



UMEÅ UNIVERSITY

Neck pain in women

Effect of tailored treatment and impact of work environment

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To my beloved family

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Abstract

Introduction: Musculoskeletal pain is a common problem in the working population. In Sweden, 40% of women and 30% of men report suffering from neck and shoulder pain weekly. The underlying cause for neck pain is often not known and the treatment is commonly guided by the individual's symptoms. However, there is a lack of knowledge on how to receive the best effect based on the individual's symptoms and functional limitations, and therefore this has been scarcely evaluated in research. Furthermore, the impact of work exposure and stress on long-term treatment for persons with neck pain is not clear.

Aims: To develop (paper 1) and to evaluate a decision model for tailored treatment in women with neck pain (paper 2). Moreover, to determine if risk factors at work and stress influence intermediate and long-term treatment results (paper 3). Further, to investigate if changes in self-reported pain and disabilities are associated with changes of physical test outcomes of the neck and shoulder region after treatment (paper 4).

Methods: In an RCT, 120 working women with non-specific neck pain were randomized to three different groups – tailored treatment (TT), non-tailored treatment (NTT) or treatment-as-usual (TAU) for an 11 weeks intervention with short-term, intermediate-term and long-term follow-ups. The TT group was guided by a decision model with cut-off levels to indicate impairments. The NTT group received two established treatment components randomly from those not indicated, and TAU group did not receive any treatment within the study. The RCT primary outcomes were self-reported neck pain and neck disability. A linear mixed model was used for analysing the effects. One week after the end of intervention work exposure and stress were assessed at a work-place visit and associations to treatment results were tested for, and mixed models were used to estimate longitudinal associations. Associations between self-reported neck problems and physical outcomes were estimated with univariate and multiple regressions analysis.

Results: No differences between TT and NTT were revealed for neck pain and disability. In comparison to TAU, the TT and NTT groups both showed improvements at short-term follow-up, but not at intermediate and long-term follow-up. High stress level and low self-estimated control at work were associated with more pain and disability at the intermediate and long-term follow-ups. After intervention and at the intermediate-term follow-up, reduced neck pain, disability and frequency of symptoms were associated with increased peak speed of head rotation and cervical range of motion.

Conclusion: Tailored treatment according to the decision model was not superior to the non-tailored treatment in women with non-specific neck pain. One explanation for this can be the weak relationships found between neck pain and disability and physical test outcomes. Further, perceived stress and psychosocial work exposure were associated with self-reported neck problems and should be taken into account to optimize the effects in neck pain rehabilitation.

Abbreviations

Anova	Analysis of variance
A-ROM	Axial-Range Of Motion
BMI	Body Mass Index
CCF	Cranio-Cervical Flexion
CH	Cervicogenic Headache
C-PILE	Cervical-Progressive Isoinertial Lifting Evaluation
C-ROM	Cervical-Range Of Motion
CTE	Cervico-Thoracic Extension
CTF	Cervico-Thoracic Flexion
EMG	Electromyography
HADS	Hospital Anxiety and Depression Scale
IASP	The International Association for the Study of Pain
ICF	International Classification of Functioning, disability and health
kPa	KiloPascal
MAQ	Muscle Action Quality
MVC	Maximal Voluntary Contraction
N	Newton
NDI	Neck Disability Index
Nm	Newton meter
NRS	Numeric Rating Scale
NTT	Non-Tailored Treatment
PET	Problem Elicitation Technique
PGICS	Patient Global Impression of Change Scale
PPT	Pressure Pain Threshold
ProFitMap	
-neck	Profile Fitness Mapping neck questionnaire
QEC	Quick Exposure Check
QPS Nordic	The Nordic questionnaire for psychological and social factors at work
RCT	Randomized Controlled clinical Trial
ROM	Range Of Motion
SD	Standard Deviation
TAU	Treatment-As-Usual
TT	Tailored Treatment
VIF	Variance Inflation Factor
WHO	World Health Organization

Enkel sammanfattning på svenska

Nacksmärta hos kvinnor. Effekten av individanpassad rehabilitering och betydelsen av arbetsmiljöfaktorer.

Bakgrund: Nack- och skulder-smärta är ett vanligt tillstånd som förekommer över hela världen. I Sverige skattar 30-40% besvär från nacke och skuldror mätt under en veckas tid. Generellt rapporterar kvinnor mer nack- och skulder-besvär än män. I avhandlingen är det ospecifik nacksmärta som har studerats, det inkluderar *inte* t.ex. Whiplash-skador, diskbräck eller andra mer specifika diagnoser. Den bakomliggande orsaken till ospecifik nacksmärta är, precis som beteckningen antyder, ofta inte känd och individens symptom och funktion är istället vägledande i undersökning och behandling samt utvärdering av behandling. Studier har visat att i jämförelse med friska har individer med ospecifika nackbesvär ofta sämre muskulär nackstyrka, minskad rörlighet i nacken och är något långsammare vid test av huvudrörelser. Behandlingen riktar sig ofta mot något av dessa fynd med bl.a. styrketräning av nackmuskler och/eller manuella tekniker för rörelseökning. Studier har dock visat att behandlingen endast ger måttliga resultat och att de positiva resultaten bara är kortvariga. I kliniken försöker man individanpassa behandlingen utifrån patientens behov men det finns väldigt lite forskning om detta utan studier utvärderar likadan behandling för hela grupper. Det saknas fortfarande kunskaper om hur man på bästa sätt individanpassar behandling så att den blir skräddarsydd utifrån individens symptom och funktion samt utvärderar detta.

Syftet med avhandlingen var att undersöka om en intervention med skräddarsydd behandling (som också innehöll specifik aktiv träning) utifrån en beslutsmodell med fysiska tester och frågor om symptom är effektivt för att uppnå positiva effekter i självskattad smärta och funktion (artikel 1 och 2). Den skräddarsydda behandlingen jämfördes mot en grupp som fick samma upplägg *inte* skräddarsydd behandling. Vidare undersöktes om båda dessa behandlingsgrupper var effektivare än en grupp som inte fick någon behandling i studien. Dessutom undersöktes om påverkan från arbetsmiljön i form av fysisk och psykosocial belastning samt upplevd stress påverkade behandlingsresultaten efter interventionen (artikel 3). Slutligen undersöktes om de fysiska testerna och den självskattade smärtan, funktionen och symptomen hade koppling till varandra dels före interventionen och dels i termer av förändringar efter interventionen (artikel 4).

Metod: I en randomiserad kontrollerad interventionsstudie (RCT) inkluderades 120 kvinnor i åldrarna 20-65, alla i arbete, och som hade ospecifika nackbesvär. De lottades till tre grupper, (1) skräddarsydd behandling (Tailore treatment, TT),

(2) icke-skräddarsydd behandling (Non-tailored treatment, NTT) och (3) en kontrollgrupp (Treatment-as-usual, TAU) som inte fick någon behandling i studien men var fria att söka vård på egen hand. Kvinnorna i TT-gruppen fick behandlings-komponenter utifrån testresultaten i beslutsmodellen. Det kunde läggas till någon behandlingskomponent om det visade sig behövas utifrån individens behov i vardagen. Detta undersöktes genom en strukturerad intervju-teknik som kallas Problem Elicitation Technique (PET). Kvinnorna i NTT-gruppen fick två lottade behandlings-komponenter som inte matchade deras behov utifrån testerna i beslutsmodellen. För båda behandlings-grupperna var interventionen 11 veckor med inbokade behandlingstillfällen 2-3 gånger per vecka, samtliga tillfällen vägleda av fysioterapeut. Data för alla tre grupper samlades in innan interventionen samt 3, 9 och 15 månader efter start av interventionen. Gruppkillnaderna analyserades med en "linear mixed model". En vecka efter intervention gjordes ett arbetsplatsbesök hos individerna i alla tre grupper. En erfaren ergonom observerade individernas fysiska arbetsbelastning med ett ergonomiskt bedömningsinstrument, Quick Exposure Check (QEC), och individerna skattade också den psykosociala arbetsmiljön i ett frågeformulär, QPS Nordic, samt upplevd stress. För att undersöka om den fysiska och psykosociala arbetsbelastningen samt stress påverkade resultaten från interventionen analyserades data med linjär regression och mixed model. För att undersöka om de fysiska testerna och den självskattade smärtan, funktionen och symptomen hade något samband användes linjär regressionsanalys.

Resultat: Att skräddarsy behandlingen utifrån den testade beslutsmodellen var inte effektivare än att inte skräddarsy. I jämförelse med kontrollgruppen självskattade båda behandlingsgrupperna mindre smärta, bättre funktion och mindre symptom efter interventionen. I de länge uppföljningarna (9 och 15 månader) var dock skillnaderna mellan grupperna inte längre signifikanta förutom att båda behandlingsgrupperna, till skillnad från kontrollgruppen, upplevde sig bättre än innan behandling. Det visade sig att upplevd hög stressnivå och låg kontroll på arbetet hade samband med mer självskattad nacksmärta, sämre funktion och lägre arbetsproduktivitet. De fysiska testerna och självskattade nackbesvär hade bara svaga samband. På baslinjenivå, innan interventionen, fanns det samband mellan hög nackstyrka och låg självskattad funktion och låg frekvens på symptomen, samt mellan att vara långsam i testet av snabba huvudrörelser och hög smärta. Efter interventionen hade individernas förändring i självskattad smärta fortfarande bara samband med snabba huvudrörelser. Förbättring i självskattad funktion och symptom hade samband till ökad hastighet i snabba huvudrörelser och ökat rörelseutslag nackrotation.

Sammanfattning: För kvinnor i arbete med ospecifika nackbesvär var det inte mer effektivt att skräddarsy behandling/träning utifrån en beslutsmodell jämfört med att slumpmässigt välja ut behandlingskomponenter från samma

behandlingsarsenal. En förklaring kan vara att det fanns endast låga samband mellan självskattad smärta och funktion och de fysiska testerna. Upplevd stress och kontroll i arbetet visade sig ha samband med självskattad smärta, funktion och arbetsproduktivitet och bör tas i beaktande i framtida interventioner för individer med nacksmärta.

Original papers

Paper 1. Björklund M, Djupsjöbacka M, **Svedmark Å**, Häger C. Effects of tailored neck-shoulder pain treatment based on a decision model guided by clinical assessments and standardized functional tests. A study protocol of a randomized controlled trial. *BMC Musculoskelet Disord.* 2012 (13): 75.

Paper 2. **Svedmark Å**, Djupsjöbacka M, Häger C, Jull G, Björklund M. Is tailored treatment superior to non-tailored treatment for pain and disability in women with non-specific neck pain? A randomized controlled trial. *BMC Musculoskelet Disord.* 2016 (17): 408.

Paper 3. **Svedmark Å**, Björklund M, Häger CK, Sommar J, Wahlström J. Impact of workplace exposure and stress on neck pain and disabilities in women – a longitudinal follow-up after a rehabilitation intervention. (Manuscript; submitted august 2017).

Paper 4. **Svedmark Å**, Häger CK, Björklund M. Associations between self-rated and physical test outcomes before and after intervention in women with non-specific neck pain - Cross-sectional and longitudinal analyses. (In manuscript).

Introduction

Neck pain definition and classification

The pain experience is subjective and personal and defined by the International Association for the Study of Pain (IASP) as “*an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage*” [1]. In most cases the specific cause for neck pain is unclear [2] and the term non-specific neck pain is used. Non-specific neck pain does not include trauma related neck pain, cervical radiculopathy or detailed patho-anatomic origin to the neck pain. The term idiopathic neck pain is sometime used, meaning that there is no obvious origin for the pain. In this thesis the term non-specific neck pain is used.

In this thesis, the anatomic distribution for non-specific neck pain is specified to the neck and shoulder, down to the spine of scapula (figure 1). The duration of neck pain can be classified as acute (less than 7 days), short-lasting or subacute (7 days up to three months), and long-lasting or chronic (more than three months) [3]. Women with non-specific neck pain included in the thesis had a duration of six weeks or more, meaning subacute and chronic according to the classification. An example of another classification (not used in the thesis) is the Neck Pain Task Force classification system that is according to functions in daily life and severity of the condition. This system is presented as Grade 1: no signs or symptoms of major structural pathology and minor interference with activities of daily living, Grade 2: no signs or symptoms of major structural pathology, but major interference with activities of daily living, Grade 3: no signs or symptoms of major structural pathology, but presence of neurologic signs such as decreased deep tendon reflexes, weakness, or sensory deficits, and Grade 4: signs or symptoms of major pathology [3]. Another example is the CANS model defined as “musculoskeletal complains of arm, neck and/or shoulder not caused by acute trauma or by any systemic disease”. The model includes (i) specific CANS with diagnosable disorders, and (ii) non-specific CANS with all other complains [4].

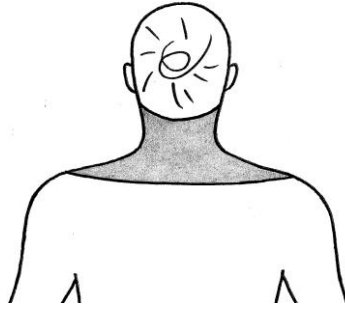


Figure 1 The figure illustrates the region of neck-shoulder pain for non-specific neck pain in this thesis.

