with physical demands. This suggests that any association between a psychosocial risk factor and musculoskeletal disorders may actually reflect a relationship between a physical risk factor and musculoskeletal disorders.

As stated above it is hypothesised that psychosocial and physical demands may be highly correlated. Studies on psychosocial risk factors for neck pain should therefore also take the physical workload into account in their analyses. In this review, several studies did not assess the physical workload.[17,19,20,34,35,37,38] In order to test the effect of these studies on the level of evidence of the psychosocial factors, a sensitivity analysis was carried out. In this analysis, studies that did not assess or control for work-related physical exposure (studies that scored negative or unknown on item F of the quality list) were eliminated. Without these studies, the level of evidence for the different psychosocial variables in this review was determined again. Exclusion of these studies had no effect on the results regarding the level of evidence for the different psychosocial factors in this review.

Three other literature reviews were found focusing on psychosocial risk factors for neck pain. Bongers *et al.* discussed the literature for psychosocial risk factors at work for musculoskeletal disorders.[44] They concluded that a relationship between psychosocial variables, such as monotonous work, time pressure, poor work content, and high workload, and symptoms of the neck or shoulders seemed likely. For the risk factor social support, they found contradictory results, whereas in our review some evidence was found for co-worker support and inconclusive evidence was found for supervisor support. However, a comparison between the results of the review of Bongers *et al.* and this review is difficult, since Bongers *et al.* also included studies that combined neck symptoms with shoulder symptoms.

Hales and Bernard have critically examined the literature to describe psychosocial risk factors that are associated with neck disorders.[46] Hales and Bernard stated that high work load, perceived time pressure, work pressure, high work load variability, poor work content, and monotonous work are associated with musculoskeletal complaints of the upper extremities. However, they stated that most of the studies based the case-definition of musculoskeletal disorders on self-reports of neck and shoulder symptoms. In the present review, studies using a combined outcome measure (for example the combination of the neck region and shoulder region) were not included, therefore making it hard to compare the results of this review with the results found by Hales and Bernard.

In the NIOSH-review of Bernard neck disorders were combined with shoulder, elbow, hand, and wrist disorders.[47] Bernard concluded that intensified workload, monotonous work, and low levels of support have a positive association with these upper extremity disorders. Moreover, lack of control over the job and low job satisfaction were also positively associated with these disorders, although not as strongly. Bernard also stated that the evidence for the relationships between these factors and upper extremity disorders were stronger for disorders related to the neck/shoulder region in comparison to the hand/wrist region. Again, the comparison of the results of the review of Bernard with this review is difficult, since no results for the neck as a separate region were reported by Bernard.

For this review several databases were systematically searched to identify all relevant studies. It is crucial to find all possible studies, involving the subject of this review. Many risk factor studies do not consider one outcome measure, but investigate several outcome measures, neck pain being one of them. If in these studies the main focus is not on neck pain but, for example on low back pain, these studies might have used keywords relating only to low back pain in stead of also to neck pain. Consequently, it is possible that these studies were missed during the literature search. The number of studies that was found in the literature for several psychosocial factors in this review was small. One additional study could have changed the conclusion regarding the level of evidence. Consequently, missing a study, even if this was not selective with regard to the study results, may have influenced the conclusion regarding the level of evidence for these psychosocial factors.
The most important reason for exclusion of a study from this review was the fact that results of a study were not reported for the neck region separately. A lot of studies do not use neck pain as an outcome measure, but used a combination of neck and/or shoulders pain as the outcome measure.[10-16] Since the objective of this review was to identify risk factors for neck pain, these studies were excluded. In the excluded studies, it is often unclear what was meant by neck and/or shoulder pain. Pain in the proximal part of the upper arm may also have been included in these studies. Other risk factors may be of influence to determine whether pain in this region will exist, and therefore these studies were excluded. However, on the other hand this may have lead to the exclusion of studies that did actually investigate the neck region.
Most of the studies identified were cross-sectional studies. No case-control study and only one prospective cohort study entered this review.[9] In cross-sectional research both risk factors and outcome are measured at the same time. Therefore, in cross-sectional research, cause and effect cannot be distinguished and a causal relationship can hardly be established. The reason to include cross-sectional studies in this review, despite of this disadvantage, was that most research on risk factors for neck pain is actually carried out with the use of a cross-sectional design. Although perhaps desirable from a pure methodological standpoint, it would not be acceptable to neglect this large amount of information obtained from cross-sectional research. The maximum level of evidence that consequently could be reached was 'some

evidence', due to the fact that there was only one (high-score) prospective study included in this review.

A quality list was constructed to assess the methodological quality of the studies in this review. This list consists of several items in different categories concerning information, validity and precision. A total quality score was calculated by counting the number of validity and precision items in the criteria list that were scored positively. Based on this obtained total quality score, studies were labelled as either being a high-score study or a low-score study. Four levels of evidence were defined to establish the strength of evidence for a relationship between a risk factor and neck pain. Obviously, this procedure and our rating system had a considerable influence on the assessment of the level of evidence, meaning that changes in this procedure may have had an impact on the results. The methodology of rating of the methodological quality of studies is widely used in systematic reviews on the effectiveness of certain clinical treatments, but is new and still in an experimental stage for systematic reviews of observational studies. No established guidelines for rating procedures for such studies are available yet. In the quality list developed for this review some items, especially the items on the use of standardised methods for the collection of exposure and outcome (items G,I and P), in retrospect did not really discriminate between high and low-score studies, since almost all studies scored negative on these items. If these three items would not be taken into account the number of high-score studies would increase from 5 till 12 studies.[3,9,27-31,33,38,40-43] This sensitivity analysis would lead to the conclusion that, in addition to the previously mentioned factors, some evidence is also found low supervisor support (data not shown).

Many studies in this review just reported that the relationship between a risk factor and neck pain was not significant, without mentioning the risk estimate. Since the direction of such a result is unclear, it was decided not to take these studies into account for the determination of the level of evidence. If the report of a nonsignificant relationship would be interpreted as no relationship, and these results would be taken into account for the determination of the levels of evidence, some evidence would be found for a positive relationship between neck pain and low social support, low job satisfaction and high skill discretion. In addition, some evidence would be found for no relationship between limited rest-break opportunities and neck pain. Inconclusive evidence would be found for all other risk factor discussed in this review.

Conclusions

In conclusion, this systematic review shows some evidence for a positive relationship between neck pain and the following psychosocial risk factors: high quantitative job demands, low social (co-worker) support, low job control, high as well as low skill discretion, and low job satisfaction. Furthermore, it should be concluded that, due to the study design, study population and data analysis of observational studies, it appeared to be difficult to construct a valid and reliable quality assessment list, that could be used to determine the quality of observational studies. Although major pitfalls still have to be accounted for, we still feel that there is much to gain from a systematic and transparent method for the review of observational studies.

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APPENDIX Methodological quality scores

The scores on the items of the quality assessment list for all studies in the review. The letters on the first row correspond with the letters in front of the item definitions in Table 3.1.

Reference	A	B	C	E	F	G	H	I	J	K	L	M	P	R	S	T	U	V	tot[a]
Kilbom *et al.*[26]	+	+	-	.[b]	+	?	+	?	+	+	-	-	?	.	.	-	+	?	5
Chang *et al.*[18]	+	+	-	.	+	?	+	?	-	+	-	-	?	.	.	-	-	-	3
Dartiques *et al.*[39]	+	+	?	.	+	?	+	?	+	-	?	-	?	.	.	+	+	?	5
Ursin *et al.*[19]	+	-	+	.	-	-	+	?	-	-	-	-	?	.	.	-	+	?	3
Musson[27]	+	-	-	.	+	?	+	?	-	-	-	-	?	.	.	+	+	-	4
Linton[28]	+	+	?	.	+	?	+	?	+	-	-	-	?	.	.	+	+	+	6
Kamwendo *et al.*[29]	+	+	+	.	+	?	+	?	-	+	-	-	?	.	.	+	+	+	7*
Mäkelä *et al.*[43]	+	+	+	.	+	+	+	+	-	-	?	-	+	.	.	+	+	+	9*
Flodmark and Aase[20]	+	?	+	.	-	-	+	?	-	-	-	-	?	.	.	-	-	-	2
Rosecrance *et al.*[21]	+	+	-	.	+	?	+	?	-	-	-	-	?	.	.	-	-	-	2
Westgaard & Jansen[17]	+	-	?	.	-	-	-	-	+	-	+	-	?	.	.	-	+	?	3
Ignatius *et al.*[42]	+	+	-	.	+	?	+	?	-	+	-	-	?	.	.	+	+	+	6
Johansson *et al.*[22]	+	+	?	.	+	?	+	?	-	+	-	-	?	.	.	-	-	-	3
Bernard *et al.*[30]	+	+	+	.	+	?	+	?	-	+	-	+	?	.	.	+	+	?	7*
Hales *et al.*[31]	+	+	+	.	+	?	+	?	+	+	-	-	?	.	.	+	+	-	7*
Johansson & Rubenowitz[32]	+	-	+	.	+	?	+	?	-	-	-	-	?	.	.	-	+	+	5
Johansson[23]	+	+	?	.	+	?	+	?	-	+	-	-	?	.	.	-	-	-	3
Viikari-Juntura *et al.*[9]	+	+	-	+	+	?	+	?	+	+	?		?	+	-	+	+	+	9*
Ahlberg-Hultén *et al.*[34]	+	+	-	.	-	-	+	?	-	+	-	-	?	.	.	+	+	+	5
Bergqvist *et al.*[41]	+	?	+	.	+	?	+	?	-	-	-	-	?	.	.	+	+	+	6
Johansson[33]	+	+	-	.	+	?	+	?	-	+	-	-	?	.	.	+	+	+	6
Lagerström *et al.*[35]	+	+	+	.	?	?	+	?	-	-	-	-	?	.	.	+	+	+	5
Pockacy *et al.*[24]	+	+	-	.	+	?	+	?	-	-	-	-	?	.	.	-	+	?	3
Tharr[40]	+	+	+	.	+	?	+	?	-	+	-	-	?	.	.	+	+	?	6
Bru *et al.*[36]	+	+	+	.	+	?	+	?	-	-	-	-	+	.	.	-	+	?	5
Ingelgård *et al.*[25]	+	+	-	.	+	?	+	?	-	-	-	-	?	.	.	-	-	-	2
Skov *et al.*[3]	+	+	-	.	+	?	+	?	+	-	-	-	?	.	.	+	+	+	6
Toomingas *et al.*[37]	+	+	-	.	?	?	+	?	-	-	-	-	?	.	.	+	+	+	4
Zettenberg *et al.*[38]	+	+	+	.	-	-	+	?	-	+	-	+	?	.	.	-	+	+	6

[a] Total score calculated by counting the number of positive validity/precision items. Studies marked with an asterisk (*) are high-score studies; [b] An empty cell in the table implies that the item was not in the methodological quality list for the study design of the study at issue

Chapter four

Are neck flexion, neck rotation and sitting at work risk factors for neck pain? Results of a prospective cohort study in an occupational setting

Summary

In order to study the relationship between neck pain and work-related neck flexion, neck rotation and sitting, a prospective cohort study was performed with a follow-up period of three years among 1,334 workers from 34 companies. Work-related physical load was assessed by analysing objectively measured exposure data (video-recordings) of neck flexion, neck rotation and sitting posture. Neck pain was assessed by means of a questionnaire. Adjustments were made for various work-related and non-work-related physical factors, psychosocial factors, and individual characteristics.

A statistically significant positive relationship was found between the percentage of the working time in a sitting position and neck pain, implying an increased risk of neck pain for workers who were sitting for more than 95% of the working time (crude RR=2.01, 95% CI 1.04-3.88; adjusted RR=2.34, 95% CI 1.05-5.21). A trend for a positive relationship between neck flexion and neck pain was found, suggesting an increased risk of neck pain for people working with the neck at a minimum of 20 degrees of flexion for more than 70% of the working time (crude RR=2.01, 95% CI 0.98-4.11; adjusted RR=1.63, 95% CI 0.70-3.82). No clear relationship was found between neck rotation and neck pain.

Sitting at work for more than 95% of the working time appears to be a risk factor for neck pain and there is a trend for a positive relationship between neck flexion and neck pain. No clear relationship was found between neck rotation and neck pain.

Ariëns GAM, Bongers PM, Douwes M, Miedema MC, Hoogendoorn WE, Wal G van der, Bouter LM, Mechelen W van. Are neck flexion, neck rotation, and sitting at work risk factors for neck pain? Results of a prospective cohort study ~~in an occupational setting~~. Occup Environ Med 2001;58:200-207.

Neck pain is a major health problem in modern society. Prevalence data have shown that in a general population the one-year prevalence of neck pain can be as high as 40%, the prevalence for females being slightly higher. One-year prevalences in occupational settings showed values varying between 6% and 76%, also with higher values for female workers.[1]
Neck pain is assumed to be of multi-factorial origin, implying that several risk factors can contribute to its development. Most studies which are reported in the literature focus on only one or a few risk factors. Moreover, most studies on risk factors for neck pain are of cross-sectional design, which makes it difficult to formulate any conclusion about the temporal relationship between risk factors and neck pain.
Among the many different putative risk factors for neck pain, work-related physical risk factors may play a major role. Most studies on work-related physical risk factors have collected information on exposure by means of questionnaires which are filled in by the workers. However, in order to validly measure the physical load at work, the duration and frequency of certain postures need to be assessed objectively.
Several literature reviews have specifically addressed the work-related physical risk factors for the development of neck pain.[2-5] However, due to differences in the design of these reviews, their conclusions are not fully consistent, although there seems to be consensus that potential major physical risk factors for neck pain are static postures and repetitive movements of the neck (neck flexion), static posture and repetitive or forceful movements of the arm, and a sitting posture at work.
The purpose of this study is to assess the longitudinal relationship between neck pain and three work-related physical risk factors, i.e., neck flexion, neck rotation and sitting posture. To our knowledge this is the first prospective cohort study in which this relationship has been assessed on the basis of objectively quantified exposure data, and in which the potential confounding effect of various psychosocial factors, non-work-related physical factors and individual characteristics has been taken into account.

Methods

Design

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a large prospective cohort study with a follow-up period of three years, was initiated among a working population. The main purpose of this study was to determine the risk factors for musculoskeletal disorders, with a focus on back, neck and shoulder disorders. Approximately 1800 male and female workers from 34 companies participated in this study. The companies recruited for this study were located throughout the Netherlands. Each company supplied 15 to 200 participants. In The Netherlands, all companies are connected to an Occupational Health Service. The Occupational Health Services gave information about possible interested companies for this study. A company may not have planned a major reorganisation

or change in production within the next three years. Furthermore, to be included, the turnover rate of the workforce had to be less than 15%. Companies from various industrial and service branches were included in the study, such as the metal industry, computer software industry, chemical industry, pharmaceutical industry, food industry, wood construction industry, insurance companies, childcare centres, hospitals, distribution companies, and bricklayers. This resulted in a study population of workers with various tasks and a with a wide range of physical and mental workloads. Workers who were included had to have a more or less fixed workplace (in order to make video-recordings at the workplace) and had to be able to read and write in the Dutch language (in order to fill in questionnaires).
Only those aspects of the methods that are relevant for the present study will be described in more detail. Extensive information on the study design and data collection can be found elsewhere.[6]

Study population

At baseline, 1,789 (87%) of the 2,064 workers who were invited to participate in SMASH filled in the questionnaire. Furthermore, at baseline, workers had to meet the following five criteria.

1. No other paid job for any substantial amount of time (18 workers were excluded).
2. No work disability payment due to neck pain in the previous 12 months (3 workers were excluded).
3. Working for at least 20 hours a week (11 workers were excluded).
4. Working for at least 1 year in their current job (18 workers were excluded).
5. No self-reported regular or prolonged neck pain in the 12 months prior to baseline (405 workers were excluded).

After applying these selection criteria, 1,334 workers were eligible for participation in the study.

Assessment of exposure

At baseline, work-related physical load was quantified by means of video-recordings and force measurements at the work-place and subsequent observation and analysis of these video-recordings.
Research assistants who made the video-recordings were trained to ascertain repeatable results and to minimise inter-observer-variability. A standardised protocol was given to each research assistant, including an extensive description on how the video-recordings at the work-place should be made. Four 10- or 14-minute video-recordings of each participant were taken randomly during a working day. All participants were assigned to groups of workers with similar tasks, based on on-site inspection of the work. Video-recordings of one fourth of the workers in each of these groups of workers were subsequently observed and analysed for relevant measures. To ease observations afterwards, markers were placed on different body sites of the worker. Video-recordings were observed afterwards by a trained research assistant according to a standardised protocol. Video-recordings were studied several

times. Each time the research assistant concentrated on a different body site, and observations of that body site only were made. Multi-moment observations (every 15 seconds) were made of head inclination (in 3 categories: 0-20, 20-45, more than 45 degrees out of the neutral position), and head rotation (in 2 categories: 0-45, more than 45 degrees out of the neutral position). Continuous observations were made of working in a sitting position. Based on these observations, the following 4 physical exposure variables were calculated:

1. The percentage of the working time with the neck at a minimum of 20 degrees of flexion.
2. The percentage of the working time with the neck at a minimum of 45 degrees of flexion.
3. The percentage of the working time with the neck at a minimum of 45 degrees of rotation.
4. The percentage of the working time in a sitting position.

For each group of workers, mean values were calculated for the physical exposure variables, based on the individuals observed within that group of workers. The mean value for each of the four physical exposure variables was then allocated to all individuals within that group.

Assessment of neck pain

At baseline, and annually during the follow-up period, data on neck pain were collected by means of an adapted version of the Nordic Questionnaire.[7] On a 4-point scale (seldom/never; sometimes; regular; prolonged) workers had to rate the occurrence of neck pain in the previous 12 months. Cases of neck pain were considered to be workers who reported regular or prolonged neck pain during the previous 12 months on at least one of the three follow-up measurements.

Assessment of potential confounders

Three confounding work-related physical factors were also derived from the video-recordings (number of times lifting 25 kg or more in an 8 hour working day, the percentage of the working time with a minimum of 60 degrees of upper arm elevation, and the percentage of the working time making repeated movements with the hand or arm more than 4 times a minute). Furthermore, by means of a questionnaire, data were collected on other work-related physical factors (video-display terminal work, working with the hands above shoulder level, working with vibrating tools, driving a vehicle, frequent flexion and/or rotation of the upper part of the body) and non-work-related physical factors (prolonged sitting, video-display terminal work, activities with the hands above shoulder level, force exertion with hand and/or arms, activities in the same position for a long time, working with vibrating tools, frequent flexion and/or rotation of the upper part of the body, making repeated movements with the hand or arm many times a minute, driving a vehicle, frequency of participating in sports or performing heavy physical activities which cause sweating during the previous 4 months).[8,9] The Job Content

Questionnaire (JCQ) was used to collect information on work-related psychosocial factors.[10] The different items on this questionnaire were combined into the four dimensions proposed by Karasek *et al.*, i.e., quantitative job demands, decision latitude, supervisor support and co-worker support.[10] The precise calculation of these dimensions has been described by de Jonge *et al.*[11] One other single item from the JCQ was used to collect information on job security. Finally, three individual characteristics were taken into account as potential confounders: sex, age and body mass index (BMI). Body height (in metres) and body weight (in kg) were measured during a physical examination. If no measurements of body height and body weight were available from the physical examination, the relevant self-reported measurements on the questionnaire were used to calculate BMI (BMI = weight/height^2).

Assessment of the endurance time of the neck muscles

The relationship between physical load at work and neck pain may be influenced by the level of physical fitness of a worker, so that workers with a high level of physical fitness can be exposed to a higher physical load before problems with the musculoskeletal system will occur. From the physical examination at baseline, information was available on the endurance time of the neck muscles, measured by means of a sub-maximal static strength test of these muscles (adapted version of Hagberg and Hogstedt).[12-14] During this test, the endurance strength of the neck muscles was evaluated on the basis of the number of seconds the seated worker could keep the neck flexed at a 45 degree angle, while wearing a helmet loaded with a weight of 2.5 kg for females and 5 kg for males. During this test the 'Localised Musculoskeletal Discomfort' (LMD) method was applied to obtain a rating of the perceived feeling of discomfort in any part of the body. The LMD method consists of a 10-point Borg scale which indicates the amount of discomfort. In addition, a body diagram was used to indicate the location of the discomfort. The test was concluded and the endurance time was clocked if a worker reached an LMD score of 5 in the neck or upper back region, or if a subject reached an endurance time of 420 seconds, which was considered to be the maximum endurance time. Only those subjects without neck pain at the time of testing had to perform the submaximal strength test of the neck muscles.

Statistics

Cox regression analysis, with a constant time variable, was used to model the relationship between neck pain and the percentage of the working time with the neck at a minimum of 20 degrees of flexion, the percentage of the working time with the neck at a minimum of 45 degrees of flexion, the percentage of the working time with the neck at a minimum of 45 degrees of rotation, and the percentage of the working time in a sitting position, resulting in the calculation of a relative risk (RR) and its corresponding 95% confidence interval.[15,16]
First, univariate analyses of the relationship between each of the physical exposure variables and neck pain were performed. Each physical exposure variable was divided

into small categories of approximately 5-10% of the working time. Categories showing similar effect estimates were combined into broader categories, resulting in the following categorisation of the 4 physical exposure variables: the percentage of the working time with the neck at a minimum of 20 degrees of flexion in three categories (less than 60%, 60-70%, and more than 70% of the working time), the percentage of the working time with the neck at a minimum of 45 degrees of flexion in three categories (less than 5%, 5-10%, and more than 10% of the working time), the percentage of the working time with the neck at a minimum of 45 degrees of rotation in three categories (less than 25%, 25-30%, and more than 30% of the working time), and the percentage of the working time in a sitting position in five categories (less than 1%, 1-50%, 50-75%, 75-95%, and more than 95% of the working time). For all four physical exposure variables, the first category mentioned served as the reference category in all analyses. A comparable strategy was used to categorise the potential confounding psychosocial dimensions assessed by means of the questionnaire and the three potential confounding physical factors assessed by means of video-recordings.

Univariate analyses were performed to test the relationship between neck pain and all potential confounders. Variables associated with neck pain with a p-value higher than 0.25 were not considered as likely confounders.[17] For all potential confounders with a univariate p-value of less than 0.25, the actual confounding effect on the estimated RR of each physical exposure variable of interest was examined. Therefore, the estimated RR for each physical exposure variable resulting from a bivariate analysis (physical exposure variable and confounder) was compared to the crude RR. If the change in RR was in the region of 10% or higher, the potential confounder was considered to be a real confounder in this dataset. Age, sex, and the other three physical exposure variables were selected a priori as confounders, and included in all multivariate analyses. Finally, in the last step of the analysis, a multivariate model was constructed for each physical exposure variable, in which all confounders determined during the previous steps of the analysis were included.

