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156

Petri Salo

Assessing Physical Capacity, Disability, and Health-Related Quality of Life in Neck Pain

JYVÄSKYLÄN YLIOPISTO

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To my father for guiding my way

ABSTRACT

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The objective of this study was to examine the predictive value, psychometric properties, and clinical utility of the measurements generally used in assessing patients with neck pain.

Data on three separate subject groups were analyzed. The effect of age on isometric neck muscle strength and passive mobility of the cervical spine was studied among 220 female volunteers without neck pain (aged 20 to 59 years) stratified into four age groups. Six years later the predictive value of these physical capacity measures for onset of neck pain was evaluated. To assess the psychometric properties of the subjective outcome measures, the Finnish version of the Neck Disability Index (NDI-FI) and the Finnish modified Neck Pain and Disability Scale (mNPDS-FI), data from a total of 101 (59 females and 42 males, aged 21 to 82 years) patients with neck pain were studied. The responsiveness of the aforementioned measurements and the generic 15D health-related quality of life (HRQoL) instrument was evaluated in a randomized controlled trial (RCT) with 180 females with chronic neck pain.

Isometric neck muscle strength did not differ between the age groups, although the passive range of motion declined with age. These physical capacity measures were not able to predict later onset of neck pain in a 6-year follow-up among the initially neck pain-free subjects. The subjective outcome measures, the NDI-FI and mNPDS-FI, proved to be highly reliable and valid instruments for assessing disability related to neck pain. Of the physical capacity measures, the isometric neck muscle strength measurement, and of the subjective outcome measures, the NDI-FI and mNPDS-FI proved to be the measures most responsive to change in rehabilitative context.

In conclusion, both physical capacity measures and subjective outcome measures are useful and thus recommended for use in monitoring response to treatment and evaluating the results of rehabilitative procedures among patients with neck pain.

Keywords: neck pain, measurement, strength, range of motion, disability, health-related quality of life, responsiveness

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"You are the sunshine of my life / That's why I'll always be around /
You are the apple of my eye / Forever you'll stay in my heart"

Stevie Wonder

Muuratsalo, October 2010

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LIST OF ORIGINAL ARTICLES

The thesis is based on the following five original articles, which are referred to in text by their Roman numerals:

I Salo P, Ylinen J, Mälkiä E, Kautiainen H, Häkkinen A. 2006. Isometric strength of the cervical flexor, extensor, and rotator muscles in 220 healthy females aged 20 to 59 years. J Orthop Sports Phys Ther 36(7):495-502

II Salo P, Häkkinen A, Kautiainen H, Ylinen J. 2009. Quantifying the effect of age on passive range of motion of the cervical spine in healthy working age women. J Orthop Sports Phys Ther 39(6):478-483.

III Salo P, Ylinen J, Kautiainen H, Häkkinen K, Häkkinen A. Neck muscle strength and mobility of cervical spine as predictors of neck pain. A prospective 6 year study. Submitted.

IV Salo P, Ylinen J, Kautiainen H, Arkela-Kautiainen M, Häkkinen A. 2010. Reliability and validity of the Finnish version of the Neck Disability Index and the modified Neck Pain and Disability Scale. Spine 35(5):552-556.

V Salo P, Häkkinen A, Kautiainen H, Ylinen J. 2010. Effect of neck strength training on health related quality of life in female patients with neck pain: A randomized 1-year follow-up study. Health and Quality of Life Outcomes 8:48.

The thesis also contains unpublished data

ABBREVIATIONS

ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
AROM	Active range of motion
AUC	Area under curve
BMI	Body Mass Index, kg/m^2
CG	Control group
CI	Confidence interval
CMS	Cervical measurement system
DNF	Deep neck flexor
ETG	Endurance training group
HRQoL	Health-related quality of life
ICC	Intraclass correlation coefficient
mNPDS-FI	modified neck pain and disability scale – Finnish
N	Newton, a measure of force (1 kilopond = 9,81 N)
NDI	Neck disability index
NDI-FI	Neck disability index – Finnish
NPDS	Neck pain and disability scale
Nm	Newton meter, a measure of torque
PROM	Passive range of motion
ROC	Receiver operator characteristics
ROM	Range of motion
SD	Standard deviation
STG	Strength training group
VAS	Visual analogue scale
VRS	Verbal rating scales
WAD	Whiplash associated disease