Epidemiology of neck pain

Most people experience an episode with neck pain at some point during life [5]. More than 50% of the people that have experienced an episode of neck pain will also report neck pain 1-5 years later [6]. Neck pain is ranked 4th in the world in terms of years lived with disability and 21st in terms of overall burden (291 conditions studied) [7]. The incidence of neck pain increases with age, peaks in the middle age, and then levels out or declines; this is the same pattern as for musculoskeletal pain [8]. Each year 11% to 14% of workers are limited in their activities because of neck pain [8]. The prevalence varies across occupations with health care, administrative and industry production workers being among the highest [9, 10]. Among office workers and those that use computers frequently, the annual prevalence is as high as 50% and the incidence is about 20% [8]. In many studies, women report more neck pain than men both among workers [7, 11] and in the general population [7, 12]. In Sweden, about 40% of women and about 30% of men reported pain from the upper spine or neck every week [13]. In recovery from neck pain no gender differences have been observed [14].

Neck pain and risk factors in workers

Most neck pain in workers is non-traumatic and is generated by a combination of multifactorial individual and workplace risk factors [8]. Possible work-related risk factors can be classified as individual, physical and psychosocial although the interaction varies with work environment and between individuals and can be mediated by cultural and social factors [15].

Examples of *Individual risk factors* among workers are low-to-moderate physical capacity in lifting and static neck endurance [16], or a history of musculoskeletal pain in the neck, upper extremities, lower back or headache [9]. In a longitudinal study from Sweden, high BMI predicted neck and shoulder pain 18 years later for

women, but not for men [17]. Depressed mood was also shown to be an individual risk factor for the onset of neck pain among workers [18]. An individual risk factor for work-related neck pain is sex/gender, and women report a higher incidence of neck and musculoskeletal pain than men [8]. Anatomical and physiological structural differences are hypothesised to partly explain the higher prevalence of neck pain in women [19]; however, differences in the working conditions and the fact that men and women are not exposed to the same risk-factors [20-22] might be more important. A report by The Swedish Work Environmental Authority found that the higher prevalence of musculoskeletal pain for women was explained by the fact that women had occasions with less variation, and if women and men had the same occupation they did different tasks. Regarding working with tools, the design of the tool was for a medium men size, thus presenting women with more load and sometimes awkward postures [23]. The psychosocial work environment for women more often included work with high demands and low resources. Men were more common in management positions, men had less employees to be responsible for. The authors discussed that these were examples of so-called female-coded work organizations than can receive increased stress and secondary muscle strain and muscle pain (The Swedish Work Environmental Authority, report 2013:1/2016:2). Instead of the stereotypical views of men and women, more research is needed on variations within the group of women and men [24]. This along with the higher prevalence of neck pain among women is the reason why the thesis includes only women with the intention to contribute more knowledge about neck pain among women at work.

Examples of *physical risk factors* for neck pain are repetitive work, precision work tasks, sedentary work position, poor computer workstation design, and with less evidence awkward work posture [8]. Complements to this, but with modest evidence are heavy load at work and flexion or rotation of the body (The Swedish Council on Health Technology Assessment (SBU) 2012). A poor general physical environment, for example, air quality, temperature, acoustics and lighting, can also increase the risk of neck pain [10]. Most data concerning work-related musculoskeletal disorders are based on self-reports or are assessed by observations (SBU 2012). Opposite, recently publicized Norlander et al. quantitative data pooled from cross-sectional studies regarding exposure-response relationships between work-related risk factors and neck and shoulder disorders. The authors presented significant associations between neck and shoulder disorders with neck flexion, upper arm elevation, activity in the trapezius muscle, forearm extensor muscle and wrist posture and angular velocity [25].

Examples of *psychosocial risk factors* for neck pain are little influence on work situation [26], high quantitative job demands, low social support at work, and job insecurity [9]. Two job stress models often used are the effort-reward imbalance

model [27] and the demand-control model [28]. In this thesis none of these models are used. In theory, the psychosocial work environment can induce stress and secondarily increase muscle strain and finally neck pain. The perceived stress, however, can include more than the work factors measured. In 1956, a researcher, Hans Selye, was the first to present a definition of stress – “stress is the non-specific response of the body to any demands, whether it is caused by, or results in, pleasant or unpleasant conditions”. Perceived stress is normally harmless and the body is able to adapt to that. The autonomic nervous system is the regulatory system and problems occur if there is an imbalance in this stress response system that promotes adaption; this has been named allostatic load [29]. This imbalance can be a result of frequent and high stress without recovery episodes, inability to shut down stress response after the exposure, or when the stressor persists over a long time such as muscle pain [30]. Perceived stress can be an independent predictor of neck-shoulder pain [31] with an impact on work productivity. A combination of musculoskeletal pain and perceived stress nearly doubled the risk for decreased work performance and reduced work ability [32].

Biopsychosocial model

The biopsychosocial model originated from the psychiatric field but has been adapted to other fields of medicine [33]. This model has broadened the view of factors that can affect neck pain – biological, psychological and social factors. In an individual perspective the model can have more or less influence from the three factors as illustrated in figure 2 [34]. The three factors for individuals can change during time (within individuals), but also between individuals. This means that the model is not constant and the influence from each of the modules can change.

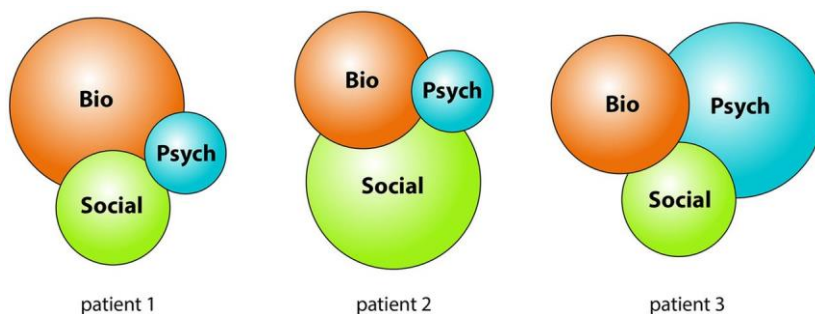


Figure 2 An illustration of how each factor of the biopsychosocial model’s components can shift between individuals and are neither predetermined nor static.

Copy from [34] with permission from the author, Gwendolen Jull.

The International Classification of Functioning, Disability and Health

The International Classification of Functioning, Disability and Health (ICF) is published by the World Health Organization (WHO) in 2001, and make it possible to describe a person’s function and dysfunction in relation to health status. The ICF complements the International Classification of Diseases and Related Health Problems (ICD), a commonly used diagnosis instrument. ICF has developed a core set for back pain but not for neck pain. The back pain core set is complemented with a self-reported checklist to better understand the patient perspective [35]. For neck pain, the self-estimated questionnaires Neck Disability Index (NDI) [36] showed a good fit with the ICF model in a study linking self-rated functional problems with ICF [37]. The Orthopedic Section of the American Physical Therapy Association has presented clinical practice guidelines for neck pain and linked this to ICF [38, 39].

Physical impairments

Compared to healthy persons, people with non-specific neck pain show reduced physical capacity and altered sensorimotor control. Examples of negative impact on *physical capacity* regard reduced isometric static strength in cervico-thoracic extension and flexion [40-42], and cranio-cervical flexion [43]. This could partly be explained by the association with pain and strength where pain inhibits strength, although this is only investigated when the test situation provokes more pain [44]. A functional lifting test, Cervical Progressive Isoinertial Lifting Evaluation (C-PILE), initially used to test industry-workers, has shown reduced capacity for neck pain patients compared to healthy people [45-47]. Neck pain

patients have also shown reduced active cervical range of motion (C-ROM) [40, 41, 48]. Recently level specific C-ROM reduction has been reported for neck pain patients with decreased extension in the upper cervical and decreased flexion in the lower cervical compared to a healthy group [48].

Altered kinematics with different muscle activation patterns during tasks have been observed among persons with neck pain. During low-load cervical flexion, a high activation of superficial neck muscles (sternocleidomastoideus) and low activation of deep cranio-cervical muscles was measured for persons with neck pain, and vice versa for healthy persons [49, 50]. Also, during computer work, cervical extensor muscles were low activated compared to trapezius muscle for persons with neck pain, and vice versa for healthy persons [51, 52]. Further, the ability for fast cervical movements (e.g. peak speed in cervical axial rotation) were shown to be reduced in persons with neck pain [53].

When walking and at the same time moving the head, women with neck pain walked with narrower step with, shorter step length and slower gait speed compared to controls [54]. Also recognized was a reduced rotation of the trunk during walking that theoretical can have consequences over time on the spinal health [55].

Interventions

In the clinic, patient's symptoms and signs are indicative for treatments, and the individual perspective and tailored treatment are a corner-stone. Because there is a lack of knowledge of specific causes and patho-anatomical sources, it is important to assess the patient's symptoms and function and to tailor the treatment to findings. Systematic reviews point out the evidence for chronic neck pain rehabilitation to be multifactorial with an advantage for manual therapy and exercises for the upper body and neck [56-58]. The strengthening exercises should focus on neck, shoulder, and shoulder blade regions [56]. The effects were though minimal when only stretching or endurance training [56]. Overall, there is still some uncertainty about effectiveness of exercises for neck pain [38].

Recent updates of the Neck Pain Task Force with systematic reviews and they found complemented evidence for treatment on neck pain with thoracic manipulation on short-term benefits, and clinical massage (e.g. myofascial trigger point therapy, myofascial release, passive stretching) [59]. They also suggested that electro acupuncture, low-level laser therapy, ultrasound, relaxation massage, heat and cold were not effective to manage neck pain. In the updated review for patient education they found that structured patient education alone is not more effective then conservative interventions for patients with non-specific neck pain [60]. The conservative treatment was described as

physiotherapy, supervised exercises and massage. The review for multimodal care found that multimodal care (at least two distinct therapeutic modalities) including education, exercise and manual therapy could benefit patients with non-specific neck pain [61]. The low to moderate evidence is still a problem in neck pain treatment, and the results are dominantly short-term follow-ups, and the impact from confounders and mediators are seldom discussed.

Tailored treatment

There is a lack of treatment studies tailored to participants need with rules for decision model for treatment, whereas so called individualized approaches are more common. For example McLean et al. investigated effects of graded exercise treatment for patients with non-specific neck pain [62]. Results showed modest effect with no difference to usual physiotherapy and low levels of adherence reduced the quality of the study. Wang et al. used a tailored to need treatment approach for neck pain patients [63] with a clinical decision-making algorithm to choose treatments. The tailored group had significantly less pain and disability after treatment compared to a control group. However, the value of the study is reduced due to that the control group did not receive sham or alternative treatment. Even though studies about clinical decision support tools are increasing [64], treatment algorithms and models used, are diverse and often without formal and rigorous testing.

Interventions at workplace

A systematic review from 2008 found no clear evidence for interventions aimed at modifying workstations or workers posture, but the study quality was overall low [9]. However, Neumann et al. [65] published a discussion paper about quality criteria selection bias, and inferred that in many work-place studies the RCT designs are problematic and more case studies exist but they were excluded in systematic reviews. Recently, a longitudinal cohort showed that using prizma-spectacles for dental personnel significantly reduced neck pain and increased work ability compared to a reference group [66]. The authors felt that one explanation could be the less awkward neck posture. A Danish research group investigated interventions for office workers with upper body exercise training at work and found significant reduction of neck and shoulder pain [67-69]. In order to investigate the impact of frequency and session duration during a 20-week intervention, three time sessions were tested: 3 x 20 minutes, 9 x 7 minutes, or 1 x 60 minutes per week. Interestingly they found no differences between sessions but significantly reduced neck and shoulder pain in all programs [70]. The effect of doing exercises at home or at work was also investigated, and Danish female healthcare workers with musculoskeletal pain had better effects of physical exercise at work than at home [71]. In contrast to physical exercise at work, more sitting time was associated with decreased neck-shoulder pain in a study on

manual worker in cleaning and transport industries [72]. This highlights the differences between work tasks and the need for change in exposure across working time (The Swedish Work Environmental Authority, report 2016:1).

Placebo – nocebo

The outcomes in an intervention can be positively or negatively affected by psychological and contextual factors, phenomena referred to as placebo and nocebo, respectively. For example, participants' expectation of treatment outcome is a complex mental activity and participants with negative recovery expectations have shown less treatment effect [73] than those with positive recovery expectations [74]. Emotions that modulate anxiety and activate reward mechanisms can positively affect behavior and therapeutic outcomes [74]. Studies have shown that placebo mechanisms are modulating neurotransmitters like opioids, oxytocin and dopamine and involving numerous brain areas [75]. In trials with high rate of placebo responders was an increase of endogenous dopamine measured [74]. Examples of placebo in neck pain treatments are "physiotherapist's effect" [76] and the patient's expectation for pain relief strategies [77]. Skatteboe et al. studied if expectations before rehabilitation changed with a specialist consultation for persons with musculoskeletal disorders, and they found that 24% of the persons expected a more positive outcome after consultation than before [78]. These same authors found no association between expectation and pain and disability outcomes after rehabilitation; overall the expectation was more positive than the results [79]. Others have investigated participants mood and have shown that persons with depressive symptoms perform less in physical tests [80], and persons with non-depressive symptoms tend to overestimate their abilities or performance on a given task [81]. In a systematic review of factors that contribute to nocebo effects, for example, an explicit suggestion was that the exposure triggers symptoms and a higher expectations of symptoms [82]. The authors conclude that clinicians can reduce nocebo induced symptoms, but there is a challenge to develop innovative ways to reduce nocebo effects without withholding information. In research is it important to as far as possible control for placebo and nocebo mechanism.