In order to assess the influence of possible misclassification of physical exposure due to changes in work during the follow-up period, which may result in an under or over-estimation of the relative risk, the multivariate analysis of each physical exposure variable, with adjustment for confounders, was repeated for those workers who experienced no major changes in their work during the follow-up period, with the reason for change in work being other than neck pain (N=686).

It may be expected that for workers with a relatively high endurance time of the neck muscles, the relationship between neck flexion and neck pain would be less pronounced than for workers with a relatively low endurance time. In order to test this hypothesis, a stratified analysis of the relationship between neck flexion and neck pain was performed, dividing the population into tertiles, based on the results of the static endurance strength test of the neck muscles.

Results

Selectiveness of loss to follow-up

In total, 1,334 subjects met the inclusion criteria. A total of 357 subjects (26.8%) did not provide complete data on the occurrence of neck pain, and were therefore considered to be lost to follow-up. No difference was found in the distributions of neck flexion and neck rotation between the groups, whereas in the group of workers who were lost to follow-up, significantly fewer were working in a sitting position for a high percentage of the working time. The incidence of neck pain during the first year of follow-up showed that there was no statistically significant difference between the group of workers with complete follow-up data and the group of workers for whom data on the incidence of neck pain were missing for the second or third year of follow-up.

Of the 977 subjects included in the analyses, 686 subjects (70.2%) did not experience major changes in their work during the follow-up period, with the reason for change in work being other than neck pain.

Descriptive information on the study population

Table 4.1 presents descriptive information (sex, age, nationality, years of employment in current job and working hours per week), and the baseline distribution of the physical exposure variables for the 977 workers in the study. The mean percentage of the working time was 36.3% (range 0-79.1%), 4.0% (range 0-36.5%), 16.2 (range 1.8-44.6%) and 38% (range 0-100%) for neck flexion more than 20 degrees, neck flexion more than 45 degrees, neck rotation more than 45 degrees and sitting, respectively.

A total of 56 workers (5.7%) reported that they had neck pain during the first year of follow-up, and a total of 141 workers (14.4%) reported that they had neck pain at least once during the total follow-up period of three years. The putative confounders are listed in Table 4.2. Variables marked with an asterisk were univariately associated with neck pain, with a p-value of less than 0.25.

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Table 4.1 Descriptive information and the distribution of the four work-related physical exposure variables calculated from the video-recordings of the workers included in the analyses (N=977)

Variable	Classification	Distribution N (%) Males	Distribution N (%) Females	Distribution N (%) Total
Sex		737 (75.4)	240 (24.6)	977 (100)
Age in years[a,b]		36.8 (8.1)	32.1 (8.8)	35.7 (8.5)
Nationality[b]	Dutch	721 (97.8)	228 (95.0)	949 (97.1)
Working hours per week[a,b]		39.2 (3.4)	35.3 (6.5)	38.2 (4.7)
Years of employment in job[a,b]		10.5 (8.1)	6.7 (5.1)	9.6 (7.7)
Percentage of the working time with the neck in a minimum of 20 degrees of flexion[b,c]	Less than 60%	683 (95.9)	191 (80.9)	874 (92.2)
	60-70%	23 (3.2)	22 (9.3)	45 (4.7)
	More than 70%	6 (0.8)	23 (9.7)	29 (3.1)
Percentage of the working time with the neck in a minimum of 45 degrees of flexion[b,c]	Less than 5%	547 (76.8)	154 (65.3)	701 (71.8)
	5-10%	135 (19.0)	38 (16.1)	173 (17.7)
	More than 10%	30 (4.2)	44 (18.6)	74 (7.6)
Percentage of the working time with the neck in a minimum of 45 degrees of rotation[c]	Less than 20%	609 (85.5)	211 (89.4)	820 (86.5)
	20-30%	64 (9.0)	15 (6.4)	79 (8.3)
	More than 30	39 (5.5)	10 (4.2)	49 (5.2)
Percentage of the working time in a sitting position[b,c]	Less than 1%	209 (29.4)	18 (7.6)	227 (23.9)
	1-50%	288 (40.4)	101 (42.8)	389 (41.0)
	50-75%	23 (3.2)	22 (9.2)	45 (4.7)
	75-95%	152 (20.6)	69 (29.2)	221 (23.3)
	More than 95%	40 (5.6)	26 (11.0)	66 (7.0)

[a] Mean (and standard deviation); [b] Statistically significant difference between males and females ($p<0.05$); [c] For 29 workers, data on the physical exposure variables were missing

Table 4.2 Potential confounders of the association between work-related physical exposure and neck pain

Potential confounders in the analyses
Work-related physical factors
Number of times lifting 25 kg or more per 8 hour working day (no lifts, 0-25 times, >25 times)
Percentage of working time with a minimum of 60 degrees of upper arm elevation (<5%, 5-25%, >25%)*
Percentage of working time carrying out repeated movements >4 times a minute (0%, 0-50%, >50%)
Video-display terminal work (seldom/never, sometimes, quite often, very often)
Working with the hands above shoulder level (seldom/never, sometimes, quite often, very often)
Working with vibrating tools (seldom/never, sometimes, quite often, very often)*
Driving a vehicle (seldom/never, sometimes, quite often, very often)*
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often, very often)*
Non-work-related physical factors
Prolonged sitting (seldom/never, sometimes, quite often or very often)
Video display terminal work (seldom/never, sometimes, quite often or very often)*
Activities with the hands above shoulder level (seldom/never, sometimes, quite often or very often)*
Force exertion with hand and/or arms (seldom/never, sometimes, quite often or very often)*
Activities in the same posture for a long time (seldom/never, sometimes, quite often or very often)*
Working with vibrating tools (seldom/never, sometimes, quite often or very often)
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often or very often)
Repeated movements with hands/arm many times/minute (seldom/never, sometimes, quite or very often)
Driving a vehicle (seldom/never, sometimes, quite often or very often)*
Frequency of sports or heavy physical activities which cause sweating during the past 4 months (more than 3 times/week, 1-2 times/week, 1-3 times/month, less than once/month)
Work-related psychosocial factors
Quantitative job demands (low, medium, high)*
Decision latitude (high, low)*
Supervisor support (high, medium, low)
Co-worker support (high, medium, low)*
Job security (agree, disagree)
Individual characteristics
Sex (male, female)*
Age (continuous variable)
Body Mass Index (less than 25, 25-30, more than 30)

* These variables were univariately associated with neck pain with a p-value of less than 0.25

The results of the univariate and multivariate analyses (RR and 95% confidence intervals) of the association of the 4 physical exposure variables and neck pain are presented in Table 4.3.

Neck flexion

Compared with the reference category, workers with the neck at a minimum of 20 degrees of flexion for 60%-70% and for more than 70% of the working time had an increased crude RR for neck pain of 1.62 (95% CI 0.85-3.09) and 2.01 (95% CI 0.98-4.11), respectively. In the multivariate analysis these risks were smaller (RR=1.21 for neck flexion for 60-70% of the working time and RR=1.63 for neck flexion for more than 70% of the working time), and, again, not statistically significant. Unexpectedly, only slightly increased relative risks were found for the percentage of the working time with the neck at a minimum of 45 degrees of flexion. The results of the univariate analysis of this variable showed an RR of 1.50 (95% CI 0.78-2.58) for neck flexion for more than 10% of the working time, whereas in the multivariate analysis the RR was 1.16 (95% CI 0.62-2.17).

Table 4.3 Univariate and multivariate analysis of the association between work-related physical exposure variables and neck pain

Work-related physical exposure variables	**NP[a]**	**No NP[b]**	**Crude RR[c] (95% CI)**	**Adjusted RR[d] (95% CI)**	**Sub-cohort, no change in work[e] Adjusted RR (95% CI)**
Neck flexion $\geq$20 degrees					
<60% working time	120	754	1.00	1.00[f]	1.00
60-70% working time	10	35	1.62 (0.85-3.09)	1.21 (0.58-2.53)	1.76 (0.78-3.94)
>70% working time	8	21	2.01 (0.98-4.11)	1.63 (0.70-3.82)	1.66 (0.57-4.81)
Neck flexion $\geq$45 degrees					
<5% working time	95	606	1.00	1.00[g]	1.00
5-10% working time	28	145	1.19 (0.78-1.82)	1.27 (0.81-1.97)	1.16 (0.66-2.04)
>10% working time	15	59	1.50 (0.87-2.58)	1.16 (0.62-2.17)	1.30 (0.61-2.76)
Neck rotation $\geq$45 degrees					
<25% working time	117	703	1.00	1.00[h]	1.00
25-30% working time	15	64	1.33 (0.78-2.28)	1.40 (0.81-2.43)	1.25 (0.61-2.55)
>30% working time	6	43	0.86 (0.38-1.95)	0.98 (0.42-2.26)	1.13 (0.41-3.17)
Sitting					
<1% working time	24	203	1.00	1.00[i]	1.00
1-50% working time	58	331	1.41 (0.88-2.27)	1.25 (0.75-2.09)	1.79 (0.86-3.74)
50-75% working time	8	37	1.68 (0.76-3.74)	1.43 (0.59-3.50)	1.85 (0.56-6.11)
75-95% working time	34	187	1.46 (0.86-2.45)	1.29 (0.71-2.37)	1.58 (0.68-3.63)
>95% working time	14	52	2.01 (1.04-3.88)*	2.34 (1.05-5.21)*	3.28 (1.22-8.81)*

[a] The number of workers with neck pain in each exposure category; [b] The number of workers without neck pain in each exposure category; [c] Relative risk and 95% confidence interval from univariate Cox regression analysis; [d] Relative risk and 95% confidence interval from multivariate Cox regression analysis; [e] Relative risk and 95% confidence interval from multivariate Cox regression analysis, workers who experienced no major changes in work during the follow-up period, for a reason other than neck pain (N=686); [f] Adjusted for sex, age, neck rotation, sitting posture, driving a vehicle (W), video display terminal work (LT), activities with hands above shoulders (LT), activities in same posture for a long time (LT), and quantitaive job demands; [g] Adjusted for sex, age, neck rotation, sitting posture, driving a vehicle (LT), activities with hands above shoulders (LT), and force exertion with hands or arms (LT); [h] Adjusted for sex, age, neck flexion, and sitting posture; [i] Adjusted for sex, age, neck flexion, neck rotation, driving a vehicle (W), frequent flexion/rotation of upper part of body (W), force exertion with hands or arms (LT), driving a vehicle (LT), quantitative job demands, and decision latitude; * $P<0.05$; (W) work-related; (LT) leisure time

Neck rotation

25-30% of the working time with the neck at a minimum of 45 degrees of rotation showed an RR of 1.33 (95% CI 0.78-2.28) and 1.40 (95% CI 0.81-2.43) for neck pain in the univariate and the multivariate analysis, respectively. More than 30% of the working time with the neck at a minimum of 45 degrees of rotation gave no increase in RR for neck pain in either the univariate or the multivariate analysis (a crude RR of 0.86 and an adjusted RR of 0.98).

Sitting posture

Those who worked in a sitting position for more than 1% of the working time were at higher risk for neck pain than those who seldom worked in a sitting position (less than 1% of the working time). The univariate analysis showed an RR varying from 1.41 (95% CI 0.88-2.27) for workers who were sitting for less than half of the working time to a statistically significant RR of 2.01 (95% CI 1.04-3.88) for workers who were sitting for more than 95% of the working time. After adjustment for confounders, the RRs remained more or less the same, with the exception of the RR for sitting for more than 95% of the working time, which increased to 2.34 (95% CI 1.05-5.21).

Change in physical work load during the follow-up period

For the workers who had experienced no, or only minor changes in work during the follow-up period (N=686) the multivariate analyses of the four physical exposure variables of interest showed, in general, a slightly higher estimated RR for neck pain for all physical exposure variables (last column of Table 4.3), with the only statistically significant RR being the one for working in a sitting position for more than 95% of the working time (RR=3.28, 95% CI 1.22-8.81).

Endurance time of the neck muscles

Increasing risks for neck pain due to neck flexion were found with decreasing endurance times (Table 4.4). However, the interaction term between neck flexion and endurance time in the multivariate analysis was not statistically significant. Workers with the lowest endurance time (the lowest tertile) showed a statistically significant increase in RR for neck pain with the percentage of the working time when the neck was in a minimum of 20 degrees of flexion and with the percentage of the working time when the neck was in a minimum of 45 degrees of flexion. For the other two tertiles the relative risks for neck pain were smaller, and not statistically significant (Table 4.4).

Table 4.4 Univariate analysis of the association between work-related neck flexion and neck pain for workers with a low, medium and high endurance time of the neck muscles

	Low endurance time	**Medium endurance time**	**High endurance time**
	Crude RR (95% CI)[a]	**Crude RR (95% CI)**	**Crude RR (95% CI)**
Neck flexion ≥20 degrees			
<60% working time	1.00	1.00	1.00
>60% working time	2.50 (1.11-5.61)*	1.32 (0.52-3.35)	1.11 (0.34-3.65)
Neck flexion ≥45 degrees			
<5% working time	1.00	1.00	1.00
>5% working time	1.89 (1.02-3.52)*	1.08 (0.57-2.05)	0.84 (0.38-1.86)

[a] Relative risk and 95% confidence interval from univariate Cox regression analysis; * P<0.05

Discussion

The purpose of this study was to identify the longitudinal relationship between work-related physical load and neck pain. To our knowledge this is the first prospective cohort study in which this relationship has been assessed on the basis of objectively quantified exposure data, and in which the potential confounding effect of various important psychosocial factors, non-work-related physical factors and individual characteristics was taken into account.

A trend for a positive relationship between neck flexion and neck pain was found, although not statistically significant, suggesting an increased risk of neck pain for those who spent a high percentage of the working time (more than 70%) with the neck in a minimum of 20 degrees of flexion. Working with the neck at a minimum of 20 degrees of flexion for 25% to 50% or 50% to 60% of the working time showed no increased relative risk for neck pain. For this reason, the analysis of the neck in a minimum of 20 degrees of flexion was concentrated on percentages higher than 60% of the working time. Unexpectedly, the relative risks for neck pain were lower for the percentage of the working time with the neck in a minimum of 45 degrees of flexion. Other studies found in the literature reported results on the relationship between neck flexion and neck pain, with odds ratios ranging from 1.7 to 3.4.[18-20] In contrast to the present study, these studies were of a cross-sectional design and used a questionnaire for the assessment of neck flexion.

No clear relationship was found between neck rotation and neck pain. In the literature, the results reported for neck rotation are not very consistent. For example, Dartiques *et al.* reported a positive effect (odds ratio of 2.4, 95% CI 1.5-3.8) of cervical spine rotation on self-reported neck pain[18], whereas Musson *et al.* reported that the association between neck rotation and neck pain was not significant.[21]
In the present study, the power to investigate prolonged neck rotation was limited, since for only a small number of the workers the percentage of the working time

with the neck rotated more than 45 degrees was above 30%. Setting the limit for prolonged neck rotation at an even higher level (for example more than 50% of the working time) was impossible due to this small number of workers.

A statistically significant positive relationship was found between sitting posture and neck pain. For workers who were sitting for more than 95% of the working time the risk of neck pain was twice as high as for workers who hardly ever worked in a sitting position. The results of the present study confirmed previous findings. Skov *et al.* also investigated the effect of working time in a sitting position on self-reported neck pain.[22] They found that the odds ratios for neck pain increased with the time spent working in a sitting position (an odds ratio of 2.68 for a quarter of the working time in a sitting position, an odds ratio of 1.92 for half of the working time in a sitting position, an odds ratio of 2.18 for three quarters of the working time in a sitting position and an odds ratio of 2.80 for all of the working time in a sitting position), suggesting a clear relationship between sitting posture and neck pain. Kamwendo *et al.* reported an odds ratio of 1.49 (95% CI 0.86-2.61) for the relationship between sitting for more than five hours a day and self-reported neck pain.[23] Both of these studies had a cross-sectional design and used data from questionnaires to assess exposure.
A plausible mechanism for the strong relationship between prolonged sitting and neck pain which is found in this study is the static aspect of this exposure. Working in a sitting position will lead to a continuous static load of the neck muscles, especially if the work-place design is not suitable for the worker. Static loading of the neck muscles will induce biomechanical strain (for example an increased muscle tone), which may in long term lead to the development of neck pain.

The possible interrelationships between work-related neck flexion, neck rotation and sitting could have had an important influence on the results found in this study. Untangling the independent effect of these variables is difficult. By checking the correlations between the physical exposure variables, the inter-relationships between the variables were verified. All Pearson's correlation coefficients were below 0.3. These relatively low correlation coefficients may imply a relatively small influence of possible interrelationships between the physical exposure variables on the results found in this study. However, the results regarding the precise magnitude of the independent effects should be interpreted with caution.

When the multivariate analyses were performed for workers who had experienced no, or only minor changes in work during the follow-up period (N=686), slightly higher RRs for neck pain were found for neck flexion and sitting posture. However, the overall conclusions based on the results of both analyses would remain the same. It can therefore be concluded that change in work during the follow-up period did only have minor influence on the magnitude of the RRs found for the relationships between the physical exposure variables and neck pain.

In line with the hypothesis that for workers with a relatively high endurance time of the neck muscles the relationship between neck flexion and neck pain is less pronounced than for workers with a relatively short endurance time, a statistically significant increase in RRs for neck pain was found for workers with the lowest endurance times according to the static strength test of the neck muscles, whereas for the workers with medium and high endurance times, no statistically significant increase in risk for neck pain was found. These results suggest that working with a flexed neck is a real problem for workers with low endurance time of the neck muscles.

Instead of questionnaires, which were used in most studies reported on in the literature, in the present study a standardised method was used to quantify the physical load at the workplace. However, additional data concerning neck flexion, neck rotation and sitting posture were collected by means of a questionnaire. To determine whether these two methods of data-collection would result in comparable conclusions with regard to the relationships between neck flexion, neck rotation, sitting posture and neck pain, the data obtained from the questionnaire were also related to neck pain. Similar results were found for the relationship between neck pain and neck flexion (i.e., often working with a flexed neck) and neck rotation (i.e., often working with a rotated neck). However, for prolonged sitting, no increased risk for neck pain could be detected from the data obtained from the questionnaire (data not shown). Thus, the conclusion that prolonged neck flexion is related to neck pain is supported by the results based on the data obtained from the questionnaire. However, this is not the case for the relationship between working in a sitting position and neck pain.

Limitations of this study

Bias due to loss to follow-up may have occurred in the present study. Out of the initial 1,334 workers, 977 had complete follow-up data. 357 workers (26.8%) were considered to be lost to follow-up. Of these 357 workers, 211 workers did provide data at follow-up 1, but were lost at the second or third follow-up measurement. Eighteen (8.5%) of these 211 workers reported neck pain at follow-up 1. The workers who were lost to follow-up had a lower level of education. Whether this difference in level of education has influenced the relationship between the physical exposure data and the occurrence of neck pain during the follow-up period can not be investigated, because no data are available on the cumulative incidence of neck pain during the follow-up period for the workers who were lost to follow-up.
With the selection of subjects without regular or prolonged neck pain in the 12 months prior to baseline, we have eliminated a strong confounding effect of recent prior neck pain. However, it is still possible that neck pain more than one year prior to baseline may have had its influence on the relationship between the work-related physical variables and the occurrence of neck pain during the follow-up period.
Four video-recordings of 14 minutes were made of each worker who participated in

the baseline measurements. Due to time restrictions, it was impossible to observe all video-recordings of all workers in this study. Therefore all participants were assigned to groups of workers with similar tasks, based on on-site inspection of the work. The research assistant who made the video-recordings classified the workers in homogeneous groups. The division of workers into groups was not based on job title, but on on-site inspection at the workplace.

Unfortunately, no information was available on the inter-rater reliability of the video-observations. Since other studies reported considerable problems with reproducibility of ratings of posture based on video-recordings, the results of the present study should be interpreted with caution.

Non-differential misclassification of workers in exposure categories could have occurred in the present study. The size of this misclassification is unknown, however, it is the same for workers with and without neck pain. The effect of this non-differential misclassification can be an underestimation of the effect, because it tends to bias the effect estimate towards the null value.[24] Unfortunately, misclassification for the four exposure variables was not studied. However, some information is available for an important other physical exposure variable, namely trunk flexion. Results of preliminary analyses showed that for trunk flexion the grouping of workers resulted in quite homogeneous groups with relatively little within group variance and large between group variance. Other ways of grouping, for example on the basis of job titles or similar function, showed higher within group variances, however still smaller than the between group variance. Since trunk flexion was assessed in an identical way as the 4 physical exposure variables under study here, it is assumed that the within and between group variance and the attenuation of the risk estimates are of comparable size.

Video-recordings of a single worker were made on a single day. The within-person variability may be underestimated due to this, because variability in exposure over days, weeks or seasons are ignored. However, measurements of physical exposure for a single worker on separate days, in different weeks or different seasons was, for practical reasons, impossible.

According to the literature *static* loading of the neck muscles is an important risk factor for neck pain.[3] Unfortunately, our findings do not address static loading of the neck muscles. In a pilot study it turned out to be impossible to assess neck flexion and neck rotation continuously. We had to restrict our measurements of neck flexion and neck rotation to multi-moment observations from the video-recordings (every 15 seconds). We were therefore not able to estimate whether workers were exposed to neck flexion or neck rotation continuously, or for rather short periods of time.

Conclusions

1. There is a statistically significant positive association between prolonged sitting at work and neck pain, implying that there is an increased risk of neck pain for

people who are working almost all day in a sitting position (more than 95% of the working time). Due to the prospective study design and thorough adjustment for confounding, it can be concluded that this relationship between sitting posture and neck pain is probably a causal relationship.
2. There is a positive trend for an association between neck pain and work-related neck flexion, although not statistically significant, suggesting that there is an increased risk of neck pain for people who are working with the neck flexed more than 20 degrees for a major part of their working day. A low endurance time of the neck muscles seems to play an important role in the development of neck pain due to work-related neck flexion.
3. No clear relationship was found between work-related neck rotation and neck pain.
4. Based on the results of this study, prevention of neck pain should focus on the reduction of time spent working in a sitting position and the promotion of more dynamic working postures.

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Chapter five

High quantitative job demands and low co-worker support are risk factors for neck pain: results of a prospective cohort study

Summary

The objective of this study was to determine whether the work-related psychosocial factors quantitative job demands, conflicting job demands, skill discretion, decision authority, supervisor support, co-worker support and job security are risk factors for neck pain.

Data from a 3-year prospective cohort study among a working population (N=1,334) were used. At baseline, data on work-related psychosocial factors were collected by means of a questionnaire. During the three years of follow-up, data on the occurrence of neck pain were collected by means of postal questionnaires. Subjects without neck pain at baseline were selected for the analyses. Cox regression analysis was applied to examine the relationship between the work-related psychosocial factors and the cumulative incidence of neck pain. Adjustments were made for various physical factors and individual characteristics.