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1 INTRODUCTION

Neck pain is a common condition experienced by up to 70% of people sometime during their lives (Cote et al. 1998, Mäkelä et al. 1991). Neck pain is also one of the most common reasons to visit a physician, especially among working age women (Mäntyselkä et al. 2001). The costs of neck pain to the individual and society are considerable in terms of the consumption of medical services, absenteeism from work, and disability (Borghouts et al. 1999). As neck pain tends to be a persistent and recurrent condition it has substantial effects on quality of life as well.

Although neck pain can result from trauma such as whiplash, or be present in inflammatory arthropathies, the most common origin of neck pain is related to the cervical musculoskeletal system (Jull et al. 2008). The diagnosis of neck pain is difficult, while the exact cause of neck pain is rarely identified by clinical examination or diagnostic imaging (Haldeman et al. 2008). In non-emergency neck pain without radiculopathy, the validity of the most commonly used objective tests has not been demonstrated (Nordin et al. 2008). It has been claimed that in up to 80% of neck pain cases, a definitive pathophysiological cause may not be revealed (Jull et al. 2008).

Lack of clear diagnoses poses a challenge for the design and targeting of curative interventions. However, various instruments exist to identify and characterize signs and symptoms of pathology, impairments, functional limitations, and disabilities. The most commonly used methods of assessment in cases of neck pain are pain measurement tools, strength tests, range of motion measurements, questionnaires assessing disability, and general health status (Schaufele & Boden 2003). These instruments are frequently used in selecting interventions, monitoring patients' status, evaluating response to treatment, and in clinical research. They are also used to indicate achievement of the outcomes that are the end points of care.

To be able to give accurate information about the phenomenon studied, the instruments used must be reliable and valid. Ideally, such instruments will have been tested and reported according to an established scientific process (Jewell 2008). The present study aims to answer to the challenge posed in a recent best evidence synthesis, the need to evaluate the predictive value and utility of the commonly used clinical tests in patients with non serious neck pain and associated disorders (Nordin et al. 2008). In addition, it has been proposed that research efforts should focus on the design and evaluation of neck pain prevention strategies and on searching for modifiable risk factors (Hogg-Johnson et al. 2008, Hurwitz et al. 2008). This doctoral thesis responds to some of these challenges by studying the predictive value, psychometric properties and clinical utility of some of the instruments most commonly used in the assessment of neck pain.

2 REVIEW OF THE LITERATURE

2.1 Neck pain

Neck pain is usually defined by its perceived location. Pain may be considered as neck pain when sited in the anatomical region bounded superiorly by the superior nuchal line, laterally by the lateral margins of the neck, and inferiorly by an imaginary transverse line through the T1 spinous process (Bogduk 2003). Although manifesting in this area, the cause of the pain does not necessarily lie within this area. On the other hand, pain perceived elsewhere can originate from the cervical spine region as in cervical radicular pain, where the pain is perceived in the upper limb.

In order to be a source of pain, the structure must be innervated, thus all of the muscles, synovial joints, and intervertebral discs of the neck, as well as ligaments, cervical dura mater and the vertebral artery are potential sources of neck pain (Bogduk 2003).

Pain can be described as an unpleasant sensation conveyed to the brain by sensory neurons signaling actual or potential tissue damage (Wall & Melzack 1999). Thus, experience of pain is a subjective transaction where neural signals enter an active nervous system, and it is influenced by cultural learning, the meaning of the situation, attention, and other psychological variables (Katz & Melzack 1999). Thus, the sensation of pain is a process where the brain actively selects, abstracts, and synthesizes information from the total sensory input (Katz & Melzack 1999). Experience of pain comprises sensory-discriminative, motivational-affective, and cognitive-evaluative dimensions (Melzack & Katz 1999). These three components are assumed to interact with each other to provide information on the location, intensity, and duration of the stimulus, motivational tendency toward escape or attack, and cognitive information based on past experience and probability of outcome of different response strategies (Farina et al. 2003, Katz & Melzack 1999, Melzack & Katz 1999). A feature of pain that affects the subject’s functioning is that pain is known to be able to inhibit the human motor cortex, and thus to limit or impair the ability to perform movements (Farina et al. 2003). Along with muscle inhibition, lower pain threshold during strain seem to restrict patients' muscular effort (Ylinen et al. 2004b). Thus, pain experienced in the neck region can manifest as limitation or inability to normally move and control the head in space, causing functional and activity limitations, participation restrictions and decrease in quality of life.