Rationale of the present thesis

Physical outcomes, for example, neck muscle strength and endurance, cervical range of motion and sensorimotor control, differ between persons with non-specific neck pain and healthy persons [83]. Furthermore, differences in muscle activation patterns like reduced activation of the deep cranio-cervical flexors and over-activity of the superficial muscles [50, 52] have also been observed. However, treatment effects are still uncertainty and reviews found no high quality evidence [56, 57]. One explanation for this could be the large variation of pain

level, disability and impairments of neck pain groups [84] and thus the difficulty to meet each patient's need. The adaptation of treatment to neck pain patients individual status may therefore be important and in need of more research. There is a gap in the research results concerning the effect of tailored neck pain treatment based on the individual's physical impairment at the start of treatment. Tailoring can be defined as "any combination of information or change strategies *intended to reach one specific person*, based on characteristics that are unique to that person, related to outcome of interest, and have been *derived from an individual assessment* [85] **or** individual rehabilitation program derived from assessment of each patient's characteristics and needs" [86].

A need for advancement in neck pain research, with regards to tailored treatment, with the goal to develop more effective interventions constitutes the rationale for this thesis. The biopsychosocial perspective should be included with, for example, individual's work exposure, perceived stress level and the individual goal with the neck pain treatment. Further, the relations between neck pain and neck disability with cervical ROM, neck muscle strength and motor control is in need of more understanding.

Overall and specific aims

The overall aim of this thesis was to contribute to the field of rehabilitation of persons with neck pain by adding more knowledge about the effect of tailored treatment on pain and disability, the impact of work exposure and stress on long-term rehabilitation results and the association of self-rated neck problems and outcomes of physical test of the neck and shoulder region in women with non-specific neck pain. The specific aims within each paper are presented below:

Paper 1

The aim was to propose a decision model for tailored treatment of non-specific neck pain in women, and to develop a transparent protocol for a randomized controlled treatment trial to evaluate the treatment given according to the proposed model.

Paper 2

The aim was to evaluate the effect of tailored treatment, based on the proposed decision model, on pain and disability compared with non-tailored treatment and treatment-as-usual in women with subacute and chronic non-specific neck pain.

Paper 3

The aim was to evaluate if neck pain, neck disability and work productivity in women with non-specific neck pain were influenced by physical and psychosocial work exposure and perceived stress directly after a rehabilitation intervention as well as at intermediate and long-term follow-ups.

Paper 4

The aim was to determine, in women with non-specific neck pain, the association of self-rated pain, disability and frequency of symptoms of the neck with outcomes of physical tests of the neck and shoulder region at baseline, as well as for Change-scores after treatment intervention and at intermediate follow-up.

Methods

Study designs

The present thesis includes a prospective interventional single-center, single-assessor blinded randomized controlled clinical trial (RCT), a protocol article, and two prospective studies with a cross-sectional and a longitudinal design, respectively. The same sample was used in all studies, i.e. women with non-specific neck pain. Data collection started in June 2011 and ended in June 2013. An overview of the papers included in the thesis are presented in table 1.

Table 1 Overview of design, study sample, outcome measures and data collection.

	Paper 1	Paper 2	Paper 3	Paper 4
Design	Protocol	Randomized controlled clinical trial	Cross-sectional and longitudinal	Cross-sectional and longitudinal
Study sample		n=120 women with non-specific neck pain, before and after intervention	n=97 women with non-specific neck pain, after intervention	n=120/69 women with non-specific neck pain, before and after intervention
Outcome measures		Primary: neck pain, neck disability Secondary: general improvement, neck symptoms, work productivity, pressure pain threshold on trapezius	Neck pain, neck disability, neck symptoms, physical and psychosocial work load, stress at work, perceived stress level	Neck pain, neck disability, frequency of symptoms and physical tests
Data collection		Baseline, 3, 9 and 15 months after start of intervention	3, 9, and 15 months after start of intervention	Baseline, 3 and 9 months after start of intervention

Participants

The studied sample in the thesis was women with non-specific neck pain age 20-65, with a history of a minimum of six weeks of neck pain. The non-specific neck pain were defined as pain in the neck and surrounding tissues that included the neck-shoulder muscles but not complaints related to the gleno-humeral joints. In addition to neck pain, participants should have more than “no disability” but less than “complete disability” according to the Neck Disability Index (NDI) [87] and have reported impaired capacity on the quality or quantity to work the preceding month [88]. Participants with trauma related neck pain and concurred low back pain were excluded. The aim was to study the working population with mild to severe disability with non-specific neck pain without specific diagnosis that need specific treatment, and also exclude prognostic factors for poor treatment outcome. For a detailed description of inclusion and exclusion criteria see table 2.

Ethical considerations

All participants volunteered and were informed about the study and the possibility to withdraw at any time without giving reasons. All participants gave their written consent. The studies were approved by the Regional Ethical Review Board in Uppsala, Sweden (2011/081) and were carried out according to the Declaration of Helsinki.

Recruitment

Consecutive recruitment was accomplished via advertisements on web pages at Umeå University, Umeå Municipality, and University Hospital of Umeå and in local newspapers (Västerbottens kuriren och Västerbottens folkblad).

Table 2 Inclusion and exclusion criteria for study participants

Inclusion criteria	Exclusion criteria
Age: 20-65 years	Trauma related neck pain
Minimum of six weeks of non-specific neck pain	Cervical rhizopathy
Dominant pain area in the neck-shoulder region	Vestibular dysfunction
Disability score more than “no disability” but less than “complete disability” ($10 \leq \text{NDI} \% \leq 68$)	Complaints to the gleno-humeral joints
Impaired capacity on the quality or quantity to work	Temporomandibular disorders
Swedish speaking	Fibromyalgia/generalized pain
	Concurrent low back pain
	Surgery in the spine or shoulder the last 3 years
	Fracture in the spine or shoulder the last 3 years
	Low treatment expectation or catastrophizing most or all of the time
	Anxiety or depression
	Specific diagnosis such as psychiatric, inflammatory, endocrinal, rheumatic, cancer, neurological, stroke, heart infarct, type 1-diabetes, connective tissue disorders.

NDI; neck disability index

Data collection

Physical baseline data were measured in a test-laboratory by the assessor and baseline questionnaires were filled in at the participant’s home and were handed in before the test occasion. Data were followed up 3, 9 and 15 months after start of an 11-weeks long intervention. A work visit for measurements of physical (Quick Exposure Check – QEC) [89, 90] and psychosocial work exposure (The Nordic Questionnaires for psychological and social factors at work – QPS Nordic [91]), stress at work (QEC) and perceived stress level [92] was performed one week after end of intervention and assessed by an experienced ergonomist. A flow chart of the recruitment, group allocation and participation of the RCT (paper 2)

and work visit (paper 3) is presented in figure 3 and overview of analysed data is presented in table 3.

Table 3 Overview of outcome measures

	Assessment	Paper 2	Paper 3	Paper 4
Neck pain (NRS)	Questionnaire	X	X	X
Neck disability (NDI)	Questionnaire	X	X	X
Neck symptoms (ProFitMap-neck)	Questionnaire	X		X
General improvement (PGICS)	Questionnaire	X		
Work productivity	Questionnaire	X	X	
Pain pressure threshold (PPT)	Laboratory assessment	X		
Physical work load (QEC)	Observation at work		X	
Psychosocial work load (QPS Nordic)	Questionnaire		X	
Stress at work (QEC)	Questionnaire		X	
Perceived stress level	Questionnaire		X	
Cervical flexibility	Laboratory assessment			X
Cervical strength	Laboratory assessment			X
Lifting capacity (C-PILE)	Laboratory assessment			X
Sensorimotor control (Peak-Speed)	Laboratory assessment			X

NRS; *numeric rating scale*, NDI; *neck disability index*, ProFitMap-neck; *Profile Fitness Mapping neck questionnaire* PGICS; *patient global impression of change scale*, QEC; *quick exposure check*, QPS Nordic; *The Nordic questionnaires for psychological and social factors at work*, C-PILE; *cervical- progressive isoinertial lifting evaluation*

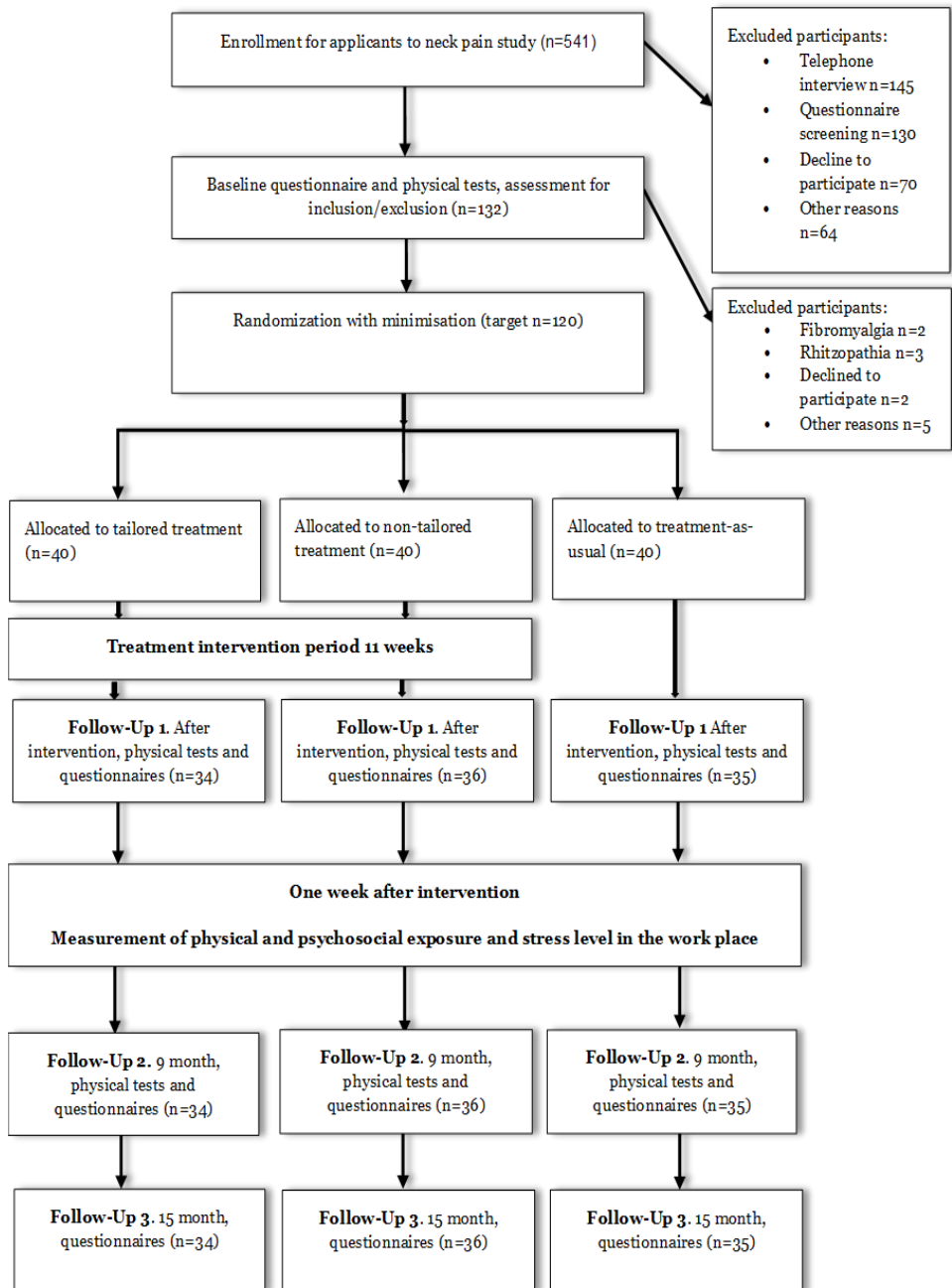


Figure 3 Flow chart of the recruitment, group allocation and participation of the RCT.

Baseline questionnaire

Neck pain

Neck pain was measured with an 11-point Numeric rating scale (NRS: 0-10) that included one single question about average pain intensity the last week between 0 “no pain” to 10 “worst pain imaginable” [93]. The NRS is a reliable and valid method [94] and the smallest clinical important pain reduction in NRS is approximately 15% [95].

Neck disability

Neck disability was assessed with a questionnaire, NDI [87]. This consists of ten items that cover pain intensity, personal care, lifting, car driving, reading, work, and symptoms like headache and concentration. The scores range from 0 to maximum 50 and can also be expressed as percentage 0-100%. In this thesis, NDI % is used. Higher score mean more disability. Disability levels described by Vernon [96] are as follows: 0-4 (0-8 NDI %) = none; 5-14 (10-28 NDI %) = mild; 15-24 (30-48 NDI %) = moderate; 25-34 (50-68) = severe; over 34 (68 NDI %) = complete. With regard to responsiveness minimal important change for NDI is reported to be 6-10 % for non-specific neck pain [96]. The NDI is highly reliable and has a strong and well-documented validity [96].

Symptoms

The ProFitMap-neck is a neck specific questionnaire that assess symptoms, (intensity and frequency indices) and functional limitations [97]. The index scores are normalized to 0-100 with higher scores reflecting less symptoms/better health. The responsiveness for minimal important change for ProFitMap-neck is reported to be 7-14%. The ProFitMap-neck has shown high reliability and validity [97, 98].

General improvement

General improvement was assessed with PGICS [93], which is a single question for an estimate of change compared to before the intervention. The scale has 7 points from 1= “very much improved” to 7= “very much worse”.

Work productivity

The self-reported work productivity was assessed with two single questions of the impact of neck symptoms on the quality and quantity of performed work the latest six weeks [88]. The response scale was 0-10, with 10 equal to working as usual.

Laboratory assessment

The tests chosen were used to capture specific functional or physical limitations and/or conditions (trapezius myalgia and cervicogenic headache).