977 subjects were included in the analyses. A total of 141 workers (14.4%) reported that they had neck pain at least once during the total follow-up period of three years. We found statistically significant relationships between high quantitative job demands (RR=2.14, 95% CI 1.28-3.58) and low co-worker support (RR=2.43, 95% CI 1.11-5.29) on the one hand, and neck pain on the other hand. An increased risk was found for low decision authority in relation to neck pain (RR=1.60, 95% CI 0.74-3.45), but this relationship was not statistically significant.

High quantitative job demands and low co-worker support are independent risk factors for neck pain. There are indications that low decision authority is a risk factor for neck pain.

Ariëns GAM, Bongers PM, Hoogendoorn WE, Houtman ILD, Wal G van der, Mechelen W van. High quantitative job demands and low co-worker support are risk factors for neck pain: results of a prospective cohort study. Spine, in press.

Neck pain is a major problem in modern society. Prevalence data showed that in a general population the one-year prevalence of neck pain can be as high as 40%, prevalences for females being slightly higher than those for males.[1] One-year prevalences in occupational settings showed values varying considerably between 6 and 76%, also with higher values for female workers than for male workers.[2] The costs (direct and indirect) related to chronic non-specific neck pain in The Netherlands in 1996 were estimated at US$ 868 million.[3]

Neck pain is assumed to be of multi-factorial origin, implying that there are several risk factors which contribute to its development. Among these various risk factors, work-related psychosocial factors appear to play a major role. According to the literature, the term 'psychosocial factors' may comprise anything from personality to job organisation. In this chapter, the term 'work-related psychosocial variables' refers to variables associated with job characteristics and work-environment, sometimes called 'work organisation variables'.[4] Work-related psychosocial variables may include aspects of the work content (e.g., mental demands or control), organisational characteristics (e.g., organisational structures or communication), interpersonal relationships at work (e.g., supervisor-employee relationship), temporal aspects of the work and task (e.g., shift work), financial and economical aspects (e.g., pay, benefit), and community aspects (e.g., occupational prestige and status).[4]

Several investigators suggest possible explanations that account for the relationship between work-related psychosocial variables and musculoskeletal disorders.[5-7] It is suggested that psychosocial demands can exceed an individual's coping capabilities, resulting in a stress response, which, in turn, can produce muscle tension or static loading of the muscles or generate other physiological responses that may result in neck pain. Individual characteristics are considered to be confounding factors, which influence the relationship between psychosocial demands and the occurrence of neck pain. Furthermore, psychosocial demands may be highly correlated with physical demands, which also indicates a confounding effect of physical factors on the relationship between work-related psychosocial variables and the occurrence of neck pain.

Several studies have been carried out in an attempt to identify risk factors for neck pain. However, most of these studies have a cross-sectional study design, and focus only on one, or a few factors, and do not take physical factors, psychosocial factors, and individual characteristics into account.

The objective of this study is to investigate the longitudinal relationship between work-related psychosocial risk factors (quantitative job demands, conflicting job demands, decision authority, skill discretion, supervisor and co-worker support, and job security) and neck pain, while taking into account the possible confounding effect of various (work-related) physical variables and individual characteristics.

Methods

Design and study population

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a large prospective cohort study with a follow-up period of three years, was initiated among a working population. Male and female workers from 34 companies participated in this study. The companies recruited for the study were located throughout The Netherlands, and included various industrial and service branches, which resulted in a study population of workers with a wide range of physical and psychosocial workloads. The requirement for inclusion in this analysis was that the worker had filled in the questionnaire at baseline (N=1789). Furthermore, at baseline, workers had to meet the following five criteria:

1. No other paid job for any substantial amount of time.
2. No work disability payment due to neck pain in the previous 12 months.
3. Working for at least 20 hours a week.
4. Working for at least 1 year in their current job.
5. No regular or prolonged neck pain in the 12 months prior to baseline.

After applying these selection criteria, 1,334 workers were eligible for participation in this study.

Assessment of work-related psychosocial factors

At baseline, data on work-related psychosocial factors were collected by means of the Job Content Questionnaire (JCQ)[8], which measures all dimensions of the widely used Demand-Control-Support model.[9,10] On a four-point scale (totally disagree, disagree, agree, totally agree) workers rated certain aspects of their work. Various items on the questionnaire were combined into dimensions (i.e., quantitative job demands, skill discretion, decision authority, supervisor support and co-worker support), as proposed by Karasek *et al.*[8] The psychometric properties and construction of these dimensions for this study have been described by De Jonge *et al.*[11] Single items of the JCQ were used for the assessment of job security ('I feel secure about my job') and conflicting job demands ('I don't get conflicting assignments from others').

Assessment of neck pain

At baseline, and annually during the follow-up period, data on neck pain were collected by means of an adapted version of the Nordic Questionnaire.[12] Cases of neck pain were those workers who reported regular or prolonged neck pain (with episodes that lasted for at least one day) during the previous 12 months and at least during one of the three follow-up measurements.

Assessment of potential confounders

Potential confounders were measured at baseline. Work-related physical factors were measured either by means of the Loquest Questionnaire[13] on a 4-point scale

(seldom/never, sometimes, quite often, very often) or by means of video-recordings at the workplace.[14] Video-recordings were observed afterwards, and analysed for relevant measures. The following work-related physical variables were assessed by means of these video-recordings: the percentage of the working time spent with the neck in a minimum of 20 or 45 degrees of flexion, the percentage of the working time spent with the neck with a minimum of 45 degrees of rotation, and the percentage of the working time sitting. Extensive information on the data collection by means of video-recordings is described elsewhere.[14]
Data on physical factors during leisure time were collected by means of the Loquest questionnaire[13] on a 4-point scale (seldom/never, sometimes, quite often, very often). In one additional question exercise behaviour in leisure time (sports participation) was assessed.[15]
The following individual characteristics were considered to be potential confounders: sex, age, coping styles and stressful life events. These were all measured by means of a questionnaire. The three coping styles 'active problem solving', 'avoidance behaviour' and 'social support seeking' were measured by means of the Utrecht Coping List.[16] Data on the occurrence of at least one stressful life event during the 12 months prior to baseline, which may have had its influence on both the work-related psychosocial variables and on the occurrence of neck pain, was also assessed.[17]

Statistics

Cox regression analysis, with a constant time variable, was applied to model the relationship between the work-related psychosocial factors and neck pain, resulting in the assessment of the relative risk (RR) and the corresponding 95% confidence interval (95% CI).[18,19]
We performed univariate analyses to determine the relationship between each of the work-related psychosocial factors and neck pain. The work-related psychosocial dimensions, i.e., quantitative job demands, skill discretion, decision authority, supervisor support and co-worker support were divided into small categories containing approximately 5-10% of the workers. Categories showing similar effect estimates were combined into broader categories, resulting in three categories (low, medium and high) for each of these five work-related psychosocial dimensions. The 'high-category' served as the reference category in all analyses, except for quantitative job demands, for which the 'low-category' served as the reference category. Job security was assessed in four categories, but due to the small number of workers in some categories, these four categories were combined, and reduced to two categories in the analysis: (totally) agree and (totally) disagree, the first of which served as the reference category. Conflicting job demands was assessed in four categories, but for the analysis two categories were combined, resulting in three categories: (totally) disagree, agree and totally agree, the first of which served as the reference category. We also performed univariate analyses to test the relationship between neck pain and all potential confounders. Variables showing a p-value higher than 0.25 were not considered to be likely confounders.[20] For all potential confounders with a univariate

Table 5.2 Potential confounders of the association between the work-related psychosocial factors and neck pain

Potential confounders in the analyses (categories between brackets)
Work-related physical factors
Percentage of working time with the neck in a minimum of 45 degrees of flexion[a] (<5%, 5-10%, >10%)*
Percentage of working time with the neck in a minimum of 45 degrees rotation[a] (<25%, 25-30%, >30%)
Percentage of working time in a sitting position[a] (<1%, 1-50%, 50-75%, 75-95%, >95%)*
Number of times lifting 25 kg or more per 8 hour working day[a] (no lifts, 0-25 times, >25 times)
Percentage of working time with a minimum of 60 degrees upper arm elevation[a] (<5%, 5-25%, >25%)*
Percentage of working time carrying out repeated movements >4 times/minute[a] (0%, 0-50%, >50%)
Video display terminal work (seldom/never, sometimes, quite often, very often)
Working with the hands above shoulder level (seldom/never, sometimes, quite often, very often)
Working with vibrating tools (seldom/never, sometimes, quite often, very often)*
Driving a vehicle (seldom/never, sometimes, quite often, very often)*
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often, very often)*
Non-work-related physical factors
Prolonged sitting (seldom/never, sometimes, quite often or very often)
Video display terminal work (seldom/never, sometimes, quite often or very often)*
Activities with the hands above shoulder level (seldom/never, sometimes, quite often or very often)*
Force exertion with hand or arms (seldom/never, sometimes, quite often or very often)*
Activities in the same posture for a long time (seldom/never, sometimes, quite often or very often)*
Working with vibrating tools (seldom/never, sometimes, quite often or very often)
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often or very often)
Repeated movements with hands/arm many times/minute (seldom/never, sometimes, quite or very often)
Driving a vehicle (seldom/never, sometimes, quite often or very often)*
Frequency of sports or heavy physical activities which cause sweating during the past 4 months (more than 3 times/week, 1-2 times/week, 1-3 times/month, less than once/month)
Individual characteristics
Sex (male, female)*
Age (continuous variable)
Coping: avoidance behaviour (low, medium, high)
Coping: social support seeking (low, medium, high)*
Coping: active problem solving (low, medium, high)*
Stressful life events in previous 12 months (no stressful life events, at least one stressful life event)

[a] These work-related physical factors were objectively measured by means of video-recordings at the workplace. All other factors listed in this table were measured by means of a questionnaire; * These variables were univariately associated with neck pain with a p-value of less than 0.25

Work-related psychosocial factors in relation to neck pain

The results of the univariate and multivariate analyses of the association between the work-related psychosocial factors and neck pain are presented in Table 5.3. Two out of the seven work-related psychosocial factors showed a statistically significant relationship with neck pain. Firstly, a statistically significant crude RR of 2.46 (95% CI 1.51-4.03) was found for the relationship between high quantitative job demands and neck pain. In the multivariate analysis, the RR was slightly smaller, but still clearly increased (RR=2.14, 95% CI 1.51-4.03). Secondly, a crude RR of 1.96 (95% CI 0.91-4.22) and a statistically significant adjusted RR of 2.43 (95% CI

1.11-5.29) were found for the relationship between low co-worker support and neck pain. An increased adjusted RR of 1.60 (95% CI 0.74-3.45) was found for low decision authority in relation to neck pain, but this relationship was not statistically significant. The other work-related psychosocial factors investigated in this study, i.e., skill discretion, supervisor support, conflicting job demands, and job security showed no statistically significant relationship with neck pain. However, the slight increase in the RRs for these factors was in the expected direction.

Table 5.3 Univariate and multivariate analyses of the association between the work-related psychosocial factors and neck pain

Work-related psychosocial factor	**Classification**	**NP[a]**	**No NP[b]**	**Crude RR[c] (95%CI)**	**Adjusted RR[d] (95%CI)**
Quantitative job demands	Low	77	558	1.00	1.00[e]
	Medium	44	227	1.34 (0.92-1.94)	1.29 (0.88-1.87)
	High	20	47	2.46 (1.51-4.03)*	2.14 (1.28-3.58)*
Skill discretion	High	82	502	1.00	1.00[f]
	Medium	50	289	1.05 (0.74-1.49)	1.09 (0.72-1.64)
	Low	9	43	1.23 (0.62-2.45)	1.27 (0.59-2.74)
Decision authority	High	63	416	1.00	1.00[g]
	Medium	70	384	1.17 (0.83-1.65)	1.21 (0.84-1.74)
	Low	8	29	1.64 (0.79-3.43)	1.60 (0.74-3.45)
Co-worker support	High	10	88	1.00	1.00[h]
	Medium	112	669	1.41 (0.74-2.68)	1.59 (0.82-3.08)
	Low	19	76	1.96 (0.91-4.22)	2.43 (1.11-5.29)*
Supervisor support	High	98	584	1.00	1.00[i]
	Medium	33	199	0.99 (0.67-1.47)	0.86 (0.57-1.32)
	Low	10	50	1.16 (0.61-2.11)	0.95 (0.47-1.93)
Conflicting job demands	(Totally) disagree	92	556	1.00	1.00[j]
	Agree	37	222	1.01 (0.69-1.47)	1.11 (0.75-1.63)
	Totally agree	10	55	1.08 (0.56-2.08)	1.32 (0.68-2.56)
Job security	(Totally) agree	108	667	1.00	1.00[k]
	(Totally) disagree	33	166	1.19 (0.81-1.76)	1.27 (0.86-1.89)

[a] The number of workers with neck pain in each exposure category; [b] The number of workers without neck pain in each exposure category; [c] Relative risk and 95% confidence interval from univariate Cox regression analysis; [d] Relative risk and 95% confidence interval from multivariate Cox regression analysis; [e] Adjusted for sex and age; [f] Adjusted for sex, age, decision authority, activities with hands above shoulder level (LT), force exertion with hands or arms (LT), and coping: active problem solving; [g] Adjusted for sex, age, quantitative job demands, activities with hands above shoulder level (LT), force exertion with hands or arms (LT), and coping: active problem solving; [h] Adjusted for sex, age, driving a vehicle (WR), and coping: social support seeking; [i] Adjusted for sex, age, quantitative job demands, decision authority, co-worker support, and sitting at work (WR); [j] Adjusted for sex, age, activities with hands above shoulder level (LT), and driving a vehicle (WR); [k] Adjusted for sex and age; * $P<0.05$; (W) work-related; (LT) leisure time

Discussion

Summary of the results and comparison with results reported in the literature

The objective of this study was to identify the longitudinal relationship between various work-related psychosocial factors and neck pain. We found statistically significant increased risks for high quantitative job demands and low co-worker support in relation to neck pain. In addition, we found an increased risk for low decision authority in relation to neck pain, but this relationship was not statistically significant.

In the literature, studies that investigated the relationship between high quantitative job demands and neck pain reported results which are in line with the results found in the present study.[21-25]

Also in line with the results of this study, Kamwendo *et al.* reported a statistically significant relationship between low co-worker support and neck pain on the basis of their cross-sectional study.[26] Neither Johansson nor Johansson and Rubenowitz found any significant relationship between low co-worker support and neck pain in their respective cross-sectional studies.[23,27]

In the prospective cohort study carried out by Erikson *et al.*, a statistically significant relationship was found between (very) little influence on own work situation and neck pain.[28] Several cross-sectional studies have reported a statistically significant relationship between low decision authority and neck pain[22,23,26], while other cross-sectional studies reported that the relationship between low decision authority and neck pain was not statistically significant.[21,24,26]

In the present longitudinal study we did not find a relationship between neck pain and low skill discretion, low supervisor support, conflicting job demands and low job security.

Several cross-sectional studies have reported statistically significant relationships between neck pain and low skill discretion[21,23,29,30] and low supervisor support[24,27], while other cross-sectional studies reported no relationship between neck pain and low skill discretion[2] and low supervisor support.[10,24,25]

Conflicting job demands and job security have not been studied as often as the other work-related psychosocial factors investigated in this study, and inconsistent results were found in the literature.[21,22,26]

In summary, work-related psychosocial factors in relation to neck pain have almost always been investigated in studies with a cross-sectional design, and the results of these studies are not always consistent.

According to the Demand-Control-Support model of Karasek *et al.* the risk for adverse health effects (for example neck pain) increases in jobs with high demands, low decision latitude and low workplace support.[10] This hypothesis could be confirmed in the present study. We found a relationship between neck pain and high quantitative job demands and low co-worker support. Furthermore, there also seemed to be a relationship between low decision authority and neck pain.

Some methodological points

Of the 1,334 workers who met the inclusion criteria of the present study, a total of 357 (26.8%) were lost to follow-up. Relatively more workers in the group who were lost to follow-up reported low skill discretion and low decision authority. This selective loss to follow-up could have biased the results of this study.

In the present study, we have decided not to adjust for prior neck pain, because a history of neck pain might also be a result of the work-related psychosocial factors under study, and therefore possibly an intermediate variable. Instead, we have selected workers without neck pain in the 12 months prior to baseline. This may have led to the selection of a group of relatively healthy workers, who were not very susceptible for the development of neck pain. This could be an explanation for the small number of subjects developing neck pain during the follow-up period of three years (14.4%). Due to this small number of subject developing neck pain during the follow-up period, the effect estimates of the work-related variables are quite unstable, and corresponding 95% confidence intervals are relatively wide.

The possibility of bias due to a healthy worker effect in this occupational cohort study can not be excluded.[31] If a healthy worker effect is present, associations between the work-related psychosocial factors and neck pain will be stronger for workers who are newly-employed or employed for a short time, compared to workers who are employed in their job longer. In the present study, it was impossible to perform a subanalysis for the group of subjects who were employed for a relatively short period of time, due to power problems. It can be argued that in order to minimise a healthy worker effect, it would be better to study newly-employed workers. However, this is beyond the scope of the present study, for which we selected workers who were employed for at least one year in their current job.

This is one of the first prospective cohort studies in which the relationship between work-related psychosocial factors and neck pain has been assessed, with appropriate adjustment for both work-related and non-work-related physical factors and individual characteristics. The work-related physical factors that were considered to be potential confounders did not play a major confounding role in the relationship between work-related psychosocial factors and neck pain. Both the prospective study design and the thorough adjustment for confounding strengthen the idea that the relationships that were found in this study may be causal relationships.

We have also performed analyses on the same dataset to investigate the relationship between work-related physical variables and neck pain.[14] The results showed that prolonged sitting at work is a risk factor for neck pain (adjusted RR=2.34, 95% CI 1.05-5.21), and that there are indications that work-related neck flexion is a risk factor for neck pain (adjusted RR=1.63, 95% CI 0.70-3.82). The magnitude of the effect estimates for these work-related physical risk factors is quite comparable to the magnitude of the effect estimates for the work-related psychosocial risk factors, implying that both work-related physical and psychosocial risk factors play an equal role in the development of neck pain.

Implications for prevention

Reduction of quantitative job demands (for example working under time pressure or working with deadlines) will have a positive effect on the prevention of neck pain. In addition, attempts should be made to increase social support between fellow workers. To a lesser extend, however still very important, workers should be given possibilities to make decisions about their own work.

So, results of this study imply that organisational changes to decrease quantitative job demands and increase the authority over decisions and social support by fellow workers, will contribute to the prevention of neck pain. Future studies should focus on the effects of such organisational changes on the occurrence of neck pain.

Conclusions

1. High quantitative job demands and low co-worker support are independent risk factors for neck pain.
2. The increased risk which we found for low decision authority in relationship to neck pain was not statistically significant.
3. Low skill discretion, low supervisor support, conflicting job demands or low job security were not related to neck pain.

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Chapter six

High physical and psychosocial load at work increase sickness absence due to neck pain: results of a prospective cohort study

Summary

The objective of this study was to investigate the relationship between physical and psychosocial load at work and sickness absence due to neck pain. A prospective cohort study with a follow-up period of three years (1994-1998) was performed among a working population. At baseline, physical load at work was quantified by means of video-recordings. Work-related psychosocial variables were measured by means of the Job Content Questionnaire. The frequency of sickness absence due to neck pain with a minimal duration of 3 days was assessed based on company registrations during the follow-up period. 758 workers were included in the analyses. Possible confounding by individual characteristics, physical load, and psychosocial load was studied.

Work-related neck flexion and neck rotation, low decision authority and medium skill discretion were prospectively related to an increased risk of sickness absence due to neck pain (adjusted rate ratios ranging from 1.6 to 4.2). There were indications that high quantitative job demands, low skill discretion and low job security were related to sickness absence due to neck pain (adjusted rate ratios of 2.0, 1.6 and 1.7, respectively). The other work-related physical and psychosocial variables (i.e., sitting, conflicting job demands, supervisor support and co-worker support) did not increase sickness absence due to neck pain.

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Neck pain is a major health problem in modern society. One-year prevalences of neck pain in occupational settings showed values varying from 6% to 76%, with higher values for female workers.[1] Data on sickness absence due to neck pain are scarce. In their longitudinal study, Burdorf *et al.* reported that the proportion of workers that experienced at least one period of sickness absence due to neck or shoulder pain during a follow-up period of two years was 17%.[2] Waersted and Westgaard reported that long-term sickness absence due to neck and upper limb disorders was 2.2% of the total number of days employed in full-time workers, and 1.8% of the total number of days employed in part-time workers.[3] Both studies did not look at neck-specific sickness absence exclusively. Borghouts *et al.* estimated the total costs of neck pain in The Netherlands in 1996 to be US$ 868 million.[4] The total number of sick days related to neck pain was estimated to be 1.4 million, with a total cost of US$ 185.4 million.

Neck pain is assumed to be of multi-factorial origin, implying that several risk factors can contribute to its development. Based on the results of two systematic reviews on physical and psychosocial risk factors for neck pain, there seems to be evidence that neck flexion and sitting are physical risk factors for neck pain, whereas high quantitative job demands, low authority over decisions, low skill discretion, and poor social support by colleagues are important work-related psychosocial risk factors for neck pain.[5,6] Whether these and other work-related variables are also related to sickness absence due to neck pain is unclear, because literature on the relationship between work-related physical and psychosocial variables and sickness absence due to neck pain is scarce.

In their literature review, Ganster and Schaubroeck have formulated recommendations regarding future research in the field of work stress and employee health.[7] They recommend longitudinal designs and the use of 'hard' outcome measures. In the present study, it is investigated whether work-related physical variables (i.e., neck flexion, neck rotation and sitting) and work-related psychosocial variables (i.e., quantitative job demands, conflicting job demands, skill discretion, decision authority, supervisor support, co-worker support and job security) are prospectively related to sickness absence due to neck pain. Data from a prospective cohort study in an occupational setting are used. Company registered sickness absence information is used as the outcome measure.

Methods

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a large prospective cohort study with a follow-up period of three years, was initiated among a working population. The main purpose of SMASH was to determine risk factors for musculoskeletal disorders, with a focus on back, neck and shoulder disorders. Approximately 1,800 male and female workers from 34 companies participated in SMASH. The participating companies were located throughout The Netherlands, and included various industrial and service branches, which resulted in a study population of workers with a wide range of physical and mental workloads. The study proposal and the manner in which informed consent was obtained from workers was approved by the Medical Ethics Committee of The Netherlands Organisation for Applied Scientific Research (TNO). Extensive information on SMASH can be found elsewhere.[8-12]

Study population

1,789 of the 2,064 workers who were invited for participation in SMASH filled in the questionnaire at baseline (87%). In order to be included in this particular analysis, at baseline, participants had to meet the following criteria:

1. No other paid job for any substantial amount of time.
2. No work disability payment due to neck pain in the previous 12 months.
3. Working for at least 20 hours a week.
4. Working for at least 1 year in their current job.
5. No sickness absence due to neck pain in the 3 months prior to baseline.
6. Registration of sickness absence covered at least a period of half a year after the time the baseline measurements took place.