2.1.1 Epidemiology

Neck pain is a common condition and the majority of people can expect to experience some neck pain during their lifetime. However, studies on the prevalence of neck pain show great variation in both quality and results (Fejer et al. 2006b). Recently, The Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders (The Neck Pain Task Force), screening over 30,000 citations, reported the 12-month prevalence of neck pain to range from 12.1% to 71.5% in the general population, depending on the definition used (Haldeman et al. 2008). There seem to be some differences in the prevalence of neck pain in different geographical regions, with the Nordic Countries showing somewhat higher prevalence values than the rest of Europe and Asia (Fejer et al. 2006b). Climate, level of education, means of livelihood and average age of the population may be some of the factors that can influence the prevalence of neck pain and explain the differences between geographical regions. Several studies indicate that the prevalence of neck pain among females is higher than among males. In the Scandinavian countries the prevalence of chronic neck pain among females ranged from 7% to 22% and among males from 5% to 16% (Aromaa & Koskinen 2002, Bovim et al. 1994, Guez et al. 2002, Mäkelä et al. 1991). The higher prevalence of neck pain among females has been seen as early as in adolescence (Auvinen et al. 2009, Ståhl et al. 2004).

The incidence of neck pain seems to increase with age, reach a peak and decrease thereafter. Two cohort studies reported the incidence of neck pain to peak at age 40 to 49 in females and 50 to 59 in males (Bot et al. 2005), and age 35 to 44 in females and 45 to 54 in males (Rekola et al. 1993). Bovim et al. (1994) reported with a random sample of 10,000 subjects that the prevalence of chronic neck pain increased with age and peaked in females at age 48 to 52 and in males as late as age 63 to 67.

Despite the high prevalence of neck pain, pain-associated disability seems to be less common, with the 12-month prevalence ranging from 1.7% to 11.5% in the general population (Haldeman et al. 2008).

2.1.2 Etiology

Analysis of risk factors suggests that neck pain has a multifactorial etiology (Haldeman et al. 2008). Risk factors that cannot be modified include age, gender, and genetics whereas risk factors that can be modified include smoking, exposure to environmental tobacco, and psychological health (Cote et al. 2008, Haldeman et al. 2008, Hogg-Johnson et al. 2008).

Females are more commonly affected by neck pain than males (Aromaa & Koskinen 2002, Bovim et al. 1994, Croft et al. 2001, Guez et al. 2002, Mäkelä et al. 1991, Rekola et al. 1993, Ståhl et al. 2004, Webb et al. 2003). This may be attributable to gender-related differences in anthropometry, physiology, and strength levels that may predispose females to overexertion and trauma more easily than males (Paller et al. 2009, Vasavada et al. 2008). However, females tend to experience more pain than males in general (Berkley & Holdcroft 1999). A recent review concluded that females experienced greater clinical pain, suffered greater pain-related distress, and showed higher sensitivity to experimentally induced pain compared with males (Paller et al. 2009).

Genes seem to play a role in neck pain, with heritability estimated to range from 35% to 48% (Fejer et al. 2006a, Hartvigsen et al. 2004, MacGregor et al. 2004) According to a Danish study on twins, genes had an important role in neck pain, particularly in females (Fejer et al. 2006a). However, with increasing age the genetic influence gradually became less important, and environmental factors dominated almost completely in the older age groups.

Two systematic reviews found some evidence that exposure to cigarette smoke in childhood and current smoking status were risk factors for neck pain (Cote et al. 2008, Hogg-Johnson et al. 2008).