Cervical flexibility

Cervical flexibility, figure 4A, was tested in active range of motion (ROM) in a seated position with the upper body 4-point belted and eyes closed [48]. An electromagnetic tracking system (FASTRAK®, Polhemus Inc.) was used to measure cervical sagittal extension and flexion from a neutral head position, axial rotation, protraction and retraction (not used in this thesis), and a combined movement of maximal forward neck flexion and axial rotation. The last ROM test, combined flexion and rotation was passively imposed by the test leader. The ROM in the upper and lower cervical parts during extension and flexion were recorded separately in a three-segment model [48]. The instructions were standardized and read out from a speaker. Outcomes were maximal range of motion (degrees).



A

B

C

Figure 4 Cervical flexibility and strength test: A) ROM tests in an electromagnetic tracking system (FASTRAK®, Polhemus Inc); B) isometric strength with cervico-thoracic flexion and extension test; C) isometric strength and endurance with cranio-cervical flexion test.

Cervical muscle strength and endurance

Isometric strength with cervico-thoracic flexion (CTF) and extension (CTE) test, figure 4B, were tested with participants in a seated position and with wide belts around the chest and waist [99]. A bar with a force cell was placed against the participant's forehead for flexion strength and against the occiput for extension strength. Outcomes were maximal strength values in Newton (N). Isometric strength and endurance, figure 4C, of cranio-cervical flexors (CCF) were tested in a standing position with the body secured by wide strips around the chest and waist. An application pad was positioned under the mandible and participants were instructed to push against the pad as if performing a “nod” with the head.

Torque was recorded in Newton-meters (Nm). The protocol was based on that of O'Leary et al. [100] in conformity with Van Wyk et al. [101]. The test leader gave instructions and encouraged participants to do their best.



A

B

Figure 5 Lifting capacity and pain pressure on trapezius: A) Dynamic lifting task called Cervical-Progressive Isoinertial Lifting Evaluation (C-PILE); B) Pain pressure thresholds (PPT) on the upper part of trapezius.

Lifting capacity

Lifting capacity, figure 5A, was measured by a dynamic lifting task from the waist to shoulder height, C-PILE [47]. Maximal lifting capacity was measured in maximal lifted kilogram divided by the participant's weight. To minimize the effects of participant's body under or over weights, a formula called "adjusted weight" according to Mayer et al [47] was used.

Cervical sensorimotor control

This was a test of maximal speed of cervical axial rotation measured in degrees per second. This was performed in the same setup as the test for cervical flexibility and was measured by FASTRAK® [102]. The subject sat with the head in a neutral position and waited for a sound that indicated the start of a fast axial rotation to the right or left.

Pressure pain thresholds (PPT)

The pressure pain thresholds, figure 5B, was measured using an algometer to quantify muscle tenderness (kPa) on the upper trapezius muscle. The procedure started with a pressure pain test of the left arm lateral epicondyle for acquaintance with the test procedure. After that the measure of upper trapezius muscle was at a point in the middle between processus spinosus C7 and acromion. Finally, a reference PPT was measured at the middle of the tibialis anterior bilaterally.

Clinical examination

The baseline assessment included a clinical examination by a physiotherapist for eventual symptom diagnostic of trapezius myalgia and cervicogenic headache, which have empiric and/or theoretic support for specific treatment. The diagnostic of trapezius myalgia was according to a standardized examination protocol of the neck [103] with amendments of trapezius myalgia criteria [104]. The diagnostic of cervicogenic headache was according to criteria of Cervicogenic Headache International Study Group [105] with amendments of reduced ROM in the upper cervical segments and palpable upper cervical facet-joints dysfunction [106].

Physical and psychosocial work environment

As mentioned above an experienced ergonomist visited the participant work-places after the end of intervention to measure physical and psychosocial work exposure. *The physical work exposure* was measured with an observation instrument called Quick exposure check (QEC) [89]. The most common work task defined by the participant was observed. According to the QEC instrument, physical factors like participant's posture, frequency of bent or rotated head, hand position and shoulder/arm movements were registered. The instrument also included a self-rated portion and participants estimated how many hours per day they performed the observed work task, whether the task was visually demanding, and if they worked with tools the maximum weight of these. The QEC has shown good validity and moderate repeatability in similar contexts [89, 90]. For assessment of *psychosocial work exposure* a questionnaire, The Nordic questionnaires for psychological and social factors at work (QPS Nordic), [91] was used. This questionnaire included 36 questions in seven different fields – quantitative demands, decision demands, learning demands, control of decision, control of work pacing, support from superior, and support from co-workers. The response scale ranged from 1-5 (1= “very seldom or never”, 5= “very often or always”), and an index score was calculated for each scale by summing the answers from the individual questions and then dividing by the number of questions. The QPS Nordic is a psychometrically tested questionnaire and is considered to be of good quality [91].

Stress at work and perceived stress level

For assessment of perceived stress, the following single question was answered [92]: “Stress means a situation in which a person feels tense, restless, nervous or anxious or is unable to sleep at night because his/her mind is troubled all the time. Have you felt this kind of stress during the last month?” The response alternatives ranged from 1= “not at all” to 5= “very much”. To measure if participants experienced their job as stressful, a specific question from the Quick Exposure Check (QEC) assessment was answered; “In general, how do you find

your job?” The response scale ranged from 1= “not at all stressful” to 4= “very stressful”.

Randomization

The RCT randomization was accomplished with minimization [107, 108] to assert balance between groups on the factors age, duration of pain, neck pain last week (NRS) and neck disability (NDI). The minimization was performed using a computer program administrated by a technician, not involved in the recruitment or data collection. An independent administrator informed the participants to which of three groups they were allocated, i.e. tailored treatment (TT), non-tailored treatment (NTT) or treatment as usual (TAU).

Intervention

Participants in the TAU group did not receive any treatments within the study and no restrictions were given to seek care themselves. Participants in the TT and NTT groups received 11 weeks of intervention, 2-3 times per week (27 sessions in total). The physiotherapists, two men and two women, had additional education in manual therapy and were experienced in treating musculoskeletal disorders. They received 12 hours education within the study before the intervention for familiarization with the trial procedures. The physiotherapists treated participants in both groups and were not blinded for treatment group (unfortunately this was not possible). However, group allocation and study hypothesis were concealed for the participants. All interventions took place in Umeå, Sweden, in two clinics built up for the study. At the start the participants could choose clinic out of most practical for them.

Decision model for treatment

The aim with the decision model was to capture each participant’s specific physical or functional limitations and/or conditions like trapezius myalgia or cervicogenic headache for the sake of identify appropriate treatment components. For this, cut-off values for impairment, based on empirics and own reference data, were decided in the test of cervical flexibility, muscle strength/endurance, lifting capacity and sensorimotor function, respectively. The selected tests, cut-off criteria and rationale for cut-off are presented in table 4. In brief, the decision models rationale for cut-off was decided at a minimum of 20% below reference data (non-symptomatic controls) thus avoiding > 40% of positive tests predicted by reference data from a parallel study (women with neck pain) [109] and to give precedence to a high specificity before high sensitivity. For cervical strength, the sub-factor *arm strength in lifting task* was complemented with participants’ subjective rating; this was also the case for sensorimotor control sub-factor *symptoms and activity limitations*. The reason for this was

Table 4 Decision model for selecting tailored treatment

<i>Main and sub-factors</i>	<i>Tests and questions</i>	<i>Cut-off criteria</i>	<i>Rationale for cut-off</i>
1. Cervical mobility	1.1	1.1	1.1
1.1 Range of motion, upper cervical	a) Flexion-extension	a) < 68°	a) 20% below reference values of normative control data [48] resulting in 97% specificity.
	b) Passive rotation in maximal flexed position	b) < 32° Qualifier: Either a) or b)	b) 18-29% below reference values of normative control data [110-112]. Also discriminating cut off for cervicogenic headache.
1.2 Range of motion, lower cervical	1.2	1.2	1.2
	Flexion-extension	< 17°	35% below reference values of normative control data [48] resulting in 94% specificity.
1.3 Range of motion, upper and lower cervical	1.3	1.3	1.3
	Axial rotation	< 109°	20% below reference values of normative control data [48] resulting in 97% specificity.
2. Cervical muscle strength-endurance and functional strength	2.1	2.1	2.1
2.1 Cranio-cervical flexion test	a) Maximal voluntary contraction (MVC)	a) < 2.5 Newton meter (Nm)	a) Empirical experience, value indicating clear impairment (Shaun O’Leary, personal com.)
	b) Endurance (50% MVC)	b) < 20 sec Qualifier: Either a) or b)	b) 88, 5% specificity based on normative control data (unpublished data).
2.2 Cervico-thoracic test	2.2	2.2	2.2
	a) Flexion MVC	a) < 40 Newton (N)	a) 95% specificity according to data simulation based on [99, 113].
	b) Extension MVC	b) < 140 N Qualifier: Either a) or b)	b) 95% specificity according to data simulation based on [99, 113].
2.3 Lifting ability	2.3	2.3	2.3
	a) Cervical Progressive Isoinertial lifting evaluation test (C-PILE).	a) Max weight / adjusted body weight: <0.12 kg/kg	a) Cut-off to discriminate between neck pain and healthy: Specificity 81% [45].
	b) Subjective rating of the ability to carry and to lift on a scale 1-6;	b) At least answer “rather bad, rather difficult” on the questions “Because of your neck	b) Specificity data N/A. Chosen cut-off renders 47% of women with neck pain positive.

	1= Very good, 6= Very bad	problems, how do you manage to carry/lift?" (≥4) Qualifier: a) and b)	
3. Sensor-motor control	3.1.	3.1	3.1
3.1 Symptoms and activity limitations	Combinations of: - Dizziness or balance disturbances - Headache associated to neck problems - Difficulties to rotate the head due to neck problems Questionnaire with scale 1-6;	a) Rather strong/often dizziness or balance disturbances: (≥4 on both questions) b) Light dizziness or balance disturbances (3 on both questions, or >3 on one) and headache associated to neck problems (but not cervicogenic headache) c) Light dizziness or balance disturbances and, due to neck problems, difficulties to rotate the head (≥4) Qualifier: Either a) or b) or c)	a) Prediction 11%. b) or c) Prediction 30%. To predict the number of positive cases for the combinations in a), b) and c) we used own non-published data.
	3.2	3.2	3.2
3.2 Peak speed of cervical rotation	Peak speed of cervical axial rotation.	< 170°/sec	50% below reference control data giving 97% specificity [53].
4. Trapezius myalgia	a) Physiotherapy assessment b) Pain pressure threshold, upper trapezius muscles	a) Criteria according to Ohlsson and co-workers with amendments. b) < 175 N right trapezius, < 168 N left trapezius Qualifier: a) and b)	a) Specificity N/A. b) 20% below reference values of nonspecific neck pain subjects without trapezius myalgia. The combination predict 40% positive tests (non-published data)
5. Cervicogenic headache	a) Physiotherapy assessment b) Range of motion, passive rotation in maximal flexed position	a) Criteria of the Cervicogenic Headache International Study Group with amendment. b) < 32°, see above, range of motion upper cervica Qualifier: a) and b)	a) Specificity N/A b) 18-29% below reference values of normative control data [110-112]

that from a clinical perspective we thought it was important to combine physical capacity and subjective rating for these factors. The sub-factor *cranio-cervical flexion test* was a test of strength and endurance. This test was created with personal communication with Shaun O' Leary, a researcher at the University of Brisbane, Australia. The cut-off values were set from empirical experiences from O' Leary and a pilot study on healthy women at our laboratory.

The decision model included two symptom based diagnoses, trapezius myalgia and cervicogenic headache. The trapezius myalgia diagnosis was complemented with the measurement of pain pressure threshold of the upper trapezius muscle. This was done to sharpen and objectify the criteria. The cervicogenic headache diagnosis was complemented with amendment from Jull et al. 2007 [106], e.g. reduced ROM for the upper cervical levels and palpable upper cervical joint dysfunction.

Tailored treatment (TT)

Treatment components were assigned to impairments captured in the decision model algorithm, the components are presented in table 5. Participants were to receive at least two components. For more details about the rules see Björklund et al. [114]. In a structured interview called Problem Elicitation Technique (PET) [115], specific problems and complains were defined and a goal set followed up later. The interview could lead to additional treatment components if clearly indicated. If the trapezius myalgia or cervicogenic headache symptom based diagnoses were obtained, pre-decided treatment components were assigned. Participants could be assessed by an optician if they regularly performed visually demanding near work. At the latter half of the intervention time, the treatment program was complemented with functional training of daily activities relevant to individual needs as determined in the PET interview. The purpose for this was to use new motor learning in other tasks and contexts according to principles of motor learning theory, retention and transfer [116].

Non-tailored treatment (NTT)

Treatment components were assigned to impairments *not* captured in the decision models algorithm. Participants received two components. For more details about the decision models rules see Bjorklund et al. [114]. At the start of the intervention was a formal anamnesis performed by the physiotherapist and like the TT group a goal set. At the latter half of the intervention time, the treatment program was complemented with a set training program with complex movement exercises called "Muscle Action Quality (MAQ) training [117]. The purpose was to add functional training like in the TT group but not tailor to impairments.