After applying these selection criteria, 1,025 workers were eligible for inclusion in the analysis.

Work-related physical variables

At baseline, work-related physical load was quantified by means of video-recordings and force measurements at the work-place and subsequent observation and analysis of these video-recordings. Four 10- or 14-minute video-recordings of each participant were taken randomly during a working day. All participants were assigned to groups of workers with similar tasks, based on on-site inspection of the work. Video-recordings of one fourth of the workers in each of these groups of workers were subsequently observed and analysed for relevant measures. Multi-moment video observations (every 15 seconds) were made of head inclination (in three categories: 0-20, 20-45 and more than 45 degrees out of the neutral position) and head rotation (in two categories: 0-45 and more than 45 degrees out of the neutral position). Continuous video observations were made of working in a sitting position. Based on these observations, the following four work-related physical variables were calculated:

1. The percentage of the working time with the neck in a minimum of 20 degrees of flexion.
2. The percentage of the working time with the neck in a minimum of 45 degrees of flexion.
3. The percentage of the working time with the neck in a minimum of 45 degrees of rotation.
4. The percentage of the working time sitting.

Mean values were calculated for these physical variables, based on the observed video-tapes of individuals within each group of workers. Each individual within a group was then allocated the mean value for each of the four physical variables mentioned above.

Work-related psychosocial variables

At baseline, information on work-related psychosocial variables was collected by means of the Job Content Questionnaire (JCQ).[13] This questionnaire measures the dimensions of the widely used Demand-Control-Support model.[14,15] On a four-point scale (totally disagree, disagree, agree, totally agree) workers were asked to assess certain aspects of their work. Various items of the questionnaire were combined into dimensions (i.e., quantitative job demands, skill discretion, decision authority, supervisor support and co-worker support), as proposed by Karasek *et al.*[14] The construction of these dimensions for the data from SMASH has been described by De Jonge *et al.*[12] Single items of the JCQ were used for the assessment of job security ('I feel secure about my job') and conflicting job demands ('I don't get conflicting assignments from others').

Registration of sickness absence due to neck pain

Sickness absence was registered in a standardised way from baseline until December 1997. The participating companies registered the exact date of the onset and the end of each period of sickness absence. The occupational physician of the Occupational Health Service of each company added the diagnosis for sickness absence to each period of sickness absence, using the GDS-code system.[16] This code system is an adapted Dutch version of the International Classification of Diseases (ICD).[17] From the registration, information was derived on the frequency of sickness absence due to neck pain with a minimal duration of 3 days. Table 6.1 presents the codes that were defined as neck-specific reasons for sickness absence. In addition, the duration of the registration period was calculated in person months.

Table 6.1 GDS-codes that were defined to be neck-specific reasons for sickness absence

GDS-code	Description of the code
722.0	Discopathy, multiple sites of which the neck region is one, no root symptoms
722.1	Discopathy, cervical, no root symptoms
722.3	Discopathy, multiple sites of which the neck region is one, radiating pain, no herniated disc
722.4	Discopathy, cervical, radiating pain, no herniated disc
722.6	Herniated disc, multiple sites of which the neck region is one, with or without root symptoms
722.7	Herniated disc, cervical, with or without root symptoms
722.9	Discopathy, not described further
723.1	Neck pain, neck myalgy (no spine-abnormalities)
723.2	Brachialgy, accompanied by neck pain

Potential confounders

Potential confounders were measured at baseline. Information on other work-related physical factors was derived from the video-recordings and from a self-administered questionnaire.[18] Furthermore, by means of a questionnaire, data were collected on non-work-related physical factors[18,19] and individual characteristics.[20,21] The work-related physical and psychosocial variables were also considered to be potential confounders for each other.

Statistics

The Poisson regression technique was used to model the relationship between work-related physical and psychosocial variables and the frequency of sickness absence due to neck pain with a minimal duration of 3 days (further referred to as sickness absence due to neck pain), resulting in the calculation of a rate ratio (RR) and its corresponding 95% confidence interval (95% CI).[22] Analyses were performed with the statistical package SAS.[23]

The work-related physical variables derived from the video-recordings were divided into a number of small categories. Categories showing similar effect estimates were combined into broader categories, resulting in the following categorisation of the four work-related physical variables: the percentage of the working time with the neck in a minimum of 20 degrees of flexion in three categories (less than 30% of the working time, 30-40% of the working time and more than 40% of the working time); the percentage of the working time with the neck in a minimum of 45 degrees of flexion in two categories (less than 5% of the working time and more than 5% of the working time); the percentage of the working time with the neck in a minimum of 45 degrees of rotation in two categories (less than 25% of the working time and more than 25% of the working time); the percentage of the working time sitting in four categories (less than 1% of the working time, 1-50% of the working time, 50-95% of the working time and more than 95% of the working time).

A comparable strategy was used to categorise the work-related psychosocial dimensions quantitative job demands, decision authority, skill discretion, co-worker support and supervisor support, which were all divided in three categories (low, medium and high). The two work-related psychosocial variables job security and conflicting job demands were divided in two categories ((totally) agree and (totally) disagree).

Firstly, univariate analyses of the relationship between each of the work-related physical and psychosocial variables, and the frequency of sickness absence due to neck pain were performed. Secondly, univariate analyses were performed to test the relationship between each potential confounder and the frequency of sickness absence due to neck pain. Potential confounders associated with sickness absence due to neck pain with a p-value less than 0.25 were considered as likely confounders.[24] Thirdly, for potential confounders with a univariate p-value of less than 0.25, the actual confounding effect on the estimated RR of each work-related physical and psychosocial variable was examined. Therefore, the estimated RR for each work-related physical and psychosocial variable resulting from an analysis in which one work-related physical or psychosocial variable and one confounder were combined, was compared with the crude RR of this work-related physical or psychosocial variable. If the change in this RR was 10% or more, the potential confounder was considered to be a real confounder in this dataset. By checking the correlations, the inter-relationships between the work-related physical and psychosocial variables and the confounders were verified to avoid colinearity. Finally, in the last step of the analysis, a multivariate model was constructed for each work-related physical and psychosocial variable, in which all confounders determined during the previous steps of the analysis were included. Age and sex were selected a priori as confounders, and included in all multivariate analyses.

Finally, the effect of neck pain at baseline on the relationship between work-related physical and psychosocial variables and sickness absence due to neck pain was studied. For this purpose, the variable 'regular or prolonged neck pain in the 12 months prior to baseline' was univariately related to sickness absence due to neck pain, and the variable was added to each multivariate model.

Results

In total, 1,025 subjects met the inclusion criteria. For 267 subjects (26%) data on reasons for sickness absence due to neck pain were incomplete.
In the group of workers with missing data on the reasons for sickness absence, fewer worked with the neck flexed more than 20 degrees, or with the neck rotated more than 45 degrees for a high percentage of their working time ($p<0.05$). Also, fewer workers in the group with missing data were sitting for a high percentage of their working time ($p<0.05$). In contrast, relatively more workers among those with missing data worked with their neck flexed more than 45 degrees for a high percentage of their working time ($p<0.05$).
No difference was found in the distributions of the work-related psychosocial variables quantitative job demands, conflicting job demands and co-worker support between those included in this study and those with missing data on the reasons for sickness absence. For the other work-related psychosocial variables, i.e., decision authority, skill discretion, supervisor support and job security, a statistically significant difference ($p<0.05$) was found between the two groups. In the group of workers with missing data, the percentage of workers in the high-risk categories was higher.

Descriptive information on the study population

Of the 758 workers included in this analysis, 567 (74.8%) were male. The mean age of the study population was 36.3 years (SD 8.8). The mean duration of employment in the current job was 7.8 years (SD 7.7) and the mean number of working hours per week was 38.9 (SD 4.2). The baseline distribution of the work-related physical and psychosocial variables is presented in Table 6.2.

Table 6.2 Distribution of work-related physical and psychosocial variables at baseline (N=758)

Variable	Classification	Distribution Number (%)
Percentage of the working time with the neck in a minimum of 20 degrees of flexion	Less than 30%	230 (31.6)
	30-40%	270 (37.1)
	More than 40%	227 (31.2)
Percentage of the working time with the neck in a minimum of 45 degrees of flexion	Less than 5%	600 (82.5)
	More than 5%	127 (17.5)
Percentage of the working time with the neck in a minimum of 45 degrees of rotation	Less than 25%	602 (82.8)
	More than 25%	125 (17.2)
Percentage of the working time in a sitting position	Less than 1%	152 (20.9)
	1-50%	243 (33.4)
	50-95%	274 (37.3)
	More than 95%	58 (8.0)
Quantitative job demands	Low (score <14)	464 (61.9)
	Medium (score 14-17)	232 (30.9)
	High (score >17)	54 (7.2)
Conflicting job demands	(Totally) disagree	493 (66.0)
	(Totally) agree	254 (34.0)
Decision authority	High (score >8)	338 (45.7)
	Medium (score 7-8)	290 (38.3)
	Low (score <7)	111 (15.0)
Skill discretion	High (score >14)	432 (57.5)
	Medium (score 14)	113 (15.0)
	Low (score <14)	206 (27.4)
Co-worker support	High (score >14)	69 (9.2)
	Medium (score 11-14)	591 (79.0)
	Low (score <11)	88 (11.8)
Supervisor support	High (score >11)	533 (71.1)
	Medium (score 9-11)	128 (17.1)
	Low (score <9)	89 (11.9)
Job security	(Totally) agree	634 (83.6)
	(Totally) disagree	117 (15.4)

During the follow-up period, a total of 36 workers (4.7%) had been absent from work due to neck pain, 5 of whom were absent from work twice due to neck pain twice during the follow-up period, and one subject was absent from work three times due to neck pain. The mean duration of sickness absence was 17 days and the median was 11 days. Furthermore, the duration of the sickness absence was 8 days or longer for 20 out of these 36 workers.

The potential confounders are listed in Table 6.3. Variables marked with an asterisk were found to be univariately associated with sickness absence due to neck pain, with a p-value of less than 0.25.
The percentage of the working time with a minimum of 60 degrees of upper arm elevation and video-display terminal work were correlated with a number of work-related physical and psychosocial variables (Pearson's correlation coefficients ranging from –0.65 to 0.62). Skill discretion and decision authority were also correlated (Pearson's correlation coefficient 0.47). To avoid colinearity, it was therefore decided not to combine these variables in one single multivariate analysis.

Table 6.3 Potential confounders of the association between work-related physical and psychosocial variables and sickness absence due to neck pain with a minimal duration of 3 days

Potential confounders in the analyses (categories)
Work-related physical factors
Number of times lifting 25 kg or more per 8 hour working day (no lifts, at least 1 lift)
Percentage of the working time with a minimum of 60 degrees upper arm elevation (<5%, >5%)*
Percentage of the working time carrying out repeated movements >4 times/minute (0%, >0%)
Video display terminal work (seldom/never, sometimes, quite often or very often)*
Working with the hands above shoulder level (seldom/never, sometimes, quite often or very often)*
Working with vibrating tools (seldom/never, sometimes, quite often or very often)
Driving a vehicle (seldom/never, sometimes, quite often or very often)
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often or very often)
Non-work-related physical factors
Prolonged sitting (seldom/never, sometimes, quite often or very often)
Video display terminal work (seldom/never, sometimes, quite often or very often)
Activities with the hands above shoulder level (seldom/never, sometimes, quite often or very often)*
Force exertion with hand or arms (seldom/never, sometimes, quite often or very often)
Activities in the same posture for a long time (seldom/never, sometimes, quite often or very often)
Working with vibrating tools (seldom/never, sometimes, quite often or very often)
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often or very often)*
Repeated movements with hands/arm many times/minute (seldom/never, sometimes, quite or very often)
Driving a vehicle (seldom/never, sometimes, quite often or very often)*
Frequency of sports or heavy physical activities which cause sweating during the past 4 months (more than 3 times/month, 1-3 times/month, less than once/month)*
Individual characteristics
Sex (male, female)
Age (continuous variable)*
Body Mass Index (less than 25, 25-30, more than 30)
Coping: avoidance behaviour (low, high)
Coping: social support seeking (low, high)
Coping: active problem solving (low, high)*
Stressful life events in previous 12 months (no stressful life events, at least one stressful life event)*

* These variables were univariately associated with sickness absence due to neck pain with a minimal duration of 3 days with a p-value of less than 0.25

Work-related physical variables and sickness absence due to neck pain

The results of the univariate and multivariate analyses of the association between the work-related physical variables and sickness absence due to neck pain are presented in Table 6.4. Compared with the reference category, workers with the neck in a minimum of 20 degrees of flexion for more than 40% of the working time had a statistically significant increased crude and adjusted RR of 3.4 and 4.2 for sickness absence due to neck pain, respectively. In addition, workers with the neck in a minimum of 45 degrees of flexion for more than 5% of the working time had an increased crude and adjusted RR of 2.2 and 2.8, respectively. The crude and adjusted RR for workers with the neck in a minimum of 45 degrees of rotation for more than 25% of their working time was 1.9 and 2.8, respectively.

For the fourth work-related physical factor, i.e., the percentage of the working time sitting, a statistically significant RR of less than one was found for workers who were sitting for 1-50% of their working time (adjusted RR=0.3). The adjusted RR for sitting for 50 to 95% of the working time was still decreased, but no longer statistically significant. The effect disappeared for the group of subjects who were sitting for more than 95% of their working time.

The most important confounders in the analysis of the relationship between work-related physical variables and sickness absence due to neck pain were other physical variables. These were more important than the psychosocial variables or individual characteristics.

Work-related psychosocial variables and sickness absence due to neck pain

The results of the univariate and multivariate analyses of the associations between the work-related psychosocial variables and sickness absence due to neck pain are also presented in Table 6.4. Workers who scored relatively low on decision authority showed a statistically significant increased crude and adjusted RR of 4.4 and 3.7, respectively. Moreover, the RR for medium decision authority was also statistically significantly increased. Medium skill discretion was statistically significantly related to sickness absence due to neck pain (crude RR=2.7; adjusted RR=2.6). The crude and adjusted RRs for low skill discretion were also increased, but not statistically significant. Furthermore, increased risks were found for high quantitative job demands and low job security in relation to sickness absence due to neck pain. However, the adjusted RRs were not statistically significant for these variables. Finally, no relationship was found between conflicting job demands, supervisor support or co-worker support and sickness absence due to neck pain.

The most important confounders in the analysis of the relationship between work-related psychosocial variables and sickness absence due to neck pain were other psychosocial variables. These variables were more important than the physical variables or individual characteristics.

Table 6.4 Results of the univariate and multivariate analysis of the association between work-related physical and psychosocial variables and sickness absence due to neck pain with a minimal duration of 3 days

Work-related variable	Classification	Crude RR[a]	Adjusted RR[b]
Neck flexion ≥20 degrees	<30% of the working time	1.00	1.00[c]
	30-40% of the working time	1.56 (0.58-4.23)	2.65 (0.88-7.97)
	>40% of the working time	3.37 (1.35-8.39)*	4.19 (1.50-11.69)*
Neck flexion ≥45 degrees	<5 % of the working time	1.00	1.00[d]
	>5% of the working time	2.24 (1.12-4.45)*	2.76 (1.27-5.99)*
Neck rotation ≥45 degrees	<25% of the working time	1.00	1.00[e]
	>25% of the working time	1.89 (0.92-3.91)	2.81 (1.29-6.09)*
Sitting	<1% of the working time	1.00	1.00[f]
	1-50% of the working time	0.38 (0.17-0.87)*	0.32 (0.13-0.76)*
	50-95% of the working time	0.28 (0.11-0.68)*	0.38 (0.12-1.16)
	>95% of the working time	1.00 (0.39-2.57)	1.70 (0.46-6.31)
Quantitative job demands	Low	1.00	1.00[g]
	Medium	0.78 (0.37-1.61)	0.73 (0.35-1.53)
	High	2.43 (1.05-5.59)*	1.96 (0.83-4.62)
Conflicting job demands	(Totally) disagree	1.00	1.00[h]
	(Totally) agree	0.95 (0.50-1.80)	0.96 (0.51-1.83)
Decision authority	High	1.00	1.00[i]
	Medium	3.47 (1.56-7.73)*	3.03 (1.35-6.82)*
	Low	4.36 (1.75-10.83)*	3.66 (1.44-9.26)*
Skill discretion	High	1.00	1.00[j]
	Medium	2.70 (1.17-6.24)*	2.56 (1.08-6.04)*
	Low	2.08 (0.99-4.36)	1.64 (0.73-3.69)
Co-worker support	High	1.00	1.00[k]
	Medium	1.16 (0.36-3.81)	0.92 (0.26-3.18)
	Low	0.79 (0.16-3.91)	0.51 (0.10-2.70)
Supervisor support	High	1.00	1.00[l]
	Medium	1.91 (0.96-3.79)	1.62 (0.81-3.24)
	Low	1.23 (0.47-4.24)	0.96 (0.35-2.60)
Job security	(Totally) agree	1.00	1.00[m]
	(Totally) disagree	1.98 (0.96-4.09)	1.70 (0.80-3.60)

[a] Crude rate ratio and 95% CI from Poisson regression analysis; [b] Adjusted rate ratio and 95% CI from Poisson regression analysis; [c] Adjusted for sex, age, neck rotation ≥45°, sitting posture, decision authority, skill discretion, activities with hands above shoulder level (LT), and sport participation; [d] Adjusted for sex, age, sitting posture, and activities with hands above shoulder level (LT); [e] Adjusted for sex, age, neck flexion ≥45°, sitting posture, and sport participation; [f] Adjusted for sex, age, neck flexion ≥45°, neck rotation ≥45°, decision authority, skill discretion frequent flexion/rotation upper part of the body (LT), driving a vehicle (LT), sport participation, and coping: active problem solving; [g] Adjusted for sex, age, and decision authority; [h] Adjusted for sex and age; [i] Adjusted for sex, age, sport participation, and coping: active problem solving; [j] Adjusted for sex, age, sitting posture, and coping: active problem solving; [k] Adjusted for sex, age, neck flexion ≥20°, neck rotation ≥45°, sitting posture, decision authority, skill discretion, and supervisor support; [l] Adjusted for sex, age, quantitative job demands, and decision authority; [m] Adjusted for sex, age, neck flexion ≥20°, and decision authority; * $P<0.05$; (LT) leisure time

work-related physical and psychosocial variables were re-divided into categories containing a larger number of workers in each risk category.

Implications for prevention

The results of this study suggest that decreasing the percentage of time working with the neck flexed or rotated will have a positive effect on the prevention of sickness absence due to neck pain. Increasing a worker's authority over decisions, and increasing learning possibilities and the development of skills in a job, will probably reduce sickness absence due to neck pain. Moreover, the reduction of job demands (i.e., for example working under time pressure or working with deadlines) will possibly also reduce sickness absence due to neck pain.

The results of the present study therefore imply that both adequate work station design to optimise neck position, and organisational changes to increase decision latitude and decrease demands, will contribute to the prevention of sickness absence due to neck pain.

Conclusions

1. Working with the neck flexed more than 20 degrees for more than 40% of the working time and working with the neck flexed more than 45 degrees for more than 5% of the working time are prospectively and independently related to sickness absence due to neck pain.
2. Working with the neck rotated more than 45 degrees for more than 25% of the working time is prospectively and independently related to sickness absence due to neck pain.
3. Prolonged sitting at work does not increase sickness absence due to neck pain.
4. Low decision authority and medium skill discretion are prospectively and independently related to sickness absence due to neck pain.
5. There are indications for a relationship between high quantitative job demands, low job security and low skill discretion, and sickness absence due to neck pain.
6. Conflicting job demands, low co-worker support and low supervisor support are not related to sickness absence due to neck pain.

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Chapter seven

Physical and psychosocial load at work in relation to neck pain and neck-shoulder pain: a comparison of two outcome measures

Summary

The objective of this study was to compare the results of analyses on the relationship between work-related physical and psychosocial variables and both neck pain and neck-shoulder pain.
Data from a three-year prospective cohort study among 1,218 workers with no neck pain or shoulder pain at baseline were used. At baseline, data on quantified physical exposure variables and self-reported psychosocial variables were collected. Neck pain and neck-shoulder pain were assessed by means of questionnaires during the follow-up period. In the analyses, adjustments were made for various work-related and non-work-related physical variables, psychosocial variables and individual characteristics. Neck flexion more than 20 degrees, working in a sitting position, high quantitative job demands and low co-worker support were more strongly related to neck pain than to neck-shoulder pain. When neck-shoulder pain was used as the outcome measure, the size of the effect estimates of these four variables was clearly lower in both the univariate and the multivariate analyses. For the other work-related variables under study, i.e., neck flexion more than 45 degrees, neck rotation more than 45 degrees, conflicting job demands, decision authority, skill discretion, supervisor support and job security, no great differences were found in the effect estimates between the two outcome measures.
It is concluded that future studies on occupational risk factors for musculoskeletal symptoms should investigate this relationship for the neck region separately if the objective is to identify risk factors for neck pain. The results of this study showed that if a combination of neck-shoulder pain is used as the outcome measure, the effect estimates are lower than the effect estimates derived from an analyses in which the neck region is the sole outcome measure. A combination of the neck and shoulder region in one outcome measure may lead to an under-estimation of the effect of certain work-related physical and psychosocial factors on the occurrence of neck pain.

Ariëns GAM, Bongers PM, Wal G van der, Mechelen W van. Work-related physical and psychosocial load in relation to neck pain and neck-shoulder pain: a comparison of two outcome measures. Submitted.