A few studies have indicated overweight as a risk factor for neck pain (Luime et al. 2004, Mäkelä et al. 1991, Smedley et al. 2003, Viikari-Juntura et al. 2001), but the evidence is conflicting (Brandt et al. 2004, Cote et al. 2000, Croft et al. 2001, Gerr et al. 2002).

The evidence on the association between physical activity and neck pain also seems to vary, with no definite conclusions being drawn (Brandt et al. 2004, Korhonen et al. 2003, Luime et al. 2004, Pietri-Taleb et al. 1994, van den Heuvel et al. 2005).

The physical capacity of the neck region as a risk factor has been little explored. A recent systematic review identified only three longitudinal studies reporting results on the relationship between physical capacity and the risk for neck/shoulder pain (Hamberg-van Reenen et al. 2007). Of these three studies, only one study with a sample of 66 male fighter pilot students reported baseline measurements directed toward the cervical spine, indicating no relationship between either neck muscle strength or cervical mobility and the incidence of neck pain (Hämäläinen et al. 1994). One later study found some evidence that larger cervical mobility protected towards neck pain (Hush et al. 2009), and an earlier study reported a relationship between lower static neck extensor strength and later occurrence of neck pain (Hamberg-van Reenen et al. 2006). Kasch et al. (2001) found that the cervical ROM test had high sensitivity in the prediction of handicap after acute whiplash injury, which is in line with the findings of a later study by Sterling et al. (2006). Because of the heterogeneity and sparse number of studies, the relationship between the physical features of cervical spine and the later onset of neck pain remain unclear.

In the workplace, high quantitative job demands, low social support, a sedentary work position, repetitive work tasks, job insecurity, poor computer workstation design and working posture, prolonged sitting, and precision work were listed as risks for neck pain (Cote et al. 2008, Haldeman et al. 2008, Viikari-Juntura et al. 2009). However, it seems that no single risk factor is sufficient to cause neck pain on its own; instead a combination of risk factors needs to be present to trigger neck pain and such combinations are likely to vary between subjects (Cote et al. 2008).

Due to the expansion of motorized transportation, the incidence of whiplash associated disease (WAD) has strongly increased during the last few decades. Cote et al. (2000) reported that about 16% of the adult population in Canada had experienced neck injury in a motor vehicle accident. Previous trauma, such as whiplash, sports injury, or occupational trauma has been reported to be a risk factor for chronic neck pain (Croft et al. 2001, Miettinen et al. 2004).

2.1.3 Classification

Pathology

The international statistical classification of diseases and health-related problems (ICD-10) is the international standard diagnostic classification system for all general epidemiological and many health management purposes, and clinical use (WHO). Also neck disorders are classified in the ICD-10 (WHO).

However, specific diagnosis of neck pain is difficult due to lack of reliable and valid clinical tests and diagnostic methods (Nordin et al. 2008, Ylinen 2004). In the majority of neck pain cases, the pain is unspecific, the etiology remains unclear and thus it is commonly diagnosed as mechanical or non-specific neck pain (cervicalgia, M54.2) (WHO, Ylinen 2004). It has been estimated that only in about 20% of neck pain cases can a definite pathological cause be detected (Jull et al. 2008). Specific causes of neck pain are e.g. disc prolapse (cervical disc disorder with myelopathy M50.0 G99.2 and radiculopathy M50.1) and spondylogenic compression of spinal cord (M47.1 G99.2) or nerve root (spondylosis with radiculopathy M47.2) (WHO, Ylinen 2004). Also, neck pain may be related to trauma or infection, or to a neurological or other disease which can be identified and classified using diagnostic methods appropriate for those diseases (Ylinen 2004).

In a recent update of the Finnish Current Care Guideline for neck pain (Viikari-Juntura et al. 2009) neck pain was categorized as follows: 1) Local neck pain, 2) Radiating neck pain, 3) Whiplash, 4) Myelopathy (compression of spinal cord), and 5) Other neck pain (related to general illnesses and tumors and aftermath of fractures of cervical spine).