Table 5 Treatment categories with treatment components

1; Reduced cervical mobility
Manual therapy including ROM-mobilization and exercises. 1.1; upper cervical 1.2; lower cervical 1.3; upper and lower cervical, axial rotation
2; Impaired cervical strength-endurance and functional strength
2.1; Specific exercise program that included endurance, motor control and posture correction training [43, 118]. 2.2; High intensive strength training for neck muscles 2.3; Lifting capacity, strength training for shoulder-arm muscles. Both 2.2 and 2.3 were designed according to Ylinen et al. and the American College of Sports Medicine [119, 120].
3; Impaired cervical sensorimotor control
3.1; Cervical repositioning/movement control and oculomotor exercises. The program was based on the work of Kristjansson and Treleaven [121, 122] and included a protocol with exercises and progressions for exercise duration, number of repetitions, movement speed and introduction of unstable support. Exercises were set at a challenging level and temporary reproduction of dizziness or visual disturbances was allowed but not reproduction of head or neck pain. 3.2; Improving the ability to perform fast cervical rotations and quick head movements in different planes and trajectory lengths guided by light flashes.
4; Trapezius myalgia
EMG-biofeedback treatment program for the upper trapezius and eight standardized exercises with gradual progression of difficulty level. This was followed by exercises in specific tasks individualized for each subject in the tailored group. The aim of the EMG-biofeedback training program was to increase awareness of muscle tension in the upper trapezius muscles both in resting positions and in static and dynamic tasks.
5; Cervicogenic headache
Manual therapy including mobilization and ROM exercises for the upper cervical spine, craniocervical flexion (CCF) exercises and low-load endurance training for the lower trapezius and serratus anterior, as well as correction of scapular posture. The treatment was guided by current best evidence [123, 124].

Statistical analyses

Paper 2:

The hypothesis in this paper was that tailored treatment (TT) was more effective than non-tailored treatment (NTT) and both treatments were more effective than treatment-as-usual (TAU). This was tested with linear mixed-effect models. To evaluate treatment effects, separate models for each primary and secondary outcome were made with independent fixed factors *time* (3, 9 and 15 months after start of intervention, baseline was reference) and *group* (TT, NTT, TAU). Participants were included in the model as a random effect. Treatment effect was defined as the differences between group changes from baseline to follow-ups.

Paper 3:

Associations between outcomes (pain, disability and work productivity) and work exposure were first evaluated at the time of acquisition, 3 months after baseline (start of intervention). Confounding variables were determined *a priori* and age and pain duration were considered potential confounders based on previous studies [125]. Univariate associations between outcomes, confounders and exposure levels of potential risk factors were estimated using linear regression for the outcome neck disability and using log-linear regression for the outcomes neck pain and work productivity. Based on univariate analyses, candidate risk factors with p-values <0.25 were included in a multiple model estimating associations with each risk factor while considering exposure levels of other selected risk factors and confounders. Thereafter a backwards stepwise approach was used to identify the important risk factors among those that were of importance in univariate analyses. The p-value limit in the stepwise procedure was 0.25. The correlations between potential risk factors were calculated to assess potential multicollinearity. Secondly, longitudinal assessment was conducted using the risk factor exposure level at 3 months after baseline as predictor of outcomes at 3 months, 9 months, and 15 months, respectively. Mixed models were used to estimate longitudinal associations, accounting for within individual correlation of repeated outcome measures by incorporation of a random intercept. Multiple modelling was performed using the same method for variable selection as described for the cross-sectional analyses. In these longitudinal models, interaction terms between time and risk factors were excluded before their corresponding main effects.

Paper 4:

Associations between self-rated neck problems and physical test outcomes were evaluated at baseline. Univariate associations between outcomes, and adjusted for confounders, were estimated using linear regression. Confounding variables

were determined *a priori*. Age and physical activity were considered potential confounders based on previous studies [125]. Associations between changes in scores of self-rated neck problems and physical test outcomes were evaluated at 3 and 9 months. The change in score, Change-scores, for variable X was defined as $X_{3 \text{ months}}$ or $X_{9 \text{ months}}$ minus X_{baseline} divided with X_{baseline} . Univariate associations between Change-scores were estimated using linear regression and log-linear regression for the outcome neck pain. Based on univariate analyses, candidates with p-values <0.25 were included in a multiple model. Thereafter a backwards stepwise approach was used to identify the associations among those that were of importance in univariate analyses. The p-value limit in the stepwise procedure was 0.1. The correlations and variance inflation factor (VIF) between outcomes and physical performance tests included in the final model were calculated to assess potential multicollinearity.

Sample size determination and power calculations

Sample size determination was done before the RCT and was calculated for treatment effects of neck disability (NDI), and average pain intensity in the last week (NRS). Calculations were performed with one-way analysis of variance (ANOVA) (nQuery Advisor 3.0). Reference data from a parallel clinical trial [48] showed that the NDI standard deviation (SD) was 10.3 % (based on 117 women with neck-shoulder pain). The clinically important difference for the NDI is considered between 6–10 % [96]. Given a difference on NDI of 6 % between any of the three groups, power of 0.8 required a minimum of 20 participants per group (alpha = 0.05). The smallest clinical important pain reduction in NRS is approximately 15% [95]. In the parallel clinical trial, the SD was 15.5 %. Given these facts, 20 participants per group yield a power of >0.8 for a NRS difference of 15 % between any of the three groups (alpha = 0.05). We were conservative and recruited 40 participants per group, to account for any loss to follow-up and to improve the robustness of results.

Results

A total of 541 women enrolled for participation in this thesis studies and 120 women was finally included. The flow of participants, follow-ups and work place visit, are shown in figure 3, method section. The baseline characteristics and self-rated neck problems of women included are presented in table 6.

Table 6 Baseline characteristics and self-rated neck problems of all included participants (n=120), mean values and standard deviation.

	Mean (SD)
Age (years)	47 (11.5)
Weight ^a (kilogram)	65 (60-74)
Height (centimeter)	166 (5.6)
Pain duration ^a (months)	60 (24-124)
Physical activity (1-6) ^{a,b}	4.5 (4-5)
Pain last week, NRS (0-10)	4.6 (1.8)
Neck disability, NDI (0-100)	23.5 (8.6)
Symptoms (frequency) ProFitMap-neck (0-100)	66.0 (12.6)

a Median and first and third quartiles; b Physical activity, scale 1-6, 1-2=low, 3-4=medium, 5-6=high [126]; , NRS; *numeric rating scale, average pain intensity last week*, NDI; *neck disability index*; ProFitMap-neck; *profile fitness mapping neck questionnaire SD standard deviation*

The study protocol (paper 1)

The study protocol was mainly an extensive literature search to create the theoretical evidence based decision model with connected treatments for women with non-specific neck pain. Also, generation of the decision model entailed comparisons and calculation of sensitivity and specificity from reference data in order to determine cut-off values (see Methods).

The randomized controlled treatment trial (paper 2)

The hypothesis of the RCT was that women with neck pain would benefit more from TT than NTT. The hypothesis was rejected, the only outcome to favor TT over NTT was improvement in work productivity at 9- and 15- months follow-up, but the differences between groups were small (tables 7 and 8). The RCT's second hypothesis that TT and NTT both would have better effects than TAU was supported at the short-term follow-up (3 months). The absolute within-group differences for neck disability, NDI% was: TT, -7; NTT, -10; TAU, -0, 75 and for neck pain, NRS points: TT, -1,9; NTT, -2,0 and TAU -0,75. The only 9- and 15-month follow-up differences between treatment groups and control group was in self-estimated general improvement, PGICS (table 8). However neck disability in one of the treatment groups, the NTT-group, was significantly improved compared to TAU-group at the 15- month follow-up (table 7).

After baseline measurement, the decision model resulted in positive tests of sub-factors as shown in figure 6. (Note however, that only TT was given the corresponding treatment components). The similar distribution of positive tests between groups indicate that groups were equally limited in function. The frequency of positive tests differed largely between the sub-factors, with reduced lower cervical ROM as the most common and reduced lifting capacity as most uncommon (61% and 2% positive tests, respectively). The symptom diagnosis cervicogenic headache was noted for 8 (7%) women and trapezius myalgia for 42 (43%) women with non-specific neck pain.

Table 7 Descriptive statistics of primary outcomes measured at baseline, 3 months, 9 months and 15 months after start of intervention and treatment effects as changes from baseline compared between groups.

Primary Outcomes	TT Estimated mean (SD)	NTT Estimated mean (SD)	TAU Estimated mean (SD)	TT vs NTT Effects ^b (95%CI)	TT vs TAU Effects ^b (95%CI)	NTT vs TAU Effects ^c (95% CI)
NRS (0-10)						
Baseline	4.55 (2.08)	4.57 (2.08)	4.72 (2.08)			
3 months	2.62 (2.04)	2.56 (2.04)	3.97 (2.04)	-0.09 (-0.48 to 1.5)	1.17 (0.15 to 2.19)*	1.26 (0.27 to 2.25)*
9 months	2.85 (2.04)	3.31 (2.04)	3.5 (2.07)	0.43 (-1.55 to 2.41)	0.47 (-0.52 to 1.46)	0.04 (-0.95 to 1.03)
15 months	3.06 (2.04)	2.85 (2.04)	3.6 (2.07)	-0.24 (-2.22 to 1.74)	0.41 (-0.58 to 1.4)	0.65 (-0.34 to 1.64)
NDI (0-100)						
Baseline	21.84 (10.18)	24.39 (10.18)	24.18 (10.05)			
3 months	14.62 (9.85)	14.39 (9.96)	21.74 (9.93)	-2.78 (-6.85 to 1.29)	4.78 (0.67 to 8.89)*	7.56 (3.49 to 11.63)***
9 months	14.84 (9.85)	16.61 (9.96)	19.65 (9.93)	-0.78 (-4.87 to 3.31)	2.47 (-1.64 to 6.58)	3.25 (-0.82 to 7.32)
15 months	15.20 (9.85)	13.80 (9.96)	17.99 (9.94)	-3.95 (-8.02 to 0.12)	0.45 (-3.64 to 4.54)	4.40 (0.35 to 8.45)*

TT tailored treatment, NTT non-tailored treatment, TAU treatment as usual group, vs versus, SD standard deviation, CI confidence interval, NRS Average pain intensity last week, NDI neck disability index; b Positive values of effects favor the tailored group; c Positive values of effects favor the non-tailored group; * comparison is significant at the 0.05 level. ** comparison is significant at the 0.01 level. *** comparison is significant at the 0.001 level.

Table 8 Descriptive statistics of secondary outcomes measured at baseline, 3 months, 9 months and 15 months after start of intervention and treatment effects as changes from baseline compared between groups.

Secondary Outcomes	TT Estimated mean (SD)	NTT Estimated mean (SD)	TAU Estimated mean (SD)	TT vs NTT Effects ^b (95%CI)	TT vs TAU Effects ^b (95%CI)	NTT vs TAU Effects ^c (95%CI)
ProFitMap-neck, intensity	71.6 (11.3)	71.5 (11.3)	70 (11.3)			
Baseline						
3 months	79.6 (11.0)	80.8 (11.1)	72.0 (11.0)	-1.3 (-3 to 5.6)	5.9 (1.5 to 10.2)**	7.2 (2.8 to 11.5)**
9 months	78.4 (11.0)	81.4 (11.1)	75.91(11.2)	-3.0 (-1.22to 7.4)	0.9 (-3.4 to 5.3)	4.1 (-0.3 to 8.3)
15 months	78.5 (11.0)	82.1 (11.2)	76.9 (11.1)	-3.6 (-0.6 to 7.98)	-0.1 (-4.4- 4.2)	3.5 (-0.7 to 7.8)
ProFitMap-neck, frequency	66.0 (14.6)	67.7 (14.6)	64.0 (14.6)			
Baseline						
3 months	78.1 (14.0)	78.6 (14.2)	67.2 (14.1)	1.2 (-3.9 to 6.3)	8.9 (3.7 to 14.2)***	7.7 (2.5 to 12.9)**
9 months	75.7 (14.0)	76.0 (14.2)	71.4 (14.2)	1.3 (-3.7 to 6.5)	2.3 (-2.8 to 7.5)	0.98 (-4.1 to 6.1)
15 months	75.7 (14.0)	78.7 (14.3)	72.8 (14.2)	-1.2 (-6.4 to 3.9)	0.9 (-4.2 to 3.6)	2.1 (-2.9 to 7.3)
PGICS 3 months	2.2 (1.1)	2.2 (1.1)	3.6 (1.1)	0.01 (-0.5 to 0.5)	1.4 (1.0 to 2.0)***	1.45 (0.9 to 2.0)***
9 months	2.5 (1.2)	2.5 (1.1)	3.1 (1.2)	0.04 (-0.5 to 0.6)	0.8 (0.3 to 1.3)**	0.8 (0.4 to 1.3)***
15 months	2.5 (1.2)	2.5 (1.1)	3.2 (1.18)	-0.005 (-0.5 to 0.5)	0.8 (0.3 to 1.2)**	0.8 (0.3 to 1.2)**
PPT right	223.4 (102.7)	209.8 (102.7)	209.2 (102.7)			
Baseline						
3 months	251.6 (99.4)	237.0 (100.4)	203.3 (100.2)	1.0 (-38.3 to 40.4)	34.1 (-6.0 to 74.2)	33.0 (-6.6 to 72.7)
9 months	251.5 (100.1)	263.0 (100.5)	228.3 (102.2)	-25.1 (-65.7 to 14.5)	8.9 (-31.4 to 49.2)	34.0 (-5.6 to 73.7)
PPT left	218.0 (95.8)	204.9 (95.8)	212.2 (95.8)			
Baseline						
3 months	247.5 (93.2)	223.4 (94.1)	197.3 (94.2)	11.0 (-28.8 to 50.8)	44.4 (3.7 to 85.2)*	33.4 (-6.6 to 73.5)

9 months	244.8 (94.1)	243.6 (93.5)	224.5 (95.6)	-11.9 (- 52.0 to 28.0)	14.4 (- 26.3 to 55.2)	26.4 (-13.6 to 66.5)
WP Quantity Baseline ^d	8.5 (1.5)	8.7 (1.5)	7.9 (1.5)			
3 months	9.2 (1.6)	9.1 (1.5)	8.9 (1.5)	0.3 (-0.4 to 1.1)	-0.2 (-1.1 to 0.6)	-0.6 (-1.5 to 0.2)
9 months	9.6 (1.6)	9.2 (1.6)	8.9 (1.5)	0.6 (-0.2 to 1.4)	0.1 (-0.8 to 0.9)	-0.6 (-1.2 to 0.2)
15 months	9.8 (1.6)	9.1 (1.6)	9.5 (1.5)	0.9 (0.1 to 1.8)*	-0.3 (-1.1 to 0.5)	-1.3 (-2.1 to -0.5)**
WP Quality Baseline ^e	7.4 (1.8)	8.3 (1.9)	7.5 (1.9)			
3 months	8.8 (1.9)	9.1 (1.8)	8.6 (1.7)	0.6 (-0.3 to 1.5)	0.3 (-0.6 to 1.2)	-0.3 (-1.2 to 0.6)
9 months	9.2 (1.9)	9.0 (1.8)	8.52 (1.8)	1.1 (0.2 to 2)*	0.8 (-0.2 to 1.7)	-0.3 (-1.2 to 0.6)
15 months	9.4 (1.9)	9.1 (1.8)	9.1 (1.8)	1.2 (0.2 to 2.1)*	0.3 (-0.6 to 1.3)	-0.8 (-1.7 to 0.1)

TT tailored treatment group; NTT non-tailored treatment group; TAU treatment as usual group; vs versus; SD standard deviation; CI confidence interval; PGICS patient global impression of change scale (1-7); PPT pressure pain threshold; WP work productivity (0-10); b Positive values of effects favor the tailored treatment group; c Positive values of effects favor the non-tailored treatment group; d TAU, significant lower ($p < 0,05$) than NT; e TT, significant lower ($p < 0,05$) than NTT; * comparison is significant at the 0,05 level, ** comparison is significant at the 0,01 level, *** comparison is significant at the 0,001 level.