Pain in the neck may originate from soft tissues in the neck region and their surrounding structures. The terminology applied to musculoskeletal disorders of the neck region is confusing. Many different terms are mentioned in the literature, including repetitive strain injuries, occupational cervicobrachial disorders and tension neck syndrome.[1,2] These disorders are clinically not well-defined, but all are characterised by the absence of objective signs. Moreover, there is no agreement concerning the cause, the pathology is unknown, diagnostic instruments are not available and the prognosis is uncertain.[1]
Case-definitions in epidemiological studies on occupational risk factors for musculoskeletal disorders in the neck region are often based on self-reported symptoms or pain. When studying risk factors for neck pain it makes sense to be as specific as possible, since it is not clear whether the risk factors for neck pain and shoulder pain are the same. However, many studies have combined neck pain and shoulder pain in one outcome measure.[3-5] The reason for using a composite measure is that several muscles in the neck/shoulder area (e.g., the trapezius muscle) act on both the neck and the shoulder region simultaneously. In addition, it appears that respondents find it difficult to discriminate between the neck and the shoulder region. In contrast, other studies on occupational risk factors make a distinction between the neck region and the shoulder region, and investigate complaints concerning these two anatomical regions as separate outcome measures.[6,7]
In two systematic reviews of observational studies on risk factors for neck pain, all studies that combined the neck and the shoulder region were excluded.[8,9] This criterion was applied because in the studies under review the definition of the composite measure of neck-shoulder pain was often unclear, and because different risk factors may influence either the occurrence of pain in the neck or pain in the shoulder region. Van der Windt *et al.* also excluded studies that combined the neck and the shoulder region in their systematic review of observational studies on risk factors for shoulder pain.[10] Whether or not the results and conclusions of these systematic reviews would have been different if studies that combined the neck and the shoulder region were included in these reviews, is unclear.
Only longitudinal studies in which separate data are collected for neck pain and shoulder pain can provide an answer to the important question of whether, when studying occupational risk factors, the neck and the shoulder region should be used as separate outcome measures, or whether a composite outcome measure of neck-shoulder pain can be used. One such longitudinal study is SMASH (Study on Musculoskeletal disorders, Absenteeism, Stress and Health). Based on data from SMASH, the present study investigates whether the results would be different if two different outcome measures (i.e., neck pain versus neck-shoulder pain) were used. Therefore, the longitudinal relationship between work-related physical and psychosocial variables and the occurrence of neck pain and neck-shoulder pain, respectively, are investigated.

Methods

Design

In 1994, the Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH), a large-scale prospective cohort study with a follow-up period of three years, was initiated among a working population. The main purpose of SMASH was to determine risk factors for musculoskeletal disorders, with a focus on back, neck and shoulder disorders. Approximately 1,800 male and female workers from 34 companies participated in SMASH. The companies recruited were located throughout The Netherlands, and included various industrial and service branches, which resulted in a study population of workers with a wide range of physical and mental workloads. Only those aspects of the methods that are relevant for the present study will be described in more detail.

Study population

At baseline, 1,789 (87%) of the 2,064 workers who were invited to participate in SMASH filled in the questionnaire. Furthermore, at baseline, workers had to meet the following five inclusion criteria:

1. No other paid job for any substantial amount of time (18 workers were excluded).
2. No work disability payment due to neck pain in the previous 12 months (3 workers were excluded).
3. Working for at least 20 hours a week (11 workers were excluded).
4. Working for at least 1 year in their current job (18 workers were excluded).
5. No self-reported regular or prolonged neck or shoulder pain in the 12 months prior to baseline (521 workers were excluded).

After applying these selection criteria, 1,218 workers were eligible for inclusion in the study.

Work-related physical and psychosocial variables

At baseline, data on work-related physical and psychosocial variables were collected. The following four work-related physical variables were quantified by means of video-recordings at the workplace and subsequent observation and analysis of these video-recordings: the percentage of the working time with the neck in a minimum of 20 degrees of flexion; the percentage of the working time with the neck in a minimum of 45 degrees of flexion; the percentage of the working time with the neck in a minimum of 45 degrees of rotation; the percentage of the working time in a sitting position. Extensive details of the assessment of these work-related physical variables have been published elsewhere.[11]

At baseline, information on work-related psychosocial variables was collected by means of the Job Content Questionnaire (JCQ).[12] This questionnaire measures all dimensions of the widely used Demand-Control-Support model.[13,14] On a 4-point scale (totally disagree, disagree, agree, totally agree), workers were asked to assess certain aspects of their work. Various items on the questionnaire were combined into dimensions (i.e., quantitative job demands, skill discretion, decision authority, supervisor support and co-worker support). The construction of these dimensions has been described by De Jonge *et al.*[15] Single items on the JCQ were used for the assessment of job security ('I feel secure about my job') and conflicting job demands ('I don't get conflicting assignments from others').

Neck pain and neck-shoulder pain

At baseline, and annually during the follow-up period, data on neck pain were collected by means of an adapted version of the Nordic Questionnaire.[16] On a 4-point scale (seldom/never; sometimes; regular; prolonged) workers reported the occurrence of neck pain and shoulder pain in the previous 12 months. A case of neck pain was defined if a worker reported regular or prolonged neck pain during the previous 12 months, at least at one of the three follow-up measurements. A case of neck-shoulder pain was defined if a worker reported regular or prolonged neck pain and/or shoulder pain during the previous 12 months, at least at one of the three follow-up measurements.

Potential confounders

Potential confounders were measured at baseline. Work-related physical variables were measured either by means of the Loquest Questionnaire[17] on a 4-point scale (seldom/never, sometimes, quite often, very often), or by means of video-recordings at the workplace.[11] Data on physical variables during leisure time were collected by means of the Loquest Questionnaire on a 4-point scale (seldom/never, sometimes, quite often, very often). In one additional question, exercise during leisure time (sports participation) was assessed.[18] Finally, the individual characteristics sex, age, body mass index (BMI), coping styles[19] and stressful life events[20] were taken into account as potential confounders.

Statistics

Cox regression analysis, with a constant time variable, was used to model the relationship between work-related physical and psychosocial variables and the two outcome variables, resulting in the calculation of a relative risk (RR) and its corresponding 95% confidence interval (CI).[21,22]
Firstly, univariate analyses of the relationship between each exposure variable and the two outcome variables were performed. The physical and psychosocial variables were divided into categories, as described by Ariëns *et al.*[11,23]
Secondly, univariate analyses were performed to test the relationship between all potential confounders and the two outcome measures. Variables associated with one of the two outcome measures with a p-value higher than 0.25 were not considered to be likely confounders.[24]
Thirdly, for all potential confounders with a univariate p-value of less than 0.25, the actual confounding effect on the estimated RR of each work-related physical and psychosocial variable was examined. Therefore, the estimated RR for each work-

related physical and psychosocial exposure variable, resulting from an analysis in which one work-related physical or psychosocial factor and one confounder were combined, was compared to the crude RR of this work-related physical or psychosocial factor. If the change in the RR was 10% or higher, the potential confounder was considered to be a real confounder in this dataset. By checking the correlations, the inter-relationships between the work-related physical and psychosocial variables and the confounders were verified.
In the last step of the analysis, for each of the two outcome measures, multivariate models were constructed for each work-related physical and psychosocial variable, in which all confounders determined during the previous steps of the analysis were included. Age and sex were selected a priori as confounders, and included in all multivariate analyses. Finally, a comparison was made of the results of the multivariate analyses of the relationship between the work-related physical and psychosocial variables and both neck pain and neck-shoulder pain.

Results

Selectiveness of loss to follow-up

Of the 1,218 workers who met the inclusion criteria, 345 (28%) did not provide complete data on the occurrence of neck pain and shoulder pain during the follow-up period, and they were considered to be lost to follow-up. There was no baseline difference in the distribution of the following work-related physical and psychosocial variables between those who completed the study and those who were lost to follow-up: neck flexion more than 20 or 45 degrees, neck rotation more than 45 degrees, quantitative job demands, conflicting job demands, co-worker support, supervisor support and job security.
In the group of workers who were lost to follow-up, significantly fewer were working in a sitting position for a high percentage of the working time ($p<0.05$) and significantly more reported low decision authority and low skill discretion ($p<0.05$).

Descriptive information on the study population

Of the 873 subjects included in the analysis, 669 were male. The mean age of the study population was 35.7 years (SD 8.5). The mean duration of employment in the current job was 9.7 years (SD 7.8) and the mean number of working hours per week was 38.4 (SD 4.6). The baseline distribution of the work-related physical and psychosocial variables is presented in Table 7.1.

Table 7.1 Distribution of the work-related physical and psychosocial variables (N=873)

Variable	Classification	Distribution N (%)
Percentage of the working time with the neck in a minimum of 20 degrees of flexion	Less than 60%	785 (92.4)
	60-70%	37 (4.4)
	More than 70%	28 (3.3)
Percentage of the working time with the neck in a minimum of 45 degrees of flexion	Less than 5%	621 (73.1)
	5-10%	164 (19.3)
	More than 10%	65 (7.7)
Percentage of the working time with the neck in a minimum of 45 degrees of rotation	Less than 25%	736 (86.6)
	25-30%	73 (8.6)
	More than 30%	41 (4.8)
Percentage of the working time in a sitting position	Less than 1%	203 (23.9)
	1-50%	346 (40.7)
	50-75%	43 (5.1)
	75-95%	198 (23.3)
	More than 95%	60 (7.1)
Quantitative job demands	Low	572 (65.7)
	Medium	244 (28.0)
	High	54 (6.2)
Conflicting job demands	(Totally) disagree	593 (68.2)
	Agree	218 (25.1)
	Totally agree	58 (6.7)
Decision authority	High	428 (49.4)
	Medium	406 (46.9)
	Low	32 (3.7)
Skill discretion	High	526 (60.3)
	Medium	300 (34.4)
	Low	46 (5.3)
Co-worker support	High	89 (10.2)
	Medium	703 (80.8)
	Low	78 (9.0)
Supervisor support	High	620 (71.3)
	Medium	198 (22.8)
	Low	52 (6.0)
Job security	(Totally) agree	691 (79.4)
	(Totally) disagree	179 (20.6)

During the follow-up period, a total of 118 workers (13.5%) reported neck pain, at least at one of the follow-up measurements. A total of 181 workers (20.7%) reported neck-shoulder pain, at least at one of the follow-up measurements, of whom 58 workers had only neck pain, 63 workers had only shoulder pain, and 60 workers had neck and shoulder pain simultaneously. The potential confounders are listed in Table 7.2.

Table 7.2 Potential confounders of the association between work-related physical and psychosocial variables and neck pain and neck-shoulder pain

Potential confounders in the analyses (categories)
Work-related physical factors
Number of times lifting 25 kg or more per 8-hour working day (no lifts, at least 1 lift)
Percentage of the working time with a minimum of 60 degrees of upper arm elevation (<5%, >5%)*
Percentage of the working time carrying out repeated movements >4 times a minute (0%, >0%)
Video display terminal work (seldom/never, sometimes, quite often, very often)*
Working with the hands above shoulder level (seldom/never, sometimes, quite often, very often)*
Working with vibrating tools (seldom/never, sometimes, quite often, very often)*
Driving a vehicle (seldom/never, sometimes, quite often, very often)*
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often, very often)*
Non-work-related physical factors
Prolonged sitting (seldom/never, sometimes, quite often or very often)*
Video display terminal work (seldom/never, sometimes, quite often or very often)*
Activities with the hands above shoulder level (seldom/never, sometimes, quite often or very often)
Force exertion with hand or arms (seldom/never, sometimes, quite often or very often)
Activities in the same posture for a long time (seldom/never, sometimes, quite often or very often)*
Working with vibrating tools (seldom/never, sometimes, quite often or very often)
Frequent flexion/rotation of upper part of the body (seldom/never, sometimes, quite often or very often)
Repeated movements hands/arm many times/minute (seldom/never, sometimes, quite often or very often)
Driving a vehicle (seldom/never, sometimes, quite often or very often)
Frequency of sports or heavy physical activities which cause sweating in the past 4 months (more than 3 times/month, 1-3 times/month, less than once/month)*
Individual characteristics
Sex (male, female)*
Age (continuous variable)
Body Mass Index (less than 25, 25-30, more than 30)
Coping: avoidance behaviour (low, high)*
Coping: social support-seeking (low, high)*
Coping: active problem-solving (low, high)*
Stressful life events in previous 12 months (no stressful life events, at least one stressful life event)*

* These variables were univariately associated with neck pain or neck-shoulder pain with a p-value of less than 0.25

The percentage of the working time spent with a minimum of 60 degrees of upper arm elevation, working behind a video display terminal, and working with the hands above shoulder level correlated highly with the percentage of the working time sitting (Pearson's correlation coefficient –0.64, 0.61 and –0.40; $p<0.05$). It was therefore decided not to adjust for these three variables in the multivariate model of working in a sitting position. Skill discretion and decision authority were also highly correlated (Pearson's correlation coefficient 0.41; $p<0.05$). To avoid colinearity, it was decided not to adjust for these variables in their respective multivariate analyses. The results of the univariate and multivariate analyses of the associations of the work-related physical and psychosocial variables and neck pain and neck-shoulder pain, respectively, are presented in Tables 7.3 and 7.4.

Table 7.3 Results of the univariate analysis of the association between work-related physical and psychosocial variables and neck pain and neck-shoulder pain

Work-related physical or psychosocial variable	Classification	Neck pain, crude RR (95% CI)[a]	Neck-shoulder pain, crude RR (95% CI)
Neck flexion ≥20 degrees	<60% of the working time	1.00	1.00
	60-70% of the working time	1.47 (0.68-3.16)	0.93 (0.44-1.99)
	>70% of the working time	2.22 (1.08-4.56)	1.76 (0.93-3.34)
Neck flexion ≥45 degrees	<5 % of the working time	1.00	1.00
	5-10% of the working time	1.15 (0.73-1.82)	1.06 (0.73-1.56)
	>10% of the working time	1.57 (0.87-2.83)	1.31 (0.79-2.17)
Neck rotation ≥45 degrees	<25% of the working time	1.00	1.00
	25-30% of the working time	1.47 (0.84-2.58)	1.23 (0.76-2.01)
	>30% of the working time	1.12 (0.49-2.56)	1.34 (0.73-2.48)
Sitting	<1% of the working time	1.00	1.00
	1-50% of the working time	1.60 (0.93-2.74)	1.44 (0.96-2.15)
	50-75% of the working time	2.10 (0.91-4.82)	1.43 (0.71-2.90)
	75-95% of the working time	1.59 (0.88-2.88)	1.09 (0.68-1.75)
	>95% of the working time	2.44 (1.20-4.99)	1.74 (0.97-3.12)
Quantitative job demands	Low	1.00	1.00
	Medium	1.37 (0.92-2.05)	1.32 (0.96-1.81)
	High	2.44 (1.39-4.29)	1.72 (1.03-2.86)
Conflicting job demands	(Totally) disagree	1.00	1.00
	Agree	1.03 (0.68-1.57)	1.05 (0.75-1.48)
	Totally agree	1.04 (0.50-2.14)	1.20 (0.69-2.09)
Decision authority	High	1.00	1.00
	Medium	1.20 (0.82-1.74)	1.38 (1.02-1.87)
	Low	1.80 (0.82-3.96)	1.81 (0.93-3.50)
Skill discretion	High	1.00	1.00
	Medium	1.05 (0.72-1.54)	1.10 (0.81-1.50)
	Low	0.98 (0.43-2.26)	1.09 (0.57-2.08)
Co-worker support	High	1.00	1.00
	Medium	1.50 (0.73-3.09)	1.22 (0.72-2.08)
	Low	2.14 (0.91-5.05)	1.60 (0.82-3.10)
Supervisor support	High	1.00	1.00
	Medium	0.96 (0.62-1.49)	1.26 (0.91-1.75)
	Low	0.98 (0.45-2.12)	0.67 (0.31-1.44)
Job security	(Totally) agree	1.00	1.00
	(Totally) disagree	0.99 (0.63-1.54)	1.03 (0.72-1.47)

[a] Crude relative risk (RR) and 95% confidence interval (CI) from Cox regression analysis

Table 7.4 Results of the multivariate analysis of the association between work-related physical and psychosocial variables and neck pain and neck-shoulder pain

Work-related physical or psychosocial variable	Classification	Neck pain[a]	Neck-shoulder pain[a]
Neck flexion ≥20 degrees	<60% of the working time	1.00[b]	1.00[b]
	60-70% of the working time	1.56 (0.67-3.65)	0.99 (0.43-2.24)
	>70% of the working time	1.80 (0.73-4.46)	1.46 (0.67-3.21)
Neck flexion ≥45 degrees	<5 % of the working time	1.00[c]	1.00[c]
	5-10% of the working time	1.09 (0.68-1.74)	1.06 (0.72-1.56)
	>10% of the working time	1.13 (0.59-2.17)	1.10 (0.63-1.93)
Neck rotation ≥45 degrees	<25% of the working time	1.00[d]	1.00[d]
	25-30% of the working time	1.68 (0.94-3.00)	1.31 (0.79-2.17)
	>30% of the working time	1.49 (0.64-3.50)	1.51 (0.80-2.84)
Sitting	<1% of the working time	1.00[e]	1.00[e]
	1-50% of the working time	1.50 (0.86-2.60)	1.32 (0.87-1.99)
	50-75% of the working time	1.48 (0.60-4.68)	1.06 (0.49-2.28)
	75-95% of the working time	1.41 (0.76-2.60)	0.98 (0.60-1.60)
	>95% of the working time	1.69 (0.77-3.70)	1.26 (0.66-2.40)
Quantitative job demands	Low	1.00[f]	1.00[f]
	Medium	1.36 (0.91-2.03)	1.31 (0.95-1.80)
	High	2.44 (1.39-4.28)	1.71 (1.03-2.86)
Conflicting job demands	(Totally) disagree	1.00[f]	1.00[f]
	Agree	1.08 (0.71-1.64)	1.09 (0.77-1.53)
	Totally agree	1.04 (0.50-2.15)	1.20 (0.69-2.10)
Decision authority	High	1.00[g]	1.00[g]
	Medium	1.17 (0.80-1.73)	1.32 (0.96-1.81)
	Low	1.46 (0.64-3.35)	1.47 (0.74-2.93)
Skill discretion	High	1.00[h]	1.00[h]
	Medium	1.07 (0.71-1.62)	1.11 (0.80-1.54)
	Low	0.90 (0.38-2.15)	0.93 (0.46-1.88)
Co-worker support	High	1.00[i]	1.00[i]
	Medium	1.63 (0.79-3.37)	1.27 (0.74-2.18)
	Low	2.27 (0.95-5.42)	1.59 (0.81-3.12)
Supervisor support	High	1.00[j]	1.00[j]
	Medium	0.80 (0.50-1.29)	1.06 (0.74-1.52)
	Low	0.84 (0.37-1.92)	0.63 (0.28-1.39)
Job security	(Totally) agree	1.00[f]	1.00[f]
	(Totally) disagree	1.05 (0.67-1.66)	1.08 (0.76-1.56)

[a] Adjusted relative risk and 95% CI from Cox regression analysis; [b] Ajusted for sex, age, sitting (WR), upper arm elevation >60° (WR), and sport participation; [c] Adjusted for sex, age, and sitting (WR); [d] Adjusted for sex, age, sitting (WR), upper arm elevation >60° (WR), and co-worker support; [e] Adjusted for sex, age, neck flexion >20° (WR), and coping: social support-seeking; [f] Adjusted for sex and age; [g] Adjusted for sex, age, sitting (WR), upper arm elevation >60° (WR), and quantitative job demands; [h] Adjusted for sex, age, activities in same posture for a long time (LT), and coping: active problem-solving; [i] Adjusted for sex, age, decision authority, and coping: social support-seeking; [j] Adjusted for sex, age, sitting (WR), quantitative job demands, decision authority, co-worker support, and coping: social support-seeking; WR Work-related; LT Leisure time

Risk factors for neck pain and neck-shoulder pain

Neck flexion of more than 20 degrees for more than 70% of the working time and working in a sitting position for more than 95% of the working time were statistically significantly related to neck pain, with a crude relative risk of 2.2 and 2.4, respectively (Table 7.3). In the multivariate analysis, none of the work-related physical variables were statistically significantly related either to neck pain or to neck-shoulder pain (Table 7.4).

High quantitative job demands was statistically significantly related to neck pain with a crude relative risk of 2.4, and to neck-shoulder pain, with a crude relative risk of 1.7 (Table 7.3). The multivariate analysis also showed a statistically significant relationship between high quantitative job demands and both neck pain and neck-shoulder pain (Table 7.4).

Comparison of neck pain and neck-shoulder pain (work-related physical variables)

The crude relative risks found for neck flexion more than 20 degrees and working in a sitting position in relation to neck pain were higher (approximately 0.5 and 0.7, respectively) than the crude relative risks found for these same variables in relation to neck-shoulder pain. Between the two outcome measures hardly any differences were found in the crude relative risks for neck flexion more than 45 degrees and neck rotation more than 45 degrees (Table 7.3).

The results of the multivariate analyses showed a comparable outcome for neck flexion more than 20 degrees and working in a sitting position. However, the estimated adjusted relative risks were overall lower, compared to the crude relative risks. Consequently, differences in the adjusted relative risk were smaller. In line with the results of the univariate analysis, hardly any differences in the adjusted relative risks of neck flexion more than 45 degrees and neck rotation more than 45 degrees were found between the two outcome measures. The one exception was neck rotation more than 45 degrees for 25-30% of the working time, for which a small difference of 0.4 in the effect estimates was found between the two outcome measures (Table 7.4).

Comparison of neck pain and neck-shoulder pain (work-related psychosocial variables)

The crude relative risks found for high quantitative job demands and low co-worker support in relation to neck pain were higher (approximately 0.7) than the crude relative risks found for these same variables in relation to neck-shoulder pain. Hardly any differences were found between the crude relative risks of the other psychosocial variables (Table 7.3). The results of the multivariate analyses showed a comparable outcome for all work-related psychosocial variables. However, the estimated adjusted relative risks were overall lower, compared the crude relative risks. Consequently, differences in the adjusted relative risks of high quantitative job demands and low co-worker support were also smaller (Table 7.4).

Discussion

Summary of the results

The aim of this study was to examine differences in the relationships between work-related physical and psychosocial factors and neck pain and neck-shoulder pain, respectively. A comparison was made of the magnitude of the effect estimates with the use of these two different outcome measures.

The effect estimates for neck flexion more than 20 degrees, working in a sitting position, quantitative job demands and co-worker support were higher if neck pain was the sole outcome measure. Differences of up to 0.7 were found in the crude and adjusted effect estimates of these four variables. When neck-shoulder pain was the outcome measure, the size of the effect estimates of these four variables was clearly smaller in both the univariate and the multivariate analyses.

For the other work-related variables under study, i.e., neck flexion more than 45 degrees, neck rotation more than 45 degrees, conflicting job demands, decision authority, skill discretion, supervisor support and job security, hardly any differences were found between the effect estimates when using the two outcome measures. For these variables, the conclusions based on the analyses with neck pain as the sole outcome variable would be the same as the conclusions using neck-shoulder pain as the outcome variable. With the exception of decision authority, these variables were in any case only weakly related to either neck pain or neck-shoulder pain.

Explanation of the results

Neck flexion is a very neck-specific exposure variable, which is expected to be related more to pain in the neck region than to pain in the shoulder region. Working in a sitting position is a more general physical exposure variable. In the systematic review on occupational risk factors for shoulder pain carried out by Van der Windt *et al.*, sitting was not evaluated as a separate risk factor for shoulder pain.[10] Instead, Van der Windt *et al.* concluded that working in awkward postures and carrying out the same type of work for a prolonged period was only found to be associated with shoulder pain in studies with a relatively low score for methodological quality. On the basis of a systematic review on occupational risk factors for neck pain, Ariëns *et al.* concluded that there is evidence that working in a sitting position is a risk factor for neck pain.[8] The results of these two systematic reviews confirm the results found in the present study, namely that work-related sitting is more strongly related to neck pain than to neck-shoulder pain.