Duration

Pain, often categorized by its duration is defined by the International Association for the Study of Pain, as acute when lasting up to six weeks, as subacute when lasting from six weeks to three months, and as chronic when lasting for more than three months (IASP 1986). However, other definitions have also been reported. Neck pain was defined as chronic when lasting for more than six months in the studies by Bovim et al. (1994) and Guez et al. (2002). Webb et al. (2003) defined neck pain as chronic if initially experienced five years previously. The Finnish Current Care Guideline for neck pain (Viikari-Juntura et al. 2009) uses the same timeline between acute and chronic as IASP, three months, but without further classifying between acute and subacute.

Severity

The Neck Pain Task Force suggested a new system of classification for neck pain based on neck pain severity in 2008 (Haldeman et al. 2008). In their classification system neck pain is categorized into four grades:

> *"Grade I neck pain: No signs or symptoms suggestive of major structural pathology and no or minor interference with activities of daily living; will likely respond to minimal intervention such as reassurance and pain control; does not require intensive investigations or ongoing treatment.*
> *Grade II neck pain: No signs or symptoms of major structural pathology, but major interference with activities of daily living; requires pain relief and early activation/intervention aimed at preventing long-term disability.*
> *Grade III neck pain: No signs or symptoms of major structural pathology, but presence of neurologic signs such as decreased deep tendon reflexes, weakness, and/or sensory deficits; might require investigation and, occasionally more invasive treatments.*
> *Grade IV neck pain: Signs or symptoms of major structural pathology, such as fracture, myelopathy, neoplasm, or systemic disease; requires prompt investigation and treatment."*

As there are several classification systems for neck pain based on different phenomena it is important to cite the classification system used.

2.1.4 Prognosis

The prognosis for neck pain seems to be multifactorial. Poor psychological health, worrying, and becoming angry or frustrated in response to neck pain has shown to be associated with poorer prognosis, whereas younger age, greater optimism, a coping style that involve self-assurance, and having less need to socialize, are associated with better prognosis (Haldeman et al. 2008).

Estimates of the proportion of patients that heal or develop chronic neck pain vary. Binder (2008) reported that acute neck pain normally resolves within days or weeks, but becomes chronic in about 10% of cases. Bogduk (2003) has estimated that 10% to 30% of patients with neck pain would develop chronic neck pain. Gore et al. (1987) reported a 10-year follow-up of 205 patients with neck pain of whom 32% continued to experience moderate to severe pain. The Neck Pain Task Force concluded in their report that between 50% and 85% of patients with neck pain report neck pain again 1 to 5 years later and that this applies to the general population, workers, and subjects involved in motor vehicle collisions (Haldeman et al. 2008). Binder (2008) reported that up to 40% of subjects experiencing whiplash continued to report symptoms 15 years after the accident.

2.1.5 Recommendations for noninvasive treatment of neck pain

Acute neck pain often disappears without any special treatment, but serious or specific illness must be ruled out (Viikari-Juntura et al. 2009). Medication can be used for pain, but if disabling pain has lasted for two months, multidisciplinary treatment is recommended (Viikari-Juntura et al. 2009). As the pathogenesis of neck pain is rarely revealed, treatment is directed at reduction of symptoms rather than reversal of the underlying condition. During the past decade, evidence for the effectiveness of neck strength training in reducing neck pain and the disability associated with it has grown (Andersen et al. 2008, Blangsted et al. 2008, Bronfort et al. 2001, Chiu et al. 2005a, Ylinen et al. 2003b). Both a recent best-evidence synthesis (Hurwitz et al. 2008) and Cochrane review (Kay et al. 2005) concluded that interventions that involved exercise combined with manual therapy are more effective in treating patients with neck pain than alternative strategies. Short-term training has been shown to produce only temporary improvements in various outcome measures, and therefore intensive resistance training for at least one year is recommended in order to gain sustainable results (Ylinen 2007).

Cervical manipulation and mobilization produced similar results according to the most recent Cochrane review (Gross et al. 2010), and were concluded to provide immediate- or short-term effects on pain and function, although no long-term data were available.

With respect to electrotherapy, very low quality evidence was found on short term benefits of pulsed electromagnetic field therapy, repetitive magnetic stimulation and transcutaneous electrical nerve stimulation being more effective than placebo in the Cochrane review by Kroeling et al. (2009).