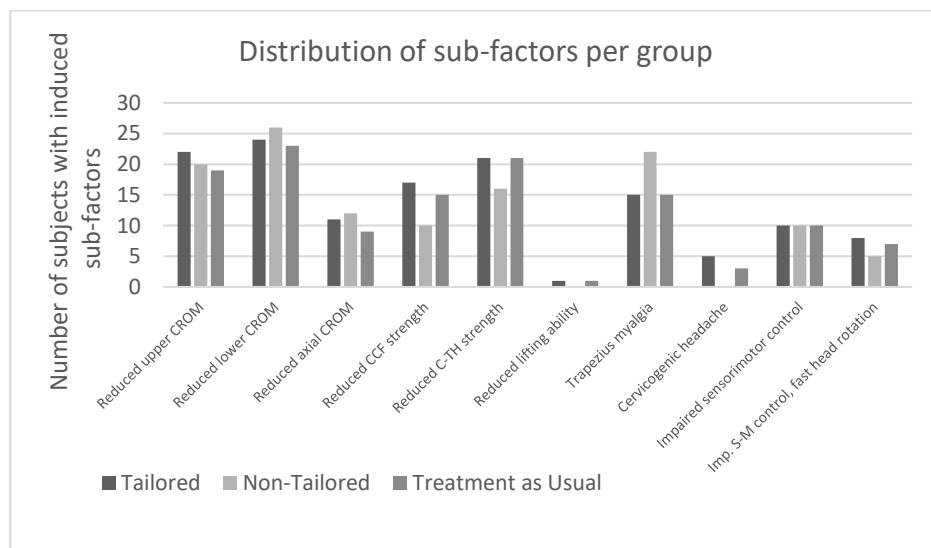


Figure 6 Distribution of positive tests at baseline of sub-factors in the decision model for the 120 women with non-specific neck pain included in the RCT.

Workplace exposure and stress (paper 3)

This study included 97 women with non-specific neck pain, close after the treatment intervention (n=67 treatment group, TT and NTT, and n=30 TAU group). All except one (reason not known) accepted a workplace visit where physical and psychosocial work exposure and stress levels were measured. Figure 7 shows the employers of participants and type of work they performed. None of the participants were on full-time sick-leave, and full-time work, 40 hours per week, was the most common.

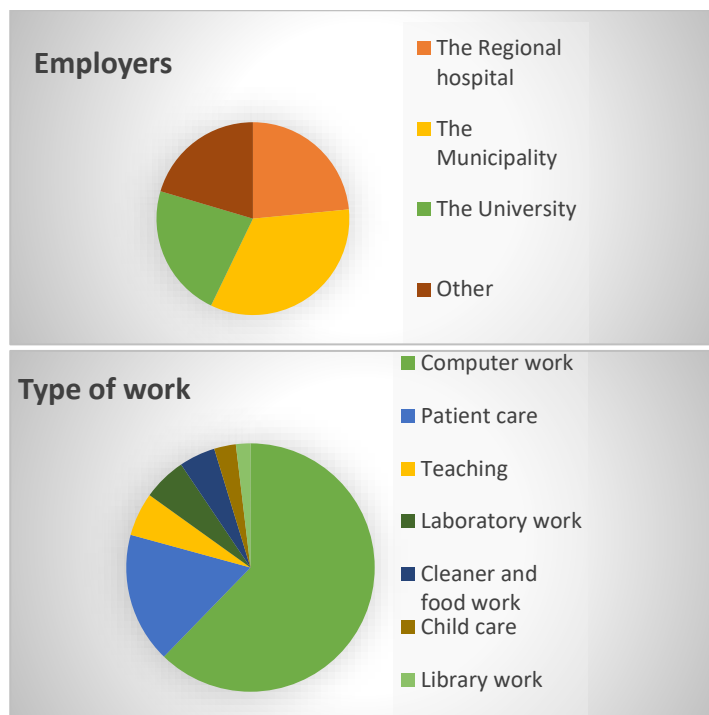


Figure 7 Distribution of different employers and type of work.

The results from the physical (QEC) and psychosocial (QPS Nordic) work exposure and stress levels measurements are presented in table 9. The tailored and non-tailored groups were pooled to one treatment group because of the equal effects from the RCT. Since, there was only small differences between the treatment group and TAU in work exposure and stress (table 9), all participants were further analyzed in one group, i.e. treatment and TAU together. The main results from the longitudinal univariate associations was that increased perceived general stress and job stress had associations to increased neck pain (NRS) and neck disability (NDI) and decreased work productivity (quality) at 3- 9- and 15-month follow ups, table 10 and 11. The psychosocial factor *quantitative demands*

had positive associations to neck pain (NRS) at the 9-month follow-up. Decreased *control of decision* had associations to increased neck disability (NDI) at 3- 9- and 15- month follow-ups and to decreased work productivity, quantity and quality at the 3-month follow-up. A significant but low association was found between increased shoulder/arm load and decreased work productivity, quantity. The multiple regression analyses, cross-sectional and longitudinal, found that high perceived stress and low *control of decision* were the most important risk factors for more neck pain and neck disability and less work productivity direct after an intervention and in follow-ups. Between treatment and TAU was only small differences observed.

Table 9 Physical and psychosocial work exposure and stress levels, presented as mean values and standard deviations. n represents the numbers of participants. For variables that had a skewed distribution the median and the first and third quartiles are presented (indicated with*).

Work exposure	Treatment group	TAU
	Mean (SD) (n=67)	Mean (SD) (n=30)
Neck load * (score range 4-18)	16 (14-16)	16 (13.5-16)
Shoulder/arm load * (score range 10-56)	26 (22-32)	26 (26-34)
Quantitative demands (score range 1-5)	3.0 (0.6)	2.9 (0.6)
Decision demands (score range 1-5)	3.3 (0.6)	3.3 (0.7)
Learning demands (score range 1-5)	2.5 (0.5) ^a	2.4 (0.7)
Control of decision (score range 1-5)	2.9 (0.7)	2.9 (0.8)
Control of work pacing (score range 1-5)	3.3 (1.1)	3.2 (1.2)
Support from superior (score range 1-5)	3.7 (0.8) ^a	3.7 (0.8)
Support from co-workers (score range 1-5)	4.0 (0.7) ^a	4.2 (0.8)
Job stress (score range 1-4)	2.5 (0.8)	2.6 (0.9)
Perceived stress (score range 1-5)	2.4 (1.0) ^a	2.6 (1.1) ^b

^a(n=66), ^b(n=29), SD standard deviation; TAU treatment-as-usual group

Table 10 Longitudinal univariate associations between exposures (physical, psychosocial, stress), confounders (pain duration, age) and outcomes (neck pain, neck disability)

	Neck Pain (NRS) ^a			Neck Disability (NDI)		
	Change (95% CI) for one unit increase in exposure			Slope estimate(95%CI)		
	3 -month	9 -month	15-month	3-month	9-month	15-month
Neck load	3%(-16; 8%)	4% (-1; 9%)	2% (-3; 6%)	0.5 (-0.3; 1.3)	0.5 (-0.3; 1.4)	0.3 (-0.5; 1.1)
Shoulder/arm load	0.3% (-1; 2%)	-1% (-2; 1%)	-1% (-2; 1%)	-0.09 (-0.4; 0.2)	0.02 (-0.3; 0.3)	-0.01 (-0.3; 0.3)
Quantitative demands	10% (-8; 32%)	22% (2; 46%)*	6% (-12; 27%)	1.9 (-1.2; 5.1)	3.1 (-0.1; 6.3)	1.8 (-1.3; 5)
Decision demands	14% (-5; 36%)	3% (-14; 23%)	2% (-15; 22%)	2.3 (-0.8; 5.5)	0.4 (-2.7; 3.6)	1.4 (-1.8; 4.6)
Learning demands	-9% (-26; 13%)	1% (-8; 25%)	-3% (-22; 21%)	0.14 (-3.5; 3.8)	2.1 (-1.5; 5.9)	3.2 (-0.5; 7.1)
Control of decision	-14% (-27; 1%)	-7% (-21; 9%)	-13% (-26; 2%)	-4.2 (-7.0; -1.5)**	-3.9 (-6.6; -1.1)**	-2.9 (-5.7; -0.1)*
Control of work pacing	-6% (-16; 4%)	-2% (-8; 14%)	-5% (-14; 6%)	-1.9 (-3.6; -0.04)*	-1.6 (-3.4; 0.1)	-1.8 (-3.7; -0.2)*
Support from superior	-3% (-6; 12%)	-9% (-21; 6%)	-0.6% (-14; 16%)	-0.8 (-3.4; 1.7)	-1.6 (-4.1; 0.9)	0.3 (-2.2; 2.9)
Support from co-workers	-12% (-26; 3%)	-10% (-23; 6%)	-14% (-30; 1%)	-0.6 (-3.5; 2.3)	0.41 (-2.4; 3.3)	0.5 (-2.4; 3.3)
Job stress	18% (3; 36%)*	16% (1; 35%)*	9% (-6; 25%)	4.0 (1.6; 6.5)***	4.07 (1.6; 6.5)***	3.1 (0.6; 5.6)**
Perceived stress	15% (2; 28%)*	15% (3; 29%)*	16% (3; 31%)*	3.4 (1.5; 5.3)***	3.6 (1.6; 5.5)***	3.1 (1.1; 5.6)**
Pain duration	3% (-7; 13%)	12% (1; 23%)*	5% (-5; 16%)	1.04 (-0.7; 2.8)	1.4 (-0.3; 3.2)	0.9 (-0.8; 2.7)
Age	0.4% (-1; 2%)	0.6% (-0.5; 2%)	0.3% (-1; 1%)	0.10 (-0.09; 0.3)	0.10 (-0.09; 0.3)	0.04 (-0.15; 0.2)

NRS *numeric rating scale*; NDI *neck disability index*; CI *confidence interval*. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. ^a *logarithmically transformed*.

Table 11 Longitudinal univariate associations between exposures (physical, psychosocial, stress), confounders (pain duration, age) and outcomes (work productivity).

	Work productivity (quantity) ^a			Work productivity (quality) ^a		
	Change (95% CI) for one unit increase in exposure			Change (95% CI) for one unit increase in exposure		
	3-month	9-month	15-month	3-month	9-month	15-month
Neck load	-1.2% (-3; 0.5%)	-1% (-3; 0.8%)	-0.5% (-2; -1%)	-0.4% (-2; -2)	-0.9% (-3; 1%)	-0.9% (-3; 1%)
Shoulder/arm load	-0.8% (-1.4; -0.2%)*	-0.2% (-0.8; 0.3%)	1% (-0.4; 0.7%)	-0.6% (-1; 0.1)	-0.2% (-1; 0.5%)	-0.1% (-1; -0.6%)
Quantitative demands	-2% (-9; 5%)	-6% (-12; 2%)	-4% (-11; 2%)	-5% (-13; 2.8%)	-7% (-15; 0.8)	-5% (-13; 2.7)
Decision demands	-3% (-10%; 4%)	-3% (-9; 4%)	-3% (-10; 4%)	-2% (-10; 6 %)	1.5% (-6; 9%)	-2% (-10; 6%)
Learning demands	6% (-2; 14%)	-3% (-11; 5%)	-2% (-10; 7%)	3% (-6; 12%)	-0.8% (-10; 8 %)	-3% (-13; 6%)
Control of decision	8% (3; 14%)*	1% (-5; 7%)	2% (-5; 7%)	8% (1.7; 16%)*	2% (-5; 9%)	6% (-1.5; 12%)
Control of work pacing	3% (-0.5; 7%)	-0.2% (-5; 4%)	0.1% (-4; 4%)	4% (-9; 8%)	0.5% (-4; 5%)	3% (-1; 7%)
Support from superior	-0.4% (-6; 5%)	3% (-2; 9%)	5% (-0.7; 11%)	3% (-4; 10%)	2% (-4; 9%)	3% (-4; 10%)
Support from co-workers	1% (-5; 8%)	-1% (-8; 6%)	2% (-5; 9%)	1% (-6; 9%)	-0.3% (-8; 7%)	-3% (-11; 5%)
Job stress	-7% (-12; -1%)*	-1% (-7; 4%)	-3% (-8; 3%)	-9% (-15; -3%)*	-6% (-13; -0.3%)*	-5% (-12; 0.9%)
Perceived stress	-5% (-9; -0.6%)*	-3% (-7; 1%)	-4% (-8; 1%)	-8% (-13; -3%)*	-5% (-10; -0.1%)*	-5% (-10; -3%)*
Pain duration	0.5% (-3; 4%)	-0.6% (-4; 3%)	-0.7% (-4; 3%)	-0.1% (-4; 4%)	2% (-2; 6%)	1% (-4; 5%)
Age	0.2% (-0.2; 0.6%)	0.1% (-0.3; 5%)	0.3% (-0.8; 0.1)	0.3% (-0.2; 1%)	0.1% (-0.4; 0.6%)	-0.1% (-0.6; 0.4%)

NRS *numeric rating scale*; NDI *neck disability index*; CI *confidence interval*. * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. ^a logarithmically transformed.