Toomingas *et al.* studied the cross-sectional relationship between work-related psychosocial factors and neck and shoulder symptoms.[25] Their results showed increased prevalence ratios for high psychological demands, high job strain and low social support in relation to neck pain. When these psychosocial variables were related to shoulder pain, no associations were found. On the basis of the cross-sectional results of their study, Toomingas *et al.* concluded that work-related psychosocial load is mainly associated with symptoms concerning the central body regions (the neck and low back) rather than the peripheral regions (arms or hands). Moreover, they reported that if data regarding work-related musculoskeletal symptoms concerning different body regions were combined, true associations could be hidden, and that the risk estimates could be attenuated. The results of the present prospective cohort study confirm the results of Toomingas *et al.*[25] Increased crude and adjusted relative risks were found for high quantitative job demands and low co-worker support in relation to neck pain. In relation to neck-shoulder pain, the crude and adjusted relative risks for high quantitative job demands and low co-worker support were clearly lower.

Neck pain and neck-shoulder pain

An adapted version of the Nordic Questionnaire was used to collect data on the occurrence of neck and shoulder pain in the previous 12 months. This is a standardised questionnaire that is widely used to measure the outcome of epidemiologic studies on musculoskeletal disorders. Data-collection was based on separate questions for the neck region and the shoulder region. The reliability and validity of the original Nordic Questionnaire is reported to be satisfactory and not to differ between body regions.[16] Selection bias, with regard to the reporting of pain in the neck and shoulder regions, is therefore not likely.

Conclusions

Due to the relatively small size of the risk estimates, the small power, and therefore nonsignificant results, the following conclusions should be interpreted with caution.

1. Increased risks were found for neck flexion of more than 20 degrees, working in a sitting position, high quantitative job demands and low co-worker support in relation to both neck pain and neck-shoulder pain.
2. The risks found for neck flexion more than 20 degrees, working in a sitting position, high quantitative job demands and low co-worker support were higher when neck pain was used at the outcome measure than when neck-shoulder pain was used as the outcome measure.
3. For the other work-related variables under study, i.e., neck flexion more than 45 degrees, neck rotation more than 45 degrees, conflicting job demands, decision authority, skill discretion, supervisor support and job security, no great differences in the effect estimates were found between the two different outcome measures.
4. Future studies on the relationship between occupational risk factors and musculoskeletal pain should investigate this relationship for specific body regions. The results of this study showed that, when a combination of neck-shoulder pain was used as the outcome measure, the effect estimates for certain work-related variables were lower, compared to the effect estimates derived from an analyses in which the neck region was used as the sole outcome measure. Combining the

neck region and the shoulder region into one outcome measure may lead to an under-estimation of the effect of certain work-related physical and psychosocial factors on the occurrence of neck pain.

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Chapter eight

General discussion

In the final chapter of this thesis, the main findings are summarised and discussed in the context of the objectives described in the Introduction (Chapter 1). In addition, attention is paid to some methodological issues pertaining to the systematic reviews and the prospective cohort study (SMASH). The implications of the findings for the prevention of neck pain are discussed and recommendations are made for future research.

Summary of the main findings

The main objective of this thesis was to determine work-related physical and psychosocial risk factors for neck pain. Firstly, a systematic review of the literature was carried out to identify risk factors for neck pain. Secondly, a prospective cohort study in an occupational setting was performed to investigate the relationship between a number of work-related physical and psychosocial variables and the occurrence of neck pain and sickness absence due to neck pain. The results of both the systematic review and the prospective cohort study will be summarised and discussed below.

Work-related physical risk factors for neck pain

Evidence for a relationship between work-related physical variables and the occurrence of neck pain, on the basis of the available literature, was evaluated in Chapter 2. The level of evidence for certain physical variables was determined. Based almost only on cross-sectional studies, some evidence was found for a relationship between neck pain and a number of work-related physical variables: neck flexion, arm force, arm posture, duration of sitting, twisting or bending of the trunk, hand-arm vibration, and workplace design.
In Chapter 4, the relationship between neck pain and work-related neck flexion (more than 20 degrees and more than 45 degrees), neck rotation (more than 45 degrees) and sitting was investigated in the prospective cohort study. The results showed that prolonged sitting (more than 95% of the working time) was an independent risk factor for the occurrence of neck pain. No clear dose-response relationship could be detected between the percentage of the working time in a sitting position and neck pain. Indications were also found that working with the neck flexed more than 20 degrees for more than 70% of the working time was a risk factor for the occurrence of neck pain. The percentage of the working time with the neck flexed more than 45 degrees, however, was not related to neck pain. Neck flexion of more than 20 degrees and of more than 45 degrees were statistically significantly related to neck pain for workers with a relatively low endurance time (i.e., low level of physical fitness) of the neck muscles. Work-related neck rotation (more than 45 degrees) was not related to neck pain. A possible explanation for not finding a (strong) relationship between neck flexion (more than 20 degrees and more than 45 degrees) and neck rotation (more than 45 degrees) on the one hand, and

the occurrence of neck pain on the other hand could be that, unfortunately, in this study it was not possible to measure the *static* aspect of neck flexion and neck rotation. During the pilot study, continuous observations of neck flexion and neck rotation from the video-recordings was found to be unreliable. Neck flexion and neck rotation therefore had to be assessed on the basis of multi-moment observations. Consequently, it was impossible to assess the static aspect of neck flexion and neck rotation.

In the review, primarily cross-sectional studies were included. Only two prospective cohort studies[1,2] and one case-control study[3] were included. Due to the lack of longitudinal studies, no strong conclusions on the level of evidence for the risk factors under study could be drawn. Thus, the results of the prospective cohort study discussed in this thesis clearly strengthen the conclusions on the available evidence for a relationship between neck flexion and prolonged sitting on one side and neck pain on the other side. Neck rotation was not related to neck pain, according to either the systematic review or the prospective cohort study. In the systematic review, some or inconclusive evidence was found for a relationship between neck pain and certain additional physical variables (i.e., neck extension, arm force and posture, twisting and bending of the trunk, hand-arm vibration, workplace design, driving a vehicle, and sports and exercise). These physical variables were not investigated in the prospective cohort study.

Work-related psychosocial risk factors for neck pain

Evidence for a relationship between work-related psychosocial variables and the occurrence of neck pain, on the basis of the available literature, was evaluated in Chapter 3. Based primarily on cross-sectional studies (only one prospective cohort study[1] was included in the review), the level of evidence for a number of psychosocial variables was determined. Some evidence was found for a relationship between neck pain and the following work-related psychosocial variables: high quantitative job demands, low job control, high and low skill discretion, low social (co-worker) support and low job satisfaction.

In Chapter 5, the relationship between neck pain and a number of work-related psychosocial variables was studied in the prospective cohort study. The results showed that high quantitative job demands and low co-worker support were independent risk factors for the occurrence of neck pain. In addition, there were indications that low decision authority was also a risk factor for the occurrence of neck pain. Low skill discretion, low supervisor support, conflicting job demands and job insecurity were not related to neck pain.

Due to the lack of longitudinal studies in the systematic review, no strong conclusions on the level of evidence for the risk factors under study could be drawn. Thus, the results of the prospective cohort study discussed in this thesis clearly strengthen the conclusions on the available evidence for a relationship between neck pain and high quantitative job demands, low co-worker support and low decision authority. Low supervisor support and low job security were not related to neck pain, according to either the systematic review or the prospective cohort study. In contrast to the systematic review, no relationship between low skill discretion and neck pain was found in the prospective cohort study. In the systematic review, some or inconclusive evidence was found for a relationship between neck pain and certain additional psychosocial variables (i.e., job satisfaction, conflicts at work and during leisure time, job strain, and rest-break opportunities). These variables were not investigated in the prospective cohort study.

According to the Demand-Control-Support model developed by Karasek, the risk for adverse health effects (for example neck pain) increases in jobs with a combination of high demands, low decision latitude and low workplace support.[4] In this study, the interaction between these variables was not investigated. However, on the basis of this thesis, it could be confirmed that high demands, low decision authority and low co-worker support are independent risk factors for neck pain.

The relative importance of physical and psychosocial risk factors for neck pain

In Chapters 4 and 5 of this thesis, it is concluded that there are various physical and psychosocial risk factors for the occurrence of neck pain, the relative importance of which can be studied on the basis of these chapters.
It was found that the relative risks for prolonged sitting (more than 95% of the working time), high quantitative job demands and low co-worker support were all comparable in size. Statistically significant adjusted relative risks of 2.3, 2.1 and 2.4 were found for prolonged sitting, high quantitative job demands and low co-worker support, respectively, implying more than a two-fold risk for the occurrence of neck pain for workers exposed to these risk factors. In Chapters 4 and 5 it was also concluded that there were indications for a relationship between the occurrence of neck pain and neck flexion of more than 20 degrees (more than 70% of the working time) and low decision authority. Both variables showed an adjusted relative risk of 1.6. However, these risks were not statistically significant. The confounding effect of both groups of variables (work-related physical and psychosocial variables) on each other was investigated. The most important confounders in the analysis of work-related physical variables in relation to neck pain were not the work-related psychosocial variables, but the other work-related physical variables. Moreover, the most important confounders in the analysis of work-related psychosocial variables in relation to neck pain were not the work-related physical variables, but the other work-related psychosocial variables.

Based on the results presented in this thesis (Chapters 4 and 5), it can be concluded that work-related physical and psychosocial risk factors play an equal and independent role in the occurrence of neck pain, and are therefore of equal importance for the occurrence of neck pain. There appeared to be no important confounding effect of work-related psychosocial variables on the relationship between work-related physical variables and neck pain, and vice versa.

Sickness absence due to neck pain

Pain in the neck may cause sickness absence, and consequently impose a considerable financial burden on society. In 1996, the total number of days of sickness absence due to neck pain in The Netherlands was estimated to be 1.4 million, with a total cost of US$185 million. The total costs related to neck pain were estimated to be US$686 million in 1996. Disability payment for neck pain accounted for the largest percentage of these total costs (50%, US$341 million).[5]

Not all episodes of neck pain will eventually lead to sickness absence. In the analysis described in Chapters 4 and 5, neck pain was the outcome measure studied. From an occupational health care perspective, it is interesting to investigate sickness absence due to neck pain as the outcome of a study. In Chapter 6, the relationship between sickness absence due to neck pain and the same work-related physical and psychosocial variables was studied, based on data from the prospective cohort study. The results showed that working with the neck flexed more than 20 degrees and more than 45 degrees for an increased percentage of the working time (more than 40% of the working time and more than 5% of the working time, respectively), working with the neck rotated more than 45 degrees for an increased percentage of the working time (more than 25% of the working time), low decision authority and medium skill discretion were prospectively and independently related to sickness absence due to neck pain. The size of the adjusted rate ratios of the work-related physical variables (4.2, 2.8 and 2.8 for neck flexion of more than 20 degrees for more than 40% of the working time, neck flexion of more than 45 degrees for more than 5% of the working time and neck rotation of more than 45 degrees for more than 25% of the working time, respectively) was comparable to the size of the rate ratios found for the work-related psychosocial variables (3.7 and 2.6 for low decision authority and medium skill discretion, respectively). In addition, there were indications that high quantitative job demands, low skill discretion and low job security were related to sickness absence due to neck pain. Work-related sitting, conflicting job demands, low supervisor support and low co-worker support did not increase sickness absence due to neck pain.

Work-related physical and psychosocial factors related to the occurrence of neck pain and to sickness absence due to neck pain

Table 8.1 presents a summary of the results of the prospective cohort study. Workers who are sitting down for a substantial amount of their working time (more than 95%) do report neck pain more often, but they are not more often absent from work due to their neck pain. Apparently, for these workers neck pain is not a reason to stay at home and stop working.

Lack of power could have been the reason why neck flexion of more than 20 degrees and more than 45 degrees, and neck rotation of more than 45 degrees were not found to be (strongly) related to neck pain. However, if only workers with low endurance time (i.e., a low level of physical fitness) of the neck muscles were included in the analysis, a statistically significant relationship was found between neck flexion of more than 20 degrees and more than 45 degrees and neck pain. In

spite of the limited power, neck flexion and neck rotation were significantly related to sickness absence due to neck pain. As mentioned earlier, the lack of a (strong) relationship between neck flexion and neck rotation, and neck pain could also have been caused by the fact that the static aspect of neck flexion and neck rotation was not measured.
High quantitative job demands and low decision authority were related to both neck pain and sickness absence due to neck pain. Conflicting job demands and low supervisor support were not related to either neck pain or sickness absence due to neck pain. Low skill discretion and low job security were not related to the occurrence of neck pain, but, they were related to sickness absence due to neck pain. And finally, for reasons we cannot explain, low co-worker support was related to the occurrence of neck pain, but not related to sickness absence due to neck pain.

Table 8.1 Summary of the results of the prospective cohort study with regard to the relationship between work-related physical and psychosocial variables and the occurrence of neck pain and sickness absence due to neck pain, respectively

Work-related physical and psychosocial variables	Occurrence of neck pain[a]	Sickness absence due to neck pain[b]	Occurrence of neck pain[c]
Neck flexion >20 degrees	+	++	-
Neck flexion >45 degrees	-	++	-
Neck rotation >45 degrees	-	++	-
Sitting	++	-	++
Quantitative job demands	++	+	++
Conflicting job demands	-	-	-
Decision authority	+	++	++
Skill discretion	-	+	-
Co-worker support	++	-	++
Supervisor support	-	-	-
Job security	-	+	-

[a] Summary of the results of the analysis of neck pain (Chapters 4 and 5); [b] Summary of the results of the analysis of sickness absence due to neck pain (Chapter 6); [c] Summary of the results of the additional analysis of neck pain, in which the same categorisation of the physical and psychosocial variables was used, as in the analysis of sickness absence due to neck pain; - no relationship; + increased relative risk, however not statistically significant; ++ statistically significant increased relative risk

Comparison of the results of the occurrence of neck pain and sickness absence due to neck pain was hampered by some important points that should be discussed. The most important issue is probably the number of workers included in the analyses. The number of workers included in the analyses of sickness absence due to neck pain was smaller than the number of workers included in the analyses of neck pain (758 versus 977). In addition, the number of workers with sickness absence due to neck pain was also relatively small (only 36 workers (4.7%) were absent from work due to neck pain for at least 3 days during the follow-up period). Therefore, the

categorisation of the exposure variables applied in the neck pain analyses had to be adapted. The same cut-off points for the reference categories of all work-related physical and psychosocial variables were used in the analyses of the occurrence of neck pain and the analyses of sickness absence due to neck pain (with the exception of neck flexion of more than 20 degrees). However, the risk-categories of the work-related physical and psychosocial variables were re-divided into categories containing a larger number of workers in each risk category.
To improve the comparability of the results of the analyses of neck pain and sickness absence due to neck pain, the analyses of the relationship between physical and psychosocial variables and neck pain were repeated. This time, the categorisation of the physical and psychosocial variables was the same as that applied in the analysis of sickness absence due to neck pain. The results of these secondary analyses of neck pain (Table 8.1, last column) were similar to the results of the initial analyses of neck pain (Table 8.1, second column), with the exception of the relationship between neck flexion and neck pain. On the basis of the initial analysis, it was concluded that there were indications that neck flexion was related to neck pain, while in the secondary analysis this relationship could not be confirmed. Furthermore, the relationship between low decision authority and neck pain was found to be stronger, and statistically significant in the secondary analysis. Because of the similarity of the results of the initial and the secondary analyses of neck pain, the comparison of the results of the secondary analysis of neck pain with the results of the analysis of sickness absence due to neck pain corresponds with the original comparison of these results.

Neck pain or neck-shoulder pain as outcome measure?

When studying risk factors for neck pain, it seems logical to be as specific as possible in the choice of the outcome measure. However, many studies have been conducted, in which the neck and the shoulder region have been combined in one outcome measure, in stead of studying neck pain and shoulder pain as two separate outcome measures. Chapter 7 addressed the question of whether or not, in occupational studies on risk factors, the neck and shoulder region should be used as separate outcome measures, or whether one single composite outcome measure for neck-shoulder pain should be used. In Chapter 7 it was concluded that studies on occupational risk factors for musculoskeletal symptoms should investigate this relationship for the neck region separately if the objective of the study is to identify risk factors for neck pain. The combination of neck and shoulder pain into one composite outcome measure will lead to an under-estimation of the effect of certain work-related physical and psychosocial variables on the occurrence of neck pain.

Methodological considerations

The systematic reviews

No methodological guidelines were available for the systematic review of observational studies, as described in this thesis, whereas they do exist for systematic reviews on the effectiveness of various types of interventions (RCTs). This lack of guidelines made it necessary to develop our own method to review observational studies systematically, making the whole procedure experimental. During the review process, certain quite arbitrary decisions were made, three of which will be discussed below.

The literature was searched for observational studies only. Consequently, longitudinal studies, case-control studies and cross-sectional studies were included. The objective of the systematic reviews was to identify risk factors for neck pain. In terms of causality, exposure should precede outcome. Thus, risk factors should be present before neck pain occurs. The preferred study design would therefore be of a longitudinal nature. However, most of the studies that were identified for inclusion in the reviews had a cross-sectional design. In cross-sectional research, the temporal relationship between exposure and outcome cannot be firmly established, since exposure and outcome are assessed at the same point in time. Despite this disadvantage of the cross-sectional study design, it was decided to include cross-sectional studies in the systematic reviews because of the lack of studies with a longitudinal design. It was thought that neglecting the vast amount of information obtainable from cross-sectional research would have been unacceptable. In the systematic reviews, four levels of evidence were defined to assess the strength of evidence for risk factors for neck pain (strong, moderate, some and inconclusive evidence). If the evidence for a risk factor for neck pain was based on cross-sectional studies only, the maximum achievable level of evidence was 'some evidence'. Thus, in this way the subordination of cross-sectional studies was settled.

The methodological quality of studies included in the reviews was assessed according to a methodological quality list. Overall, the methodological quality of the included studies in the reviews was low. As stated earlier, the quality list used in the reviews was newly developed on the basis of existing quality lists and, consequently, had not been used before. Four levels of evidence were defined on the basis of the study design, the methodological quality and the consistency of results. The methodological quality of a study had a considerable influence on the establishment of the level of evidence, indicating that changes in this list may have had a major impact on the results. Therefore, this should be taken into account in the interpretation of the results of the systematic reviews. This method of assessment of the methodological quality of observational studies is rather new. In the future, it would be of great value to develop a 'more standardised' methodological quality list, which can be widely used in systematic reviews of observational studies on (occupational) risk factors for musculoskeletal symptoms.

One of the criteria for inclusion in the systematic reviews was that the results of a study were reported separately for the neck region. Failure to meet this criteria was the most important reason for the exclusion studies. Many studies did not use neck pain as an outcome measure, but a combination of neck and shoulder because one can argue that a responder would have problems differentiating between those two regions. In addition, in the excluded studies, the definition of neck or shoulder pain was often unclear. It is of utmost importance to include a clear unambiguous definition of the outcome under study (neck pain, shoulder pain or neck-shoulder pain). Although there is some rationale to combine the neck and shoulder region, it is the opinion of the authors that studies on occupational risk factors for musculoskeletal pain should also investigate this relationship for specific body regions. This opinion is substantiated by the results described in Chapter 7, which show that if a combination of neck-shoulder pain was used as the outcome measure, the effect estimates for certain work-related variables were lower than the effect estimates derived from an analyses in which the neck region was the sole outcome measure. Therefore, the combination of the neck and shoulder region in one outcome measure may lead to an under-estimation of the effect of certain work-related physical and psychosocial factors on the occurrence of neck pain.

The prospective cohort study

The Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH) is one of the first prospective cohort studies in which physical load at the workplace was assessed on the basis of quantified exposure data (video-recordings and observations and subsequent analysis of these video-recordings). Moreover, not only the physical load at the workplace was assessed, but also the physical load during leisure time, as well as the work-related psychosocial load and individual characteristics. The longitudinal design of the study, in combination with the assessment of various work-related and non-work-related exposures, emphasise the unique and valuable character of the study. However, there are also some important points of discussion concerning the internal validity of this study, five of which will be discussed below.

Firstly, bias due to loss to follow-up may have occurred. For the analyses of physical and psychosocial load in relation to neck pain (Chapters 4 and 5), 1,334 workers met the inclusion criteria. For 977 of these workers, complete follow-up data were available, and 357 workers (27%) were considered to be lost to follow-up. For the analyses of physical and psychosocial load in relation to sickness absence due to neck pain (Chapter 6), 1,025 workers met the inclusion criteria. For 758 of these workers, complete follow-up data were available, and for 267 workers (26%) the follow-up data were incomplete. For the analyses of physical and psychosocial

variables in relation to neck-shoulder pain (Chapter 7), 1,218 workers met the inclusion criteria. For 873 of these workers, complete follow-up data were available, and 345 (28%) workers were lost to follow-up. Workers who changed jobs during the follow-up period were not necessarily lost to follow-up, because the follow-up questionnaires were sent to the home-address of each worker.
For some physical and psychosocial variables, the distribution was not comparable for the group of workers with complete follow-up data and the group of workers who were lost to follow-up. Furthermore, workers who were lost to follow-up had a lower level of education. It was not possible to investigate whether this difference in level of education has influenced the relationship between work-related physical and psychosocial variables and (sickness absence due to) neck pain, because no data were available on the cumulative incidence of neck pain during the follow-up period for the workers who were lost to follow-up. The selective loss to follow-up may have biased the results of this study. However, a baseline response rate of 87% and a drop-out rate of less than 30% after 3 years of follow-up seem to be acceptable.

Secondly, at baseline, the physical load at the workplace was assessed on the basis of quantified exposure data (video-recordings and observations, and subsequent analysis of these video-recordings). For the baseline measurements, four 14-minute video-recordings were made of each worker on a single day. Therefore, the individual assessment of exposure may not sufficiently reflect variability in exposure over days, weeks or seasons. However, in the study described in this thesis, a group-strategy was used for the assessment of physical load at the workplace, including measurements of workers over several days. All participants were assigned to groups of workers with similar tasks, based on on-site inspection of the work. Video-recordings of one fourth of the workers in each of these groups were subsequently observed and assessed for relevant measures by different observers. Unfortunately, no information is available on the inter-observer reliability of the video-observations. In addition, due to possible inter-worker differences in exposure within a group, misclassification of exposure may have occurred, which could have lead to an under-estimation of the risk assessment.