The Cochrane reviews on multidisciplinary biopsychosocial rehabilitation, patient education, mechanical traction, and massage concluded that high quality studies were few and that no recommendations for practice could be made (Graham et al. 2008, Haines et al. 2009, Haraldsson et al. 2006, Karjalainen et al. 2003).

Evidence on the effectiveness of any noninvasive interventions for persons with radicular symptoms or neurologic signs (Grade III neck pain) is entirely lacking (Hurwits et al. 2008).

2.2 Outcome measures related to neck pain

The World Confederation for Physical Therapy (WCPT) has stated that physical therapists have a responsibility to ensure that the management of patients is based on the best available evidence and that physical therapists should be prepared to critically evaluate their practice and the outcomes of their actions (WCPT 2007). To reliably evaluate the outcomes of practice the measurements used should show adequate psychometric properties. Key elements of psychometric properties are reliability, validity and responsiveness (Fitzpatrick et al. 1998).

Reliability refers to the instrument's *reproducibility,* i.e. the ability to measure something in a reproducible way, and to its internal consistency (Pietrobon et al. 2002). The intraclass correlation coefficient (ICC) is the most commonly used reliability parameter for continuous measures (Terwee et al. 2007). Two categories of reliability have traditionally been constructed and tested: intrarater reliability—the reliability within a single tester and interrater reliability—the reliability between at least 2 testers/populations/settings (Williams et al. 2010). Intrarater ICC values >0.85 are considered as good, 0.65 to 0.85 as moderate, and <0.65 as poor, while the corresponding values for interrater ICC values are >0.80, 0.60 to 0.80, and <0.60 (Williams et al. 2010). *Internal consistency* indicates whether the items constituting a scale are highly correlated, i.e. measure the same concept or construct (Pietrobon et al. 2002). Internal consistency is commonly reported in studies reporting on the reliability of outcome questionnaires.

Validity is defined as the degree to which the method measures what it is intended to measure. Four types of validity are commonly reported: face, content, criterion, and construct validity (Pietrobon et al. 2002). *Face validity* is considered to have been achieved if the instrument seems to measure what it is supposed to measure (Pietrobon et al. 2002). There is no quantification method for face validity and thus it can be biased. *Content validity* reflects the extent to which the instrument measures all the significant aspects of the construct being assessed (Pietrobon et al. 2002). *Criterion validity* is the correlation of a scale with some other measure of the disorder, ideally, a "gold standard" that has been used and accepted in the field (Terwee et al. 2007). Two measures taken at the same time indicate *concurrent criterion validity* (Williams et al. 2010). *Construct validity* is the extent to which scores on the instrument explored relate to other measures in a manner that is consistent with theoretically derived hypotheses concerning the concepts that are being measured (Terwee et al. 2007). Construct validity can be defined through *convergent and discriminative validity*.

Responsiveness refers to the instrument's ability to detect important change, such as minimal clinically important change, over time in the concept being measured (Pietrobon et al. 2002). Responsiveness is considered to be a measure of longitudinal validity (de Koning et al. 2008). A widely used method of assessing internal responsiveness is to evaluate the change in a measure within the context of a randomized clinical trial involving a treatment that has previously been shown to be efficacious (Husted et al. 2000). External responsiveness reflects the extent to which changes in a measure over a specified time frame relate to corresponding changes in a reference measure of health status (Husted et al. 2000).

In assessing patients with neck pain the most commonly used assessment methods are measurements of physical capacity, i.e. strength tests, range of motion measurements, and subjective outcomes such as questionnaires assessing pain, disability, and general health status (Schaufele & Boden 2003).