Self-rated and physical outcomes (paper 4)

Descriptive data of Change-score in self-rated neck problems (pain, disability, symptoms) and physical tests outcomes for TT and NTT groups together, in total 69 women, are presented in table 12. The analyses on associations between self-rated neck problems and physical tests outcomes are presented in table 13. The results show that neck pain had low associations to the physical outcomes. The only significant associations found for neck pain was to fast head rotation (Peak-Speed) at baseline (adjusted for age and physical activity) (β -0.005, 95% CI -0.01;-0.001) and the Change-scores from baseline to the 9-month follow-up (β -0.30, 95% CI -0.56;-0.04).

Neck disability was associated at baseline (adjusted for age and physical activity) with CCF-strength (β -0.83, 95% CI -1.51;-0.15), CTE-strength (β -0.03, 95% CI -0.06;-0.001), lifting capacity (β -32.48, 95% CI -57.83;-7.14) and Peak-Speed (β -0.03, 95% CI -0.05;-0.12). For Change-scores the neck disability was associated with A-ROM after 3 and 9 months (β -0.92, 95% CI -1.76;-0.07) (β -1.07, 95% CI -1.79;-0.36) and Peak-Speed after 9 months (β -0.64, 95% CI -0.99;-0.29).

The self-rated neck frequency of symptoms (ProFitMap-neck) were associated at baseline (adjusted for age and physical activity) with CCF-strength (β 1.16, 95% CI 0.10;2.21), CTE-strength (β 0.05, 95% CI 0.01;0.1) and Peak-Speed (β 0.05, 95% CI 0.02;0.07). In Change-scores the frequency of neck symptoms were associated with UC-ROM at 3 and 9 months (β 0.71, 95% CI 0.19;1.23)(β 0.7, 95% CI 0.16;1.25), A-ROM at 3 and 9 months (β 0.44, 95% CI 0.11;0.78)(β 0.59, 95% CI 0.29;0.90), Peak-Speed at 3 and 9 months (β 0.29, 95% CI 0.12;0.46) (β 0.32, 95% CI 0.17;0.47).

The multiple analyses show that at 9 month follow-up, 7,5 % (r^2 0.075) of the variance of neck pain was explained by changes in Peak-Speed, 20% (r^2 0.2) of the variance of neck disability were explained by changes in A-ROM and Peak-Speed and 26% (r^2 0.26) of the variance of frequency of symptom changes were explained by changes in A-ROM and Peak-Speed.

Table 12 Descriptive data, mean differences between before and after intervention, 3 and 9 months, with 95 % confidence intervals, tailored and non-tailored groups together, n=69.

	Mean differences (3 months – baseline) treated group, n= 69	95 % CI for differences	Mean differences (9 months – baseline) treated group, n=69	95 % CI for differences
Pain last week (NRS 0-10)	-1.90*	-2.60;-1.19	-1.36*	-2.10;-0.62
Neck disability (NDI 0-100)	-8.32*	-11.30;-5.35	-7.11*	-10.04;-4.19
Frequency of symptoms (PFM 0-100)	11.19*	8.02;14.34	8.65*	5.14;12.15
CTE (N)	23.61*	11.91;35.31	24.60*	13.15;36.05
CTF (N)	13.84*	8.90;18.80	9.65*	4.44;14.87
CCF (Nm)	0.81*	0.31;1.31	0.74*	0.20;1.28
UC-ROM (°)	2.87*	1.01;4.72	2.80*	0.86;4.75
LC-ROM (°)	1.26	-1.04;3.58	-1.60	-3.49;0.29
A-ROM (°)	9.48*	5.71;13.25	6.17*	2.06;10.28
Peak-Speed (°/ sec)	28.37*	11.45;45.31	25.97*	8.69;43.26
C-PILE (kg/body weight)	0.03*	0.02;0.04	0.03*	0.02;0.05

NRS; numeric rating scale 0-10, NDI; neck disability index 0-100, PFM; ProFitMap-neck, frequency of symptoms 0-100, CTE; cervico thoracic extension, CTF; cervico thoracic flexion, CCF; cranio cervical flexion, UC-ROM; upper cervical sagittal range of motion, LC-ROM; lower cervical sagittal range of motion, A-ROM; axial-range of motion, C-PILE; cervical- progressive isoinertial evaluation, CI; confidence interval, * p<0.5, ** p<0.01, *** p<0.001.; Statistical analysis to calculate mean differences; repeated measure Anova and adjusted for multiple comparison with Bonferroni post hoc test, significant level p<0.05 indicated with *.

Tables 13 Univariate association analysis between neck problems (pain, disability symptoms) and outcomes of physical test of the neck and shoulder region. Cross-sectional (baseline), unadjusted and adjusted for age and physical activity and longitudinal (Change-scores).

	NRS (unadjusted)		baseline		NRS baseline (adjusted) ^a		NRS 3 month, change scores		NRS 9 month, change scores	
	β	95%CI	β	95%CI	β	95 % CI	β	95 % CI	β	95% CI
CTE-strength	-0.003	-0.01;0.003	0.004	-0.01;0.002	-0.20	-0.13;0.09	-0.05	-0.15;0.04		
CTF-strength	0.004	-0.02;0.01	0.006	-0.02;0.01	-0.17	-0.38;0.05	-0.15	-0.31;0.02		
CCF-strength	-0.02	-0.16;0.12	-0.03	-0.18;0.12	0.03	-0.09;0.14	-0.02	-0.10;0.07		
UC-ROM	-0.01	-0.03;0.02	-0.02	-0.05;0.02	-0.63	-1.44;0.18	-0.20	-1.04;0.63		
LC-ROM	0.004	-0.04;0.03	-0.01	-0.05;0.03	-0.01	-0.03;0.02	0.01	-0.02;0.04		
A-ROM	-0.01	-0.03;0.01	-0.02	-0.04;0.001	0.01	-0.51;0.54	-0.28	-0.80;0.24		
Peak-Speed	0.003	-0.01;0.00	-0.005	-0.01;-0.001*	-0.13	-0.41;0.15	-0.30	-0.56;-0.04 *		
C-PILE	-1.26	-6.48;3.97	-2.42	-8.00;3.16	-0.05	-0.25;0.15	-0.14	-0.32;0.04		
	NDI (unadjusted)		baseline		NDI baseline (adjusted) ^a		NDI 3 month, change scores		NDI 9 month, change scores	
	β	95%CI	β	95%CI	β	95 % CI	β	95% CI	β	95% CI
CTE-strength	-0.03	-0.06;0.002	-0.03	-0.06;0.00*	0.05	-0.13;0.24	-0.08	-0.23;0.08		
CTF-strength	-0.05	-0.10;0.01	-0.05	-0.11;0.01	-0.18	-0.51;0.15	-0.24	-0.49;0.02		
CCF-strength	-0.91	-1.56;-0.26**	-0.83	-1.51;-0.15*	0.02	-0.18;0.21	-0.01	-0.14;0.12		
UC-ROM	0.02	-0.12;0.16	0.06	-0.1;0.22	-0.70	-2.07;0.66	-1.10	-2.35;0.18		
LC-ROM	-0.07	-0.23;0.10	-0.05	-0.23;0.13	0.004	-0.04;0.04	-0.01	-0.05;0.04		
A-ROM	-0.04	-0.12;0.05	-0.05	-0.15;0.05	-0.92	-1.76;-0.07*	-1.07	-1.79;-0.36**		
Peak-Speed	-0.03	-0.04;-0.01**	-0.03	-0.05;-0.12***	-0.32	-0.78;0.13	-0.64	-0.99;-0.29***		
C-PILE	32.16	-56.26;8.07**	-32.48	-57.83;-7.14**	-0.14	-0.47;0.19	-0.15	-0.44;0.14		
	PFM (unadjusted)		baseline		PFM baseline (adjusted) ^a		PFM 3 month, change scores		PFM 9 month, change scores	
	β	95%CI	β	95%CI	β	95 % CI	β	95% CI	β	95% CI
CTE-strength	0.05	0.002;0.09*	0.05	0.01;0.1*	0.04	-0.03;0.12	0.05	-0.01;0.12		
CTF-strength	0.06	-0.03;0.14	0.07	-0.02;0.16	0.12	0.00;0.01	0.08	-0.03;0.20		
CCF-strength	1.07	0.06;2.08*	1.16	0.10;2.21*	-	-0.08;0.07	-	-0.06;0.06		
UC-ROM	-0.04	-0.25;0.17	-0.02	-0.26;0.22	0.71	0.19;1.23**	0.70	0.16;1.25**		
LC-ROM	0.09	-0.17;0.34	0.13	-0.15;0.40	-0.01	-0.02;0.01	-0.01	-0.03;0.02		
A-ROM	0.03	-0.10;0.16	0.08	-0.07;0.23	0.44	0.11;0.78**	0.59	0.29;0.90***		
Peak-Speed	0.04	0.01;0.06**	0.05	0.02;0.07***	0.29	0.12;0.46***	0.32	0.17;0.47***		
C-PILE	23.26	-13.77;60.31	31.79	-7.33;70.93	0.02	-0.11;0.16	0.05	-0.08;0.18		

^a adjusted for age and physical activity; NRS; numeric rating scale 0-10, NDI; neck disability index 0-100, PFM; ProFitMap-neck, frequency of symptoms 0-100, CTE; cervico thoracic extension, CTF; cervico thoracic flexion, CCF; cranio cervical flexion, UC-ROM; upper cervical sagittal range of motion, LC-ROM; lower cervical sagittal range of motion, A-ROM; axial- range of motion, C-PILE; cervical- progressive isoinertial evaluation, CI; confidence interval, * p<0.5, ** p<0.01, *** p<0.001.

Discussion

The overall aim of this thesis was to expand the field of knowledge regarding tailored rehabilitation of persons with neck pain and the impact of work exposure and stress in the short and the long term.

Main findings

Findings from the RCT showed that TT based on a proposed decision model was not more effective than NTT, comprising same treatment components but randomly chosen. Both the TT and the NTT had however better short-term effect than TAU. In addition, self-estimated general improvement was higher for TT and NTT than for TAU at both 9 and 15 months. With only small differences between treatment groups and TAU, high perceived stress and low control of decisions at work, were associated to more neck pain, more neck disability and decreased work productivity after the intervention and at follow-ups. The associations between self-rated neck problems and physical outcome tests targeting the neck and shoulder region, were few at baseline as well as in Change-scores at follow-ups. However, higher peak speed of cervical axial rotation and larger A-ROM were the most important physical outcomes which were associated to less neck problems in Change-scores at follow-ups. Neck pain was the self-rated neck problem with least associations to physical test outcomes.

The treatment decision model

The determination of cut-off values were challenged by that women with non-specific neck pain are known to present high variability in pain and disability [84] and that a high specificity (identifying the well) was prioritized over high sensitivity (detecting the sick) to avoid false positive tests with the attempt to capture the impaired functions in each participant. The development and test of the decision model is in line with the growing field of research and development of clinical decision support (CDS) tools for musculoskeletal pain where the technology already has the potential to augment complex decisions [64]. However, a decision model with cut-off values that dichotomize the treatment components in “yes” or “no” to whether indicated or not, has limitations such as possible exclusion if values are borderline and difficulties to include the individual’s need of strength and function compared to demands. In medicine the use of “diagnostics tests” is common, and such tests have been criticized to be somewhat technological; for better diagnostics and treatment decision making complementing input from clinical experts may be needed [127]. This is an important aspect for future decision models. In an attempt to address the limitation with a decision model mainly based on physical test results, the model in this thesis was complemented with a structured interview (PET) to take

individual needs and demands into consideration; despite negative or border line indications in the decision model, a treatment component could be added according to the outcome of the interview.

Cut-off values

The process to determine cut-off values is described in paper 1. In the following section pros and cons with these choices are discussed in an attempt to make the process transparent and enable possibilities for further development.

Cervical mobility: The C-ROM flexion/extension measures separated the contributions between the upper and lower cervical segments, and with data from the study by Rudolfsson et al. [48], it was possible to find relevant cut-off levels. This was also the case for axial rotation but without possibility to separate segments. For the combined flexion/rotation test, performed in sitting, a problem was identified. The data analyses showed that maintaining full flexion during rotation was not always obtained. The cut-off of 32° rotation was based on Ogince et al. [112] where the flexion-rotation test were performed with participants laying supine, more like in the clinic. This difference in executing the test, with the problem encountered to keep full flexion, may question the validity of the cut-off values used.