Thirdly, in the study described in this thesis, work-related physical and psychosocial variables were found to be related to (sickness absence due to) neck pain. One important objective of this study was to identify a certain level of exposure that would have lead to an increased risk of (sickness absence due to) neck pain. Workers from various occupational branches participated in the study, resulting in a population of workers with adequate contrast in physical and psychosocial exposure. For the analyses, the work-related physical and psychosocial variables were divided into categories. The categorisation of these variables was not based on pre-determined cut-off points Instead, initially each variable was divided into a number of small categories. Univariate analyses were performed on these variables. Categories showing similar effect estimates were combined into broader categories, resulting in

the final categorisation of the work-related physical and psychosocial variables. This procedure may seem to be data-driven. However, if we would have used pre-determined cut-off points for the categorisation of the variables, it could have been possible that the level of exposure which leads to an increase in risk for (sickness absence due to) neck pain would have been missed.
According to the procedure described above, each work-related physical and psychosocial variable was divided in 2 to 4 categories, thus avoiding division into too many narrow categories, in order to minimise the risk of (non-differential) misclassification of workers into categories of exposure. Nevertheless, misclassification of workers into exposure categories still may have occurred in this study. The effect of this non-differential misclassification would be an under-estimation of the real effect, because non-differential misclassification tends to bias the effect estimate towards the zero value.

Fourthly, earlier episodes of neck pain (more than one year prior to baseline) showed a strong relationship with neck pain during the follow-up period (RR=3.6, 95% CI 2.5-5.2). Adjustment for this variable in the multivariate analysis of work-related physical and psychosocial variables in relation to neck pain would not have been appropriate, since earlier episodes of neck pain may also have been caused by the work-related physical and psychosocial variables under study. This implies an intermediate role of this variable in the relationship between work-related physical and psychosocial variables and neck pain during the follow-up period. The inclusion of workers who had never experienced an episode of neck pain would have caused power problems. Due to the selection of workers with no regular or prolonged neck pain in the 12 months prior to baseline, the strong confounding effect of recent prior neck pain was eliminated. However, it is still possible that neck pain more than one year prior to baseline may have influenced the relationship between the work-related physical variables and the occurrence of neck pain during the follow-up period.

Finally, in the prospective cohort study, work-related physical and psychosocial exposure at baseline was related to (sickness absence due to) neck pain during a follow-up period of 3 years. It can be questioned whether a follow-up period of 3 years is an adequate time-frame in which to study this longitudinal relationship. However, it is still unclear as to what the optimal time-frame should be to study the longitudinal relationship between work-related physical and psychosocial variables and neck pain. Furthermore, it can be argued that during the 3-year follow-up period exposure-related variables may change, which could influence the occurrence of neck pain after 3 years. Sub-group analyses were performed with data on workers who experienced no major changes in their work during the entire follow-up period. The results of these analyses were quite comparable with the results of the analyses for the total population, indicating that change in work during the follow-up period did not have a major impact on the results.

Unfortunately, the incidence of neck pain found in this study was too low to make it possible to study the longitudinal relationship between work-related physical and psychosocial variables and the occurrence of neck pain after 1 or 2 years of follow-up. Consequently, analysis after 1 or 2 years of follow-up will lead to very unstable effect estimates with very wide corresponding confidence intervals, which are difficult to interpret.

Implications for the prevention of neck pain

Based on the results presented in this thesis, the prevention of neck pain should focus on the physical as well as the psychosocial aspects of work. Prevention should aim at a reduction of prolonged working in a sitting position (more than 95% of the working time). Variation in work should be stimulated in order to reduce the time spent working with the neck in a flexed position. Since neck flexion is more strongly related to neck pain for workers with a low endurance time (i.e., a low level of physical fitness) of the neck muscles, training of the neck muscles (i.e., increasing the level of physical fitness of the neck muscles) will most likely contribute to the prevention of neck pain.
Moreover, the results described in this thesis imply that organisational changes to decrease quantitative job demands (for example, working under time pressure or working with deadlines) and increase the social support provided by fellow workers, will also contribute to the prevention of neck pain. It is also important that workers should be given more authority to make decisions about their own work.

With regard to the prevention of sickness absence due to neck pain, the results described in this thesis suggest that decreasing the percentage of time working with the neck flexed or rotated will have a positive effect on the prevention of sickness absence due to neck pain.
Increasing a worker's authority to make decisions, and increasing learning possibilities and the development of skills in a job, will probably reduce sickness absence due to neck pain. Moreover, a reduction in quantitative job demands will possibly also reduce sickness absence due to neck pain.
The results described in this thesis therefore imply that both adequate workplace design to introduce variation in the neck position, and organisational changes to increase decision latitude and decrease job demands, will contribute to the prevention of sickness absence due to neck pain.

Recommendations for future research

1. Effort should be made to develop of a 'standardised' methodological quality list, which can be widely used in systematic reviews of observational studies on

(occupational) risk factors for musculoskeletal symptoms. Systematic reviews have been performed to identify risk factors for neck pain (Chapters 2 and 3) and risk factors for shoulder pain.[6] These reviews excluded studies that combined the neck and shoulder region. A combination of these reviews, including an additional review of studies that made a combined assessment of the neck and shoulder region, would provide more insight into the differences in risks for these two body regions.

2. In future studies on risk factors for neck pain, it is important to quantify the time pattern of neck postures, for instance the duration of neck flexion without a rest-break, in order to adequately capture the static aspect of neck postures.
3. Future studies should focus on the efficacy and feasibility of preventive measures (for example organisational changes in the work to lower job demands or increase the authority to make decisions, changes in the design of the workplace to avoid neck flexion for a high percentage of the working time and prolonged sitting, or training of the neck muscles) to decrease the physical and psychosocial load at the workplace, and consequently decrease the risk of (sickness absence due to) neck pain.
4. Finally, since there will always be workers who have neck problems, the (cost-) effectiveness of specific programmes for the medical guidance of workers with neck pain should be evaluated.

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Summary

Musculoskeletal complaints are a major health problem in The Netherlands. Next to low back pain, neck pain warrants second place, considering the magnitude of the problem. For neck pain, a 12-month prevalence of 31% is reported for a general population in the Netherlands. Neck pain may cause sickness absence, and consequently imposes a considerable financial burden on society.
Neck pain is assumed to be of multi-factorial origin, implying that a number of risk factors can contribute to its development. These risk factors can be divided into three main categories: physical risk factors, psychosocial risk factors, and individual risk factors. Moreover, these risk factors can be work-related or not. The main objective of this thesis is to identify work-related physical and psychosocial risk factors for neck pain and for sickness absence due to neck pain.

In Chapters 2 and 3 of this thesis, the existing literature on physical and psychosocial risk factors for neck pain was reviewed systematically. The methodological quality of observational studies on risk factors for neck pain was assessed. Based on the methodological quality of a study and the study design, four levels of evidence were defined to establish the strength of evidence for the relationship between physical (Chapter 2) and psychosocial (Chapter 3) risk factors and neck pain, i.e., strong evidence, moderate evidence, some evidence or inconclusive evidence.
In total, 22 cross-sectional studies, 2 prospective cohort studies and 1 case-control study were included in the systematic review on physical risk factors for neck pain (Chapter 2). The results showed some evidence for a relationship between neck pain and duration of sitting and twisting and/or bending of the trunk. Inconclusive evidence for a relationship with neck pain was found for neck flexion, neck extension, neck rotation, arm force and posture, hand-arm vibration, work place design, driving a vehicle, and sports and exercise. A sensitivity analysis was carried out, excluding three items of the quality list, of which the importance seemed doubtful. Based on this sensitivity analysis it was concluded that there was some evidence for a relationship between neck pain and neck flexion, arm force, arm posture, duration of sitting, twisting and/or bending of the trunk, hand-arm vibration and workplace design.
In total, 28 cross-sectional studies and 1 prospective cohort study were included in the systematic review on psychosocial risk factors for neck pain (Chapter 3). The results showed some evidence for a relationship between neck pain and high quantitative job demands, low social (co-worker) support, low job control, high and low skill discretion and low job satisfaction. Inconclusive evidence was found for high job strain, low supervisor support, conflicts at work, low job security and limited rest break opportunities.
In the systematic reviews in Chapters 2 and 3 of this thesis, primarily cross-sectional studies were included. No strong conclusions on the level of evidence for the physical or psychosocial risk factors for neck pain could be drawn, due to the lack of longitudinal studies.

In Chapters 4 to 7 of this thesis, the results of a large 3-year prospective cohort study in an occupational setting are described. The main objective of this longitudinal Study on Musculoskeletal disorders, Absenteeism, Stress and Health (SMASH) was to identify work-related risk factors for musculoskeletal complaints. There were three important reasons for performing this large prospective cohort study:

1. Earlier research on work-related risk factors for musculoskeletal complaints was mostly cross-sectional in design, making it difficult to study the temporal relationship between risk factors and musculoskeletal complaints.
2. Most of the studies on work-related risk factors for musculoskeletal complaints described in the literature focused only on one or a few risk factors, and did not take both physical and psychosocial risk factors at work and during leisure time into account.
3. In most studies on work-related risk factors for musculoskeletal complaints described in the literature, physical load at the workplace is assessed by means of a questionnaire. It is debatable whether the physical load at the workplace can be measured in a reliable way by means of such self-reports. Moreover, it is difficult to establish a dose-response relationship between exposure and outcome on the basis of self-reported questionnaire data.

In Chapters 4 and 5 of this thesis, the longitudinal relationship between work-related physical variables (neck flexion, neck rotation and sitting at work) and work-related psychosocial variables (quantitative job demands, conflicting job demands, decision authority, skill discretion, co-worker support, supervisor support and job security) and the occurrence of neck pain was investigated. From 34 companies 977 workers, without neck pain in the 12 months prior to baseline, were included in these analyses. At baseline, work-related physical load was quantified by analysing objectively measured exposure data (video-recordings) of neck flexion, neck rotation and sitting posture. Moreover, at baseline, work-related psychosocial variables were assessed by means of a questionnaire. Neck pain was assessed by means of a questionnaire during the 3-year follow-up period. The relationship between work-related physical and psychosocial variables and the occurrence of neck pain was adjusted for the confounding effect of various work-related and non-work-related physical factors, work-related psychosocial factors, and individual characteristics, which were all measured at baseline.
A statistically significant relationship was found between the percentage of the working time in a sitting position and neck pain, implying an increased risk for neck pain for workers who were sitting for more than 95% of the working time (RR=2.34, 95% CI 1.05-5.21). The relative risk found for the relationship between neck flexion more than 20 degrees (for more than 70% of the working time) and neck pain was increased also, although statistically not significant (RR=1.63, 95% CI 0.70-3.82). Workers with a low level of physical fitness of the neck muscles had a statistically significant increased relative risk for neck pain when working with the neck flexed

more than 20 degrees (RR=2.50, 95% CI 1.11-5.61) and more than 45 degrees (RR=1.89, 95% CI 1.02-3.52). Neck rotation (more than 45 degrees) was not related to neck pain (Chapter 4).
A statistically significant relationship was found between neck pain and high quantitative job demands (RR=2.14, 95% CI 1.28-3.58) and low co-worker support (RR=2.43, 95% CI 1.11-5.29). The relative risk found for the relationship between low decision authority and neck pain was increased, however, statistically not significant (RR=1.60, 95% CI 0.74-3.45). Conflicting job demands, low skill discretion, low supervisor support and low job security were not related to neck pain (Chapter 5).
On the basis of the results described in Chapters 4 and 5 of this thesis, it was concluded that prolonged sitting (more than 95% of the working time), high quantitative job demands and low co-worker support are independent risk factors for the occurrence of neck pain. Moreover, there were indications that neck flexion and low decision authority are risk factors for the occurrence of neck pain.

In Chapter 6 of this thesis, the longitudinal relationship between the same work-related physical and psychosocial variables and sickness absence due to neck pain was investigated. From 21 companies, 758 workers without sickness absence due to neck pain in the 3 months prior to baseline were included in these analyses. The frequency of sickness absence due to neck pain with a minimal duration of 3 days was assessed based on standardised company registrations during the 3-year follow-up period. The relationship between work-related physical and psychosocial variables and sickness absence due to neck pain was adjusted for the confounding effect of various work-related and non-work-related physical factors, work-related psychosocial factors, and individual characteristics, which were all measured at baseline.
A statistically significant relationship was found between sickness absence due to neck pain and working with the neck flexed more than 20 degrees for more than 40% of the working time (RR=4.19, 95% CI 1.50-11.69), working with the neck flexed more than 45 degrees for more than 5% of the working time (RR=2.76, 95% CI 1.27-5.99), and working with the neck rotated more than 45 degrees for more than 25% of the working time (RR=2.81, 95% CI 1.29-6.09). In addition, a statistically significant relationship was found between sickness absence due to neck pain and low decision authority (RR=3.66, 95% CI 1.44-9.26) and medium skill discretion (RR=2.56, 95% CI 1.08-6.04). The relative risks found for the relationship between sickness absence due to neck pain and high quantitative job demands (RR=1.96, 95% CI 0.83-4.62), low job security (RR=1.70, 95% CI 0.80-3.60) and low skill discretion (RR=1.64, 95% CI 0.73-3.69) were increased, however, statistically not significant. Working in a sitting position, conflicting job demands, co-worker support and supervisor support were not related to sickness absence due to neck pain.
On the basis of the results described in Chapter 6 of this thesis, it was concluded that working with the neck flexed more than 20 degrees (more than 40% of the working time) and more than 45 degrees (more than 5% of the working time),

working with the neck rotated more than 45 degrees (more than 25% of the working time), low decision authority and medium skill discretion are prospectively and independently related to sickness absence due to neck pain. Moreover, there were indications that high quantitative job demands, low job security and low skill discretion were prospectively and independently related to sickness absence due to neck pain.

When studying risk factors for neck pain, it seems logical to be as specific as possible in the choice of the outcome measure. However, many studies have been conducted, in which the neck and the shoulder region have been combined into one outcome measure, in stead of studying neck pain and shoulder pain as two separate outcome measures. In Chapter 7 of this thesis, the question was addressed whether or not, in occupational studies on risk factors, the neck and shoulder region should be used as separate outcome measures, or whether or not one single composite outcome measure for neck-shoulder pain should be used. A comparison was made between the use of two outcome measures, i.e., neck pain and a combination of neck and/or shoulder pain (neck-shoulder pain). The longitudinal relationships between the same work-related physical and psychosocial variables and these two outcome measures were investigated. The results of these analyses were compared. Neck flexion more than 20 degrees, working in a sitting position, quantitative job demands and co-worker support were more strongly related to neck pain than to neck-shoulder pain. When neck-shoulder pain was used as the outcome measure, the size of the effect estimates was clearly lower for these four variables. For the other work-related variables under study no great differences were found in effect estimates between the two outcome measures.
The results described in Chapter 7 showed that, when a combination of neck-shoulder pain was used as the outcome measure, the effect estimates for certain work-related variables were lower, compared to the effect estimates derived from an analyses in which the neck region was used as the sole outcome measure. It was therefore concluded that combining the neck region and the shoulder region into one outcome measure may lead to an under-estimation of the effect of certain work-related physical and psychosocial factors on the occurrence of neck pain.

Finally, in Chapter 8 of this thesis the main findings were summarised and discussed in the context of the objectives of this thesis. Firstly, the results of the systematic reviews and the prospective cohort study were compared. This comparison showed that prolonged sitting and neck flexion are risk factors for neck pain. Thus, the results of the prospective cohort study clearly strengthened the conclusions on the available evidence for a relationship between prolonged sitting and neck flexion on the one hand and neck pain on the other hand. In addition, the presented results showed that high quantitative job demands, low job control (decision authority) and low co-worker support were also found to be risk factors for neck pain. Low supervisor support was not related to neck pain, according to either the systematic review or the prospective cohort study. Some evidence was found for a relationship between low skill discretion and neck pain according to the systematic review. However, this relationship could not be confirmed in the prospective cohort study (Table 1).

Table 1 Overview of the results of the systematic reviews and the prospective cohort study

Work-related physical and psychosocial variables	Systematic review[a]	Prospective cohort study[b]
Neck flexion	Some evidence	+
Neck rotation	Inconclusive evidence	-
Sitting	Some evidence	++
High quantitative job demands	Some evidence	++
Low job control (decision authority)	Some evidence	+
Low skill discretion	Some evidence	-
Low supervisor support	Inconclusive evidence	-
Low co-worker support	Some evidence	++

[a] Results of the systematic review; [b] Results of the prospective cohort study; - no relationship; + increased relative risk, however statistically not significant; ++ statistically significant increased relative risk

Secondly, the relative importance of work-related physical and psychosocial risk factors for the occurrence of neck pain is discussed in the concluding chapter. It was found that the relative risks found for the work-related physical risk factor prolonged sitting (more than 95% of the working time) and the work-related psychosocial risk factors high quantitative job demands and low co-worker support, were comparable in size. Moreover, the non-significant increased relative risks which were found for the work-related physical factor neck flexion and the work-related psychosocial factor low decision authority were also comparable in size. Furthermore, there appeared to be no important confounding effect of work-related psychosocial variables on the relationship between work-related physical variables and neck pain, and vice versa. It was concluded that work-related physical and psychosocial risk factors play an equal and independent role in the occurrence of neck pain and are therefore of equal importance for the occurrence of neck pain.

Thirdly, the relationship between work-related physical and psychosocial variables and the occurrence of neck pain was compared with the relationship between work-related physical and psychosocial variables and sickness absence due to neck pain. Table 2 shows an overview of the results with regard to these relationships.

Table 2 Summary of the results of the prospective cohort study with regard to the relationship between work-related physical and psychosocial variables and the occurrence of neck pain and sickness absence due to neck pain

Work-related physical and psychosocial variables	Occurrence of neck pain[a]	Sickness absence due to neck pain[b]
Neck flexion >20 degrees	+	++
Neck flexion >45 degrees	-	++
Neck rotation >45 degrees	-	++
Sitting	++	-
Quantitative job demands	++	+
Conflicting job demands	-	-
Decision authority	+	++
Skill discretion	-	++
Co-worker support	++	-
Supervisor support	-	-
Job security	-	+

[a] Summary of the results of the analysis of neck pain; [b] Summary of the results of the analysis of sickness absence due to neck pain; - no relationship; + increased relative risk, however not statistically significant; ++ statistically significant increased relative risk

Workers who were sitting down for a substantial amount of their working time (more than 95%) did report neck pain more often, but they were not more often absent from work due to their neck pain. Neck flexion of more than 20 degrees and more than 45 degrees and neck rotation of more than 45 degrees were found to be not or only weakly related to neck pain. In spite of the limited power, neck flexion and neck rotation were significantly related to sickness absence due to neck pain. High quantitative job demands and low decision authority were related to both neck pain and sickness absence due to neck pain. Conflicting job demands and low supervisor support were not related to either neck pain or sickness absence due to neck pain. Low skill discretion and low job security were not related to the occurrence of neck pain, but they were related to sickness absence due to neck pain. Finally, low co-worker support was related to the occurrence of neck pain, but not related to sickness absence due to neck pain. Possible explanations for discrepancies in the results with regard to the occurrence of neck pain and sickness absence due to neck pain, and the comparability of the two analyses were discussed (the lack of power and the difference in the number of subjects in both analysis, the fact that the static aspect of neck flexion and neck rotation was not measured in this study and the difference in the categorisation of the exposure variables).

After the discussion of the results, in Chapter 8 attention was paid to some methodological issues pertaining to the systematic reviews and the prospective cohort study. Central issues with regard to the systematic reviews were the lack of guidelines for the systematic review of observational studies, the vast amount of cross-sectional studies and the lack of longitudinal studies in the systematic reviews, the assessment of the methodological quality of the studies in the reviews, and the exclusion of studies that used a composite outcome measure (neck-shoulder pain). Important methodological issues with regard to the prospective cohort study that were discussed in Chapter 8 were: the loss to follow-up, the assessment of the physical load at the workplace (video-recordings), the categorisation of the work-related physical and psychosocial variables, earlier episodes of neck pain and the duration of the follow-up period.

Chapter 8 concludes with the implications of the findings for the prevention of neck pain and with recommendations for future research. The prevention of neck pain should focus on the physical as well as the psychosocial aspects of work. Prevention should aim at a reduction of prolonged working in a sitting position. Variation in work should be stimulated in order to reduce the time spent working with the neck in a flexed position. Since neck flexion is more strongly related to neck pain for workers with a low level of physical fitness of the neck muscles, training of the neck muscles (i.e., increasing the level of physical fitness of the neck muscles) will most likely contribute to the prevention of neck pain. Moreover, organisational changes to decrease quantitative job demands (e.g., working under time pressure or working with deadlines) and to increase the social support provided by fellow workers, will contribute to the prevention of neck pain. It is also important that workers should be given more authority to make decisions about their own work. With regard to the prevention of sickness absence due to neck pain, the results described in this thesis suggest that decreasing the percentage of time working with the neck flexed or rotated will have a positive effect on the prevention of sickness absence due to neck pain. Increasing a worker's authority to make decisions, and increasing learning possibilities and the possibilities to develop skills in a job, will probably reduce sickness absence due to neck pain. Moreover, a reduction in quantitative job demands will possibly also reduce sickness absence due to neck pain. The results described in this thesis therefore imply that both adequate workplace design to introduce variation in the neck position and organisational changes to increase decision latitude and decrease job demands, will contribute to the prevention of sickness absence due to neck pain.

Samenvatting

Klachten aan het bewegingsapparaat komen in Nederland vaak voor. Op basis van prevalentie-cijfers vormt lage rugpijn de belangrijkste groep van klachten aan het bewegingsapparaat, gevolgd door nekpijn. In een algemene populatie in Nederland werd een 12-maanden prevalentie-cijfer van 31% gevonden voor het voorkomen van nekpijn. Nekpijn kan leiden tot ziekteverzuim, hetgeen aanzienlijke financiële consequenties heeft voor de maatschappij.
Verschillende factoren kunnen leiden tot het ontstaan van nekpijn. Deze factoren worden vaak verdeeld in 3 groepen: fysieke factoren, psychosociale factoren en individu-gebonden factoren. Daarnaast wordt onderscheid gemaakt tussen werkgerelateerde factoren en niet-werkgerelateerde factoren die leiden tot het ontstaan van nekpijn.
Het doel van dit proefschrift, met de Nederlandse titel 'Werkgerelateerde risicofactoren voor nekpijn', is vast te stellen wat werkgerelateerde fysieke en psychosociale risicofactoren zijn voor het ontstaan van nekpijn, en voor ziekteverzuim als gevolg van nekpijn.