Cervico-thoracic strength: The cut-off levels for CTF-test and CTE-test were based on tests of both women without pain [99] and female office workers with non-specific neck pain [113]. The inclusion criteria in the latter study were similar to our RCT study, paper 2; pertaining to the participants' pain and disability levels. Likewise, the test set ups for all these three studies were very similar. This strengthens the assumption that these cut-off levels for indication of impairment were valid.

CCF-strength and endurance: The set-up of this test was in close cooperation with researchers where the strength-test instrument was developed and tested [100]. The cut-off values were thus based on empirical experiences. However, some of the participants in the RCT (paper 2) obtained clearly lower MVC than expected in the strength test with the consequence that the endurance test (50% of MVC) became very long. This may indicate that the maximum strength (MVC) was not achieved for those participants.

C-PILE: C-PILE was in earlier studies found to be a valid test (construct validity) and sensitive to changes for women with neck pain [46, 128]. However, the RCT sample (paper 2) performed significantly better on the C-PILE than the sample in Ljungquist et al. [45]. Thus, the cut-off chosen was obviously too low for the RCT sample resulting in only 2% positive test results, and as a consequence very

few in TT were given shoulder-arm strength training. Unfortunately, reference values of the C-PILE was sparse in the literature which highlights the limited available evidence of certain test of functioning in neck pain and the difficulty to individualize treatment based on clear cut-off values.

Peak-Speed: Peak-Speed of cervical axial rotation is a reliable and valid test for assessments in persons with non-specific neck pain [53, 109]. Meisingset et al. [129] used peak velocity also for cervical flexion, extension and lateral flexion but their test differed from ours in that self-selected speed was used. This makes direct comparisons difficult. The cut-off level in the decision model was derived from participants included in Rudolfsson et al. [109], and according to this selection about 20% from the TT group received the corresponding treatment component. This is in line with an expected outcome in accordance with the prediction in the protocol paper, the sample not to exceed 40 % (paper 1). A common clinical explanation for reduced active cervical moments in neck pain is an association to fear-avoidance behaviour, but for Peak-Speed this was tested and rejected in a cross-sectional study of 118 women with chronic non-specific neck pain [53].

Trapezius myalgia and cervicogenic headache

The decision model included the symptom based diagnoses trapezius myalgia and cervicogenic headache. The diagnostic criteria of trapezius myalgia were complemented with a PPT test to sharpen and objectify the criteria. Pressure pain threshold tests have shown to be reliable and to correlate significantly to NDI and NRS in persons with chronic neck pain [130]. The prevalence of trapezius myalgia is relatively high; in a cohort-study among female office workers aged 45 years and older, 38% were diagnosed with trapezius myalgia [104]. In comparison, in our sample 43% had the diagnosis. There is no clear best treatment, and we focused on the muscle activity pattern with EMG-biofeedback training with the aim for the persons to better control relaxation and activation of the trapezius [131, 132]. In parallel, we performed a feasibility-study that showed good utility of the EMG-biofeedback training for both physiotherapists and patients (results presented at The ISEK Congress, Svedmark 2012). Recently, high load strength training in persons with trapezius myalgia has shown positive results and is a potential treatment component in a future decision model [133].

To diagnose cervicogenic headache, criteria from the Cervicogenic Headache International Study Group [105] were used but without blockade of the upper cervical segments. Instead we included palpable pain and reduced upper cervical range of motion according to Jull et al [106]. The manual diagnostics of cervicogenic headache is commonly used and has according to a recent systematic review high reliability and diagnostic accuracy [134]. The manual diagnostics

without blockade of the upper cervical segments, has however been criticized not to be enough for a diagnostic system [135].

RCT-discussion

The extensive RCT was the main study in this thesis including a comprehensive planning process and it was resource demanding to implement and carry out. The interest for participation in the study was high but due to strict inclusion and exclusion criteria many participants were excluded. The reason for these strict criteria was to delimit the study by excluding for example psychological ill-health, concurrent low-back pain or trauma-related neck pain. Those conditions are indeed common in neck pain [8, 53, 136] but the delimitation was made to avoid a too complex and diversified treatment decision model.

Even if the included study group was well defined, the participants showed great variability in outcomes of the physical tests (figure 6). Persons with non-specific neck pain tend however to be treated as a homogeneous condition [137] where the given treatment may depend more on the practitioner and his/her competences and skills than the needs of the patient [138]. The rationale behind the RCT study of this thesis was, however, that treatment decision making at the individual level could improve rehabilitation of persons with neck pain [138].

There could be various explanations for the results, where there were no differences between TT and NT. One reason could be related to the design: the only factor that differed between TT and NTT was the tailoring since the same treatment components were used also for the NTT group, but not indicated according to the decision model. However, if a NTT participant had a test result for the allocated treatment that was just above cut-off level, there was a chance that a treatment which was actually indicated was given to the participant. Perhaps it would have been better with a study design that further increased the contrast between TT and NTT interventions, since all the included treatment components have shown some evidence of effects [57, 58, 131, 139, 140]. Another explanation could be the low associations between the physical test outcomes and self-rated neck pain and disability (paper 4) which question the usefulness of these tests for treatment decision making. Further possible explanations for the similar effect of TT and NTT is that both groups received treatments involving exercise and movements, which are known to stimulate peripheral and central mechanisms that modulate pain [141-143]. In any case, the results support active and specific exercise and are in line with other research [140, 144]. More knowledge is needed about the importance of impaired functions for the neck disorders.

Workplace exposure and stress level

In paper 3, the aim was to study physical and psychosocial workplace exposure and stress levels based on data collected in a treatment intervention (paper 2). The reason for conducting this study was the lack of long-term intervention results for neck pain and the need of understanding how factors other than the intervention may influence the results. From the work place visit and observation of physical work exposure we identified high levels of neck load, e.g. the extent to which persons were working with a flexed neck. However, no associations were found between neck load and self-rated neck pain, disability or work productivity. Sustained positions with flexed neck over longer time periods are common in working life and in leisure, for instance when using mobile phones and lap tops. A systematic review found evidence of musculoskeletal complaints, mainly neck pain, with observed neck flexion, and higher frequency of phone calls, texting and gaming [145]. Others have also shown that high neck load, such as awkward posture (i.e. prolonged neck flexion) is associated to neck and shoulder pain [146].

The observation instrument QEC that we used showed high neck load values but low variance. This low variance in exposure may partly be explained by the high proportion of computer workers with similar static postures. Lack of variance in the neck exposure variable will also reduce the possibility to explore potential associations in an analysis. Of the physical workplace exposures, only shoulder/arm load was associated to any of the self-estimated neck problems, which was work productivity due to neck pain. The association was quite low and the clinical importance is therefore uncertain. In contrast, other studies using different exposure measurement methods, have shown strong relationships between high shoulder/arm load and increased neck- and shoulder problems [25, 147]. Nevertheless, associations were found for psychosocial workplace exposure, low control of decision, and high stress levels with high neck pain and neck disability and low work productivity. This is in line with a recent systematic review that found strong relationships between stress and non-specific neck-arm pain [148]. The mechanisms behind stress and neck pain may partly be related to the finding that perceived muscular tension is associated with an increased risk of developing neck pain [149].

Associations between self-rated neck problems and physical tests outcomes

The results in paper 4 showed that the neck pain level of the participants was only associated to one of the physical outcome variables, the maximal speed of cervical axial rotation (Peak-Speed). The absent association of other physical test outcomes to pain is in line with other studies [44, 150]. One explanation could be

that pain intensity is not constant in musculoskeletal disorders [151] rather it may fluctuates markedly over time depending on daily physical and psychological load, whereas the physical outcomes should be more stable. Pain *during* testing may however be related to the outcome of neck strength tests and thereby obscure the person's true maximal strength [44]. In the present study, we did not register the participants' pain during testing in a systematic fashion, but there were no substantial complaints and not any adverted effects were reported.

In contrast to neck pain, lower levels of neck disability and frequency of symptoms were associated to higher neck strength and Peak-Speed at baseline, and to Peak-Speed and A-ROM at follow-ups (3 and 9 months). The measures of disability and frequency of symptom we used, i.e., NDI [87, 96] and ProFitMap-neck questionnaire [97], include questions that can be linked to bodily functions that may couple to physical test outcomes in a different way than merely a question of pain intensity. Associations between NDI and C-ROM are not well documented [152], but our findings with Change-scores associations between NDI and C-ROM strengthen this link. In addition, our result of reductions in neck problems being associated to improvements in cervical movement speed and flexibility is corroborated by Meisingset et al. [129]. However, peak velocity as used in the Meisingset et al. study was not a test of maximal speed such as in paper 4, but instead self-selected speed during tests of range of motion. In clinic, the common neck pain treatment of cervical mobilization or manipulation, leading to increased cervical ROM and decreased pain [153, 154] connects well with the association of neck problems to changes in flexibility.

The lack of a test for neck muscle endurance in paper 4 may retrospectively be considered a study limitation considering its possible relevance for neck pain intervention [43] and the recent attention given to isometric strength training with sustained contractions for various painful musculoskeletal conditions [155]. Another limitation is that the data were from an RCT, not primarily designed for the purpose of paper 4. That is, in the present RCT there were two treatment groups pooled to one for the purpose of paper 4 so the effects of different treatments may have influenced the test results. In theory, however, an improvement irrespective of treatment and outcome variables should hopefully reflect a self-reported improvement as well, given that the measured physical test outcomes are relevant to the problem.

Clinical implications

For women with chronic non-specific neck pain with mild to moderate neck disability, tailoring of treatment based on physical tests did not prove to be more effective than non-tailoring, at least not with the present decision model with its current cut-off levels. This despite that the tailoring is often what clinicians strive

for and it is truly important to learn much more about what works for whom specifically. Therefore this is an important field that needs to be penetrated further and there are surely reasons to improve the bases for clinical decisions and thus the foundation for evidence based clinical reasoning. The short-term results in the present thesis nevertheless advocate evidence based treatment with neck specific exercises and strength training of the neck and shoulder region. To improve intermediate and long-term results of treatment for persons with neck pain, perceived stress levels and psychosocial work place exposure particularly control of decisions, should be taken into account.

After treatment intervention, changes in neck pain have no, or only minor, association to changes in C-ROM, neck and shoulder strength and dynamic lifting capacity. This calls for caution in attributing reduced pain following exercise treatment to changes in physical test outcomes. Self-rated neck disability and frequency of symptoms seem more connected to cervical strength and cervical range of motion, and to changes in axial range of motion and maximum speed of cervical rotation, compared to pain ratings and may therefore be better indicators.

Methodological considerations

The protocol article (paper 1) and the following RCT (paper 2) followed the Consort 2010 statement [156]. In the RCT care was taken to reduce bias in the comparison between study groups in the following way: i) Both treatment groups received the same time for treatment with the physiotherapist. ii) Study hypotheses were concealed for all participants. iii) The randomization by minimization assured equal distributions between groups of participants' age, pain, pain duration and disability level. The study population (paper 2, 3 and 4) was recruited through information at work-places (municipality, hospital and university) and advertisement in newspapers and the treatment period was three months. This could have caused a slight risk of selection bias where persons working in more scheduled task or having stressful work or life situations may have had difficulties to participate. Further, the strict criteria for participation may question the generalization to the population of women with long-term non-specific neck pain. However, a positive outcome of the rigorous criteria for inclusion combined with thorough physiotherapy assessment, was a well defined study population. Even so, although the used self-estimated questionnaires were proven valid (paper 2, 3 and 4), self-reporting always constitute a risk, for example by potential misunderstanding and carelessness due to lack of time. Limitations in paper 3 include that the non-work exposures and potential stress factors in private life were not investigated. A general limitation in this thesis is that participants' use of medication was not analysed and no cost-effectiveness component was included, which could have been desirable. Finally, in this thesis

only women were included, because of their greater risk for neck pain compared to men, and the results can therefore not be generalized to men.

Future research

In order to improve rehabilitation of individuals with long-term non-specific neck pain, there are obviously many factors of importance that need to be addressed in future research. For instance, further research efforts regarding the effects of tailoring interventions to individuals are warranted and more in-depth treatment decision models to guide treatment should be explored. But firstly, due to the low associations between self-rated neck problems and cervical strength and mobility, future research urgently calls for investigations penetrating which factors that are of most importance in order to optimally tailor the treatment. It seems clear that future studies on neck pain treatment intervention should consider the impact of psychosocial workplace exposure and perceived stress when evaluating short and long term results. Finally, the low associations found between self-rated neck problems and cervical strength and mobility call for further investigations of acting mechanisms behind neck-shoulder exercise effects in neck pain.

Conclusions

- There was no support for tailored over non-tailored treatment of women with subacute or chronic non-specific neck pain when interventions were prescribed based on a decision model that used cut-off levels in physical tests and symptoms.
- Women receiving both tailored and non-tailored treatment, comprising active and specific exercise therapy, had less pain and disability at short-term follow up after intervention compared to treatment-as-usual, although therapist-patient interaction was not controlled for.
- High stress level and low self-rated control over decisions at work associated with more neck pain and neck disability and less work productivity at 3- and 9-month follow-ups after intervention.
- High self-rated neck pain at baseline and increased pain in Change-scores after treatment was only associated to one of the outcomes of physical test, maximum speed of cervical rotation (i.e., lower Peak-Speed).

- High self-rated neck disability and frequency of symptoms were associated to low neck strength and maximum speed of cervical rotation (low Peak-Speed) at baseline and decreased C-ROM and Peak-Speed in Change-scores after treatment.

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