In Hoofdstuk 2 en 3 van dit proefschrift worden de resultaten beschreven van twee systematische reviews van de literatuur. In deze reviews werd de op dat moment beschikbare literatuur over fysieke en psychosociale risicofactoren voor nekpijn geëvalueerd. De methodologische kwaliteit van observationele studies (transversale studies, patiënt-controle onderzoek, en prospectieve cohort studies) werd bepaald. Op basis van de methodologische kwaliteit en de onderzoeksopzet van de studies werden 4 niveaus gedefinieerd, die de mate van bewijs voor een relatie tussen fysieke en psychosociale risicofactoren en nekpijn aangeven: sterk bewijs, matig bewijs, beperkt bewijs, en onvoldoende bewijs.
Er werden 22 transversale studies, 2 prospectieve cohort studies, en 1 patiënt-controle onderzoek ingesloten in de systematische review naar fysieke risicofactoren voor nekpijn (Hoofdstuk 2). Beperkt bewijs werd gevonden voor een relatie tussen nekpijn en de duur van zitten, en draaien en/of buigen van de romp. Onvoldoende bewijs voor een relatie met nekpijn werd gevonden voor nekflexie, nekextensie, nekrotatie, armkracht, armhouding, hand-arm trillingen, werkplekontwerp, rijden in een voertuig, en sport en inspanning. Na het uitvoeren van een sensitiviteitsanalyse, waarbij drie items van de methodologische kwaliteitslijst werden weggelaten omdat aan de waarde van deze items werd getwijfeld, bleek er beperkt bewijs te zijn voor een relatie tussen nekpijn en nekflexie, armkracht, armhouding, duur van zitten, draaien en/of buigen van de romp, hand-arm trillingen en werkplekontwerp.
Er werden 28 transversale studies en 1 prospectieve cohort studie ingesloten in de systematische review naar psychosociale risicofactoren voor nekpijn (Hoofdstuk 3). Beperkt bewijs werd gevonden voor een relatie tussen nekpijn en hoge kwantitatieve taakeisen, weinig sociale steun (van collega's), weinig controle over het werk, het hebben van veel of weinig mogelijkheden tot het ontwikkelen van vaardigheden, en een geringe mate van werktevredenheid. Onvoldoende bewijs voor een relatie met nekpijn werd gevonden voor de volgende psychosociale factoren: hoge werkdruk,

weinig sociale steun van leidinggevenden, conflicten op het werk, een geringe mate van werkzekerheid en het hebben van weinig pauzemogelijkheden.
In de twee systematische reviews werden met name transversale studies ingesloten. Door het gebrek aan longitudinale studies konden geen conclusies worden getrokken over eventueel sterk bewijs voor een relatie tussen fysieke en psychosociale risicofactoren en nekpijn.

In Hoofdstuk 4 tot en met 7 worden de resultaten beschreven van een prospectief cohort onderzoek met een follow-up van 3 jaar binnen de Nederlandse beroepsbevolking (Study on Musculoskeletal disorders, Absenteeism, Stress and Health, SMASH). Het belangrijkste doel van dit longitudinale onderzoek was de identificatie van werkgerelateerde risicofactoren voor klachten aan het bewegingsapparaat. Drie belangrijke redenen vormden de aanleiding voor dit onderzoek:

1. Eerder onderzoek naar werkgerelateerde risicofactoren voor klachten aan het bewegingsapparaat was tot op dat moment vrijwel uitsluitend transversaal van aard. Het bestuderen van een oorzaak-gevolg relatie in de tijd is niet mogelijk op basis van transversaal onderzoek.
2. Eerder onderzoek naar werkgerelateerde risicofactoren voor klachten aan het bewegingsapparaat richtte zich meestal op één of slechts een paar risicofactoren, terwijl niet tegelijkertijd zowel fysieke als psychosociale risicofactoren werden bestudeerd.
3. In eerder onderzoek naar werkgerelateerde risicofactoren voor klachten aan het bewegingsapparaat werd de fysieke belasting op het werk meestal bepaald met behulp van vragenlijsten die door de werknemer werden ingevuld. Het is hierbij de vraag of de fysieke belasting op het werk adequaat bepaald kan worden met behulp van zelf-gerapporteerde gegevens op basis van vragenlijsten. Bovendien is vragenlijst informatie meestal van onvoldoende detail voor het vaststellen van een relatie tussen de mate van blootstelling en het effect.

In Hoofdstuk 4 en 5 van dit proefschrift wordt de longitudinale relatie tussen werkgerelateerde fysieke factoren (nekflexie, nekrotatie en zitten) en psychosociale factoren (kwantitatieve taakeisen, tegenstrijdige taakeisen, vaardigheidsmogelijkheden, autonomie, sociale steun van collega's en leidinggevenden en werkzekerheid) en het ontstaan van nekpijn onderzocht. 977 werknemers zonder nekpijn in de 12 maanden voorafgaand aan de basismeting, afkomstig van 34 verschillende bedrijven, werden geselecteerd voor de analyses. Tijdens de basismeting werd de fysieke belasting op het werk gekwantificeerd met behulp van video-opnames. Deze video-opnames werden achteraf geobserveerd om zo het percentage van de werktijd vast te stellen dat een werknemer zich bevond in een houding waarbij de nek in flexie of rotatie was, of waarbij de werknemer zich in een zittende houding bevond. Tevens werd tijdens de basismeting met behulp van een vragenlijst informatie verzameld over de werkgerelateerde psychosociale factoren. Het ontstaan van nekpijn werd jaarlijks

bepaald met behulp van een vragenlijst gedurende de totale duur van het onderzoek (3 jaar). In de analyses werd gecorrigeerd voor de verstorende invloed van verschillende werkgerelateerde en niet-werkgerelateerde fysieke factoren, werkgerelateerde psychosociale factoren en individu-gebonden factoren.
Uit de resultaten van de analyses bleek dat werken in een zittende houding gedurende meer dan 95% van de werktijd een statistisch significant verhoogd risico geeft op het ontstaan van nekpijn (RR=2.34, 95% BI 1.05-5.21). Ook nekflexie meer dan 20 graden gedurende meer dan 70% van de werktijd gaf een hoger risico op het ontstaan van nekpijn, echter dit verhoogde risico was statistisch niet significant (RR=1.63, 95% BI 0.70-3.82). Voor werknemers met een relatief lage fysieke fitheid van de nekspieren was het relatieve risico voor nekpijn bij nekflexie meer dan 20 graden 2.50 (95% BI 1.11-5.61) en bij nekflexie meer dan 45 graden 1.89 (95% BI 1.02-3.52). Er werd geen relatie gevonden tussen nekrotatie (meer dan 45 graden) en het ontstaan van nekpijn (Hoofdstuk 4).
Wat betreft de psychosociale factoren bleek dat hoge kwantitatieve taakeisen (RR=2.14, 95% BI 1.28-3.58) en weinig sociale steun van collega's (RR=2.43, 95% BI 1.11-5.29) een ongeveer twee maal zo grote kans geven op het ontstaan van nekpijn. Het relatieve risico voor de relatie tussen weinig autonomie en nekpijn was verhoogd, echter statistisch niet significant (RR=1.60, 95% BI 0.74-3.45). Tegenstrijdige taakeisen, beperkte mogelijkheden tot het ontwikkelen van vaardigheden, weinig sociale steun van leidinggevenden en een geringe mate van werkzekerheid gaven geen verhoogde kans op het ontstaan van nekpijn (*Hoofdstuk 5*).
Op basis van de resultaten die beschreven zijn in Hoofdstuk 4 en 5 van dit proefschrift wordt geconcludeerd dat langdurig zitten (meer dan 95% van de werktijd), hoge kwantitatieve taakeisen en weinig sociale steun van collega's onafhankelijke risicofactoren zijn voor het ontstaan van nekpijn. Daarnaast zijn ook aanwijzingen gevonden om aan te nemen dat nekflexie en weinig autonomie risicofactoren zijn voor het ontstaan van nekpijn.

In Hoofdstuk 6 van dit proefschrift wordt de longitudinale relatie tussen de eerder genoemde werkgerelateerde fysieke en psychosociale factoren en ziekteverzuim als gevolg van nekpijn onderzocht. 758 werknemers zonder ziekteverzuim als gevolg van nekpijn in de 3 maanden voorafgaand aan de basismeting, afkomstig van 21 bedrijven, hadden voldoende betrouwbare gegevens voor deze analyse. Gedurende de totale duur van het onderzoek (3 jaar) werd de frequentie van ziekteverzuim als gevolg van nekpijn met een minimale duur van 3 dagen bepaald, op basis van verzuimregistraties die door de bedrijven in samenwerking met de deelnemende bedrijfsartsen werden bijgehouden.
Uit de resultaten van de analyses bleek dat nekflexie (meer dan 20 graden gedurende meer dan 40% van de werktijd en meer dan 45 graden gedurende meer dan 5% van de werktijd) en nekrotatie (meer dan 45 graden gedurende meer dan 25% van de werktijd) een statistisch significant verhoogd risico geven op ziekteverzuim als gevolg van nekpijn (nekflexie meer dan 20 graden RR=4.19, 95% BI 1.50-11.69; nekflexie

meer dan 45 graden RR=2.76, 95% BI 1.27-5.99; nekrotatie meer dan 45 graden RR=2.81, 95% BI 1.29-6.09). Bovendien gaven weinig autonomie (RR=3.66, 95% BI 1.44-9.26) en een gemiddeld niveau wat betreft de mogelijkheden tot het ontwikkelen van vaardigheden (RR=2.56, 95% BI 1.08-6.04) een hoger risico op ziekteverzuim als gevolg van nekpijn. Ook hoge kwantitatieve taakeisen (RR=1.96, 95% BI 0.83-4.62), een geringe mate van werkzekerheid (RR=1.70, 95% BI 0.80-3.60) en beperkte mogelijkheden tot het ontwikkelen van vaardigheden (RR=1.64, 95% BI 0.73-3.69) gaven een hoger risico op ziekteverzuim als gevolg van nekpijn, echter deze verhoogde risico´s waren statistisch niet significant. Werken in een zittende houding, tegenstrijdige taakeisen en weinig sociale steun van collega's of leidinggevenden gaven geen verhoogd risico op ziekteverzuim als gevolg van nekpijn.
Op basis van de resultaten die beschreven zijn in Hoofdstuk 6 van dit proefschrift wordt geconcludeerd dat nekflexie meer dan 20 graden (gedurende meer dan 40% van de werktijd), nekflexie meer dan 45 graden (gedurende meer dan 5% van de werktijd), nekrotatie meer dan 45 graden (gedurende meer dan 25% van de werktijd), weinig autonomie en een gemiddeld niveau wat betreft de mogelijkheden tot het ontwikkelen van vaardigheden prospectief en onafhankelijk gerelateerd zijn aan ziekteverzuim als gevolg van nekpijn. Daarnaast zijn er aanwijzingen om aan te nemen dat hoge kwantitatieve taakeisen, een geringe mate van werkzekerheid en beperkte mogelijkheden tot het ontwikkelen van vaardigheden leiden tot ziekteverzuim als gevolg van nekpijn.

Wanneer onderzoek gedaan wordt naar risicofactoren voor nekpijn lijkt het logisch om een zo specifiek mogelijke uitkomstmaat te kiezen. In eerder uitgevoerd onderzoek naar risicofactoren werd echter de nekregio veelal met de schouderregio gecombineerd als uitkomstmaat. In Hoofdstuk 7 van dit proefschrift wordt daarom de vraag beantwoord of in werkgerelateerd onderzoek naar risicofactoren de nek- en schouderregio gebruikt moeten worden als aparte uitkomstmaten, of dat volstaan kan worden met één samengestelde uitkomstmaat, namelijk nek-schouderpijn. Een vergelijking is gemaakt tussen het gebruik van twee uitkomstmaten: nekpijn en nek-en/of schouderpijn (nek-schouderpijn). De longitudinale relatie tussen de eerder genoemde werkgerelateerde fysieke en psychosociale factoren en deze twee uitkomstmaten is onderzocht en de resultaten van deze analyses zijn vergeleken. Nekflexie (meer dan 20 graden), werken in een zittende houding, hoge kwantitatieve taakeisen en weinig sociale steun van collega's waren sterker gerelateerd aan nekpijn dan aan nek-schouderpijn. Wanneer nek-schouderpijn werd gebruikt als de uitkomstmaat, waren de relatieve risico's behorende bij deze vier factoren lager. Voor de overige werkgerelateerde fysieke en psychosociale factoren werden geen grote verschillen gevonden in de relatieve risico's wanneer de twee verschillende uitkomstmaten werden gebruikt.
Op basis van de resultaten die beschreven zijn in Hoofdstuk 7 van dit proefschrift wordt geconcludeerd dat, wanneer een combinatie wordt gemaakt van nek- en schouderpijn als uitkomstmaat, de schattingen van het risico voor bepaalde

werkgerelateerde factoren lager zijn in vergelijking met de schattingen van het risico, verkregen uit analyses waar nek- en schouderpijn als aparte uitkomstmaten worden beschouwd. Het combineren van de nek- en schouderregio in één uitkomstmaat kan dus leiden tot een onderschatting van het werkelijke effect van bepaalde werkgerelateerde fysieke en psychosociale factoren op het ontstaan van nekpijn.

Tenslotte worden in het afsluitende hoofdstuk van dit proefschrift de belangrijkste resultaten samengevat en besproken in de context van de doelstellingen van dit proefschrift (Hoofdstuk 8).
Ten eerste worden de resultaten van de systematische reviews en de resultaten van de prospectieve cohort studie vergeleken. Deze vergelijking laat zien dat langdurig zitten en nekflexie risicofactoren zijn voor het ontstaan van nekpijn. De voorzichtige conclusie op grond van de transversale studies uit de literatuur (beperkt bewijs) kon dus worden bevestigd in de kwalitatief betere prospectieve cohort studie. Eveneens bleek uit de gepresenteerde resultaten dat hoge taakeisen op het werk, weinig invloed op het werk, en weinig sociale steun van collega´s de kans op nekpijn vergroten. Volgens zowel de systematische review als de prospectieve cohort studie werd er geen ondersteuning gevonden voor een relatie tussen steun door leidinggevenden en het ontstaan van nekpijn. Het beperkte bewijs dat werd gevonden op grond van de transversale literatuur voor een rol van beperkte mogelijkheden tot het ontwikkelen van vaardigheden werd niet ondersteund door de resultaten van het prospectieve cohort onderzoek (Tabel 1).

Tabel 1 Overzicht van de resultaten van de systematische reviews en de prospectieve cohort studie

Werkgerelateerde fysieke en psychosociale factoren	Systematische reviews[a]	Prospectieve cohort studie[b]
Nekflexie	Beperkt bewijs	+
Nekrotatie	Onvoldoende bewijs	-
Zitten	Beperkt bewijs	++
Hoge kwantitatieve taakeisen	Beperkt bewijs	++
Weinig autonomie	Beperkt bewijs	+
Beperkte vaardigheidsmogelijkheden	Beperkt bewijs	-
Weinig sociale steun van collega's	Beperkt bewijs	++
Weinig sociale steun van leidinggevenden	Onvoldoende bewijs	-

[a] Resultaten van de systematische reviews; [b] Resultaten van de prospectieve cohort studie; - geen relatie; + verhoogd relatief risico, maar niet statistisch significant; ++ statistisch significant verhoogd relatief risico

Ten tweede wordt in de algemene discussie van dit proefschrift gekeken of de fysieke en psychosociale belasting op het werk even belangrijk zijn voor het ontstaan van nekpijn, of dat één van beide belangrijker is. Zowel langdurig zitten (meer dan

95% van de werktijd) hoge kwantitatieve taakeisen en weinig sociale steun van collega's bleken de kans op het ontstaan van nekpijn ongeveer te verdubbelen. Daarnaast waren de minder hoge en statistisch niet significante relatieve risico's voor nekflexie (meer dan 20 graden gedurende meer dan 70% van de werktijd) en weinig autonomie ook vergelijkbaar in grootte. Bovendien bleek het extra risico op het ontstaan van nekpijn door fysieke belasting op het werk niet erg te worden beïnvloed indien gecorrigeerd werd voor de psychosociale belasting op het werk en omgekeerd. Op basis van bovenstaande wordt geconcludeerd dat werkgerelateerde fysieke en psychosociale risicofactoren een gelijke en onafhankelijke rol spelen bij het ontstaan van nekpijn.

Ten derde wordt de relatie tussen werkgerelateerde fysieke en psychosociale factoren en het ontstaan van nekpijn vergeleken met de relatie tussen deze factoren en ziekteverzuim als gevolg van nekpijn. In Tabel 2 wordt een overzicht gegeven van de resultaten van deze relaties.

Tabel 2 Samenvatting van de resultaten van de prospectieve cohort studie voor respectievelijk het ontstaan van nekpijn en ziekteverzuim als gevolg van nekpijn

Werkgerelateerde fysieke en psychosociale factoren	Het ontstaan van nekpijn[a]	Ziekteverzuim als gevolg van nekpijn[b]
Nekflexie >20 graden	+	++
Nekflexie >45 graden	-	++
Nekrotatie >45 graden	-	++
Zitten	++	-
Kwantitatieve taakeisen	++	+
Tegenstrijdige taakeisen	-	-
Autonomie	+	++
Vaardigheidsmogelijkheden	-	++
Sociale steun van collega's	++	-
Sociale steun van leidinggevenden	-	-
Werkzekerheid	-	+

[a] Samenvatting van de resultaten voor het ontstaan van nekpijn; [b] Samenvatting van de resultaten voor ziekteverzuim als gevolg van nekpijn; - geen relatie; + verhoogd relatief risico, maar niet statistisch significant; ++ statistisch significant verhoogd relatief risico

In vergelijking met werknemers die bijna niet zitten op het werk, rapporteerden langdurig zittende werknemers (meer dan 95% van de werktijd) meer nekpijn, zij waren echter niet vaker afwezig van hun werk als gevolg van nekpijn. Blijkbaar is het bij dergelijk werk goed mogelijk om met de nekpijn te blijven functioneren. Nekflexie (meer dan 20 graden) verhoogde de kans op nekpijn enigszins, echter deze relatie was niet zo sterk. De relatie met ziekteverzuim was sterker. Voor nekflexie meer dan

45 graden en nekrotatie meer dan 45 graden geldt zelfs dat er geen duidelijk verband was met nekpijn, maar dat er wel een duidelijk verband gevonden werd met ziekteverzuim als gevolg van nekpijn. Hoge kwantitatieve taakeisen en weinig autonomie dragen zowel bij aan het ontstaan van nekpijn als aan ziekteverzuim als gevolg van nekpijn. Tegenstrijdige taakeisen en weinig sociale steun van leidinggevenden zijn niet van belang voor het ontstaan van nekpijn en voor ziekteverzuim als gevolg van nekpijn. Voor beperkte mogelijkheden tot het ontwikkelen van vaardigheden en een geringe mate van werkzekerheid geldt dat, hoewel deze factoren niet gerelateerd waren aan het ontstaan van nekpijn, zij wel het ziekteverzuim als gevolg van nekpijn verhoogden. Tenslotte was weinig sociale steun van collega's een risicofactor voor het ontstaan van nekpijn, maar deze factor bleek niet bij te dragen aan een hoger ziekteverzuim als gevolg van nekpijn.
Mogelijke verklaring voor deze discrepanties in de resultaten en de vergelijkbaarheid van de beide analyses worden vervolgens in de samenvattende discussie besproken (onder meer het gebrek aan power en het verschil in het aantal werknemers in beide analyses, het feit dat het statische aspect van nekflexie en nekrotatie niet is gemeten, het verschil in de indeling in categorieën van de verschillende werkgerelateerde fysieke en psychosociale variabelen).

Na de discussie van de resultaten wordt in Hoofdstuk 8 van dit proefschrift stilgestaan bij enige methodologische punten inzake het doen van systematische reviews en het uitvoeren van prospectief cohort onderzoek. Belangrijke methodologische punten ten aanzien van de systematische reviews zijn de afwezigheid van afspraken voor wat betreft het systematisch reviewen van observationele studies, het grote aantal transversale studies en het gebrek aan longitudinale studies in de reviews, de bepaling van de methodologische kwaliteit van de studies in de reviews en het uitsluiten van studies een samengestelde uitkomstmaten. Belangrijke methodologische punten ten aanzien van het prospectieve cohort onderzoek zijn de uitval van werknemers gedurende de loop van het onderzoek, de bepaling van de fysieke belasting op de werkplek, de indeling in categorieën van de werkgerelateerde fysieke en psychosociale factoren, eerdere episodes van nekpijn en de duur van de follow-up periode van het onderzoek.

Hoofdstuk 8 van dit proefschrift sluit af met de implicaties van de bevindingen voor de preventie van nekpijn en met aanbevelingen voor toekomstig onderzoek. De preventie van nekpijn moet gericht zijn op zowel de fysieke als de psychosociale aspecten van het werk. Preventie dient zich te richten op het reduceren van langdurig zittend werken, bijvoorbeeld door het werk te variëren of de werkplek aan te passen. Variatie in het werk dient te worden gestimuleerd om zo de tijd te verkorten waarin gewerkt wordt met een gebogen nek. Omdat nekflexie sterker gerelateerd blijkt te zijn aan nekpijn bij werknemers met een relatief lage fysieke fitheid van de nek, zal training van de nekspieren (met als gevolg een verhoogde fysieke fitheid van de nek) waarschijnlijk bijdragen aan de preventie van nekpijn.

Organisatorische veranderingen die leiden tot een reductie van taakeisen (bijvoorbeeld minder werken onder tijdsdruk) en een verhoging van de sociale steun van collega's zullen bijdragen aan de preventie van nekpijn. Daarnaast is het belangrijk dat werknemers meer invloed hebben op de beslismogelijkheden (autonomie) in hun werk.
Als de nek minder lang en minder vaak gebogen of gedraaid wordt op een werkdag, zal dit bijdragen aan minder ziekteverzuim als gevolg van nekpijn. Het vergroten van de invloed op het werk (autonomie), meer leermogelijkheden en meer mogelijkheden tot het ontwikkelen van vaardigheden (bijvoorbeeld door organisatorische veranderingen in het werk) zullen eveneens bijdragen aan een lager ziekteverzuim als gevolg van nekpijn. Minder hoge taakeisen op het werk zullen waarschijnlijk ook bijdragen aan de preventie van ziekteverzuim als gevolg van nekpijn.

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About the author

Geertje Ariëns was born in Dongen on November 7th, 1969, where she spent a pleasant childhood with her parents and two brothers. After obtaining her secondary school diploma in 1989 at the Dr. Schaepmancollege in Dongen, she started to study at the Faculty of Human Movement Sciences of the Vrije Universiteit in Amsterdam. In 1995 she graduated with a major in health science. From January 1996 until November 1996 she worked for the Amsterdam Growth and Health Study as a volunteer. In December 1996, she started working at the Institute for Research in Extramural Medicine (EMGO-Institute) and the Department of Social Medicine of the Vrije Universiteit in Amsterdam. As a PhD-student, she conducted a study on work-related risk factors for neck pain as described in this thesis, a collaborative project of TNO Work and Employment and the EMGO-Institute. Besides her research activities she attended statistical and methodological courses organised by the Postgraduate Epidemiology Programme of the EMGO-Institute and The Netherlands School of Primary Care (CaRe). In the summer of 1998, she attended the New England Epidemiology Summer Program at Tufts University in Boston, USA. She is currently registered as an Epidemiologist B and will continue to work at the EMGO-Institute and at TNO Work and Employment.