2.2.1 Measurement of physical capacity

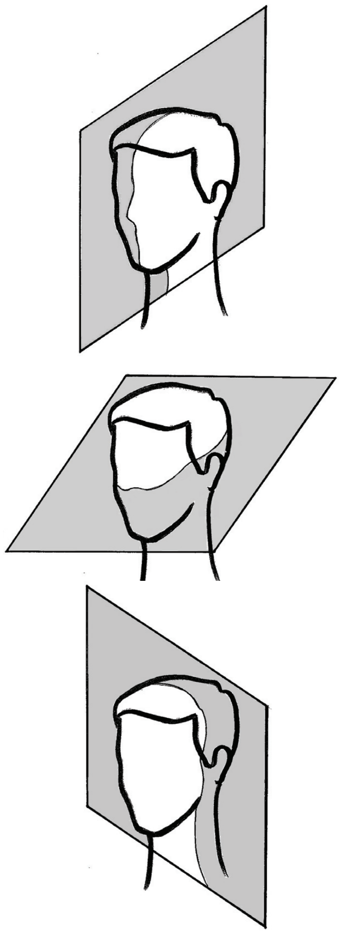
A few phenomena related to physical capacity, such as low neck muscle strength (Barton & Hayes 1996, Chiu & Sing 2002, Jordan et al. 1997, Krout & Anderson 1966, Silverman et al. 1991, Ylinen et al. 2004a, Ylinen et al. 2003c) and restricted mobility of the cervical spine (Assink et al. 2005, Chiu & Sing 2002, De Loose et al. 2009, Hagen et al. 1997, Jordan et al. 1997, Ylinen et al. 2003c) in different movement planes have been observed to be associated with neck pain. Thus, the use of strength tests and evaluation of range-of-motion, commonly included in the clinical inspection of patients with neck pain, is justified. The three different movement planes are shown in figure 1, along with a list of the primary agonist muscles in each plane.

2.2.1.1 Measurement of neck strength and endurance

Krout & Anderson (1966) observed weakness of the neck flexor muscles in patients with neck pain using manual testing. However, manual testing is not suitable for quantitative strength assessment as it provides no numerical data and is also prone to expectation bias. Even so, manual testing may be used in clinical practice as a rough indication of muscle strength (Blizzard et al. 2000).

Earlier, hand-held devices were used to assess neck muscle strength (Mansell et al. 2005, Phillips et al. 2000, Silverman et al. 1991, Staudte & Dühr 1994). However, the reliability of hand-held strength measuring devices has been questioned, particularly where the strength level of the tester is lower than that of the test subject (Wikholm & Bohannon 1991).

In consequence, to improve reliability, there has been an increase in the use of fixed measurement devices, where the subject is supported in a defined position. In contrast to isometric test devices, isokinetic devices have rarely been used to measure neck muscle strength (Cagnie et al. 2007, Seng et al. 2002). This is most likely due to the fact that the cervical spine is a multiaxial structure and thus it is difficult to develop a device suitable for conducting an isokinetic strength test (Ylinen 2004).



Sagittal plane
flexion-extension movement

Primary flexor muscles of the neck:
m. longus colli, m. longus capitis,
m. sternocleidomastoideus (Barton & Hayes 1996, Oksanen et al. 2007, O'Leary et al. 2007b, Staubesand 1989)
Primary extensor muscles of the neck:
m. semispinalis capitis et cervicis, m. splenius capitis et cervicis, suboccipital muscles (Mayoux-Benhamou et al. 1997, Schuenke et al. 2006, Staubesand 1989)

Horizontal plane
rotation movement

Primary rotator muscles of the neck:
m. sternocleidomastoideus, m. splenius capitis (Oksanen et al. 2007, Schuenke et al. 2006, Staubesand 1989)

Frontal plane
lateral flexion movement

Primary lateral flexor muscles of the neck:
m. semispinalis capitis et cervicis, m. splenius capitis et cervicis, m. trapezius (pars descendent), m. sternocleidomastoideus (Schuenke et al. 2006, Staubesand 1989)

FIGURE 1 Movement planes with listing of primary agonist neck muscles.

The literature is at its most extensive on the measurement of isometric neck muscle strength using devices specially built for this purpose (Chiu & Sing 2002, Chiu et al. 2002, Garces et al. 2002, Hogrel et al. 2007, Jordan et al. 1997, Jordan et al. 1999, Kumar et al. 2001, Peolsson et al. 2001, Phillips et al. 2000, Pollock et al. 1993, Staudte & Dühr 1994, Ylinen & Ruuska 1994, Ylinen et al. 1999). In most studies the subject is measured in the sitting position, stabilized to a varying degree, if at all, but studies where the subject is supine or prone (Cagnie et al. 2007, O'Leary et al. 2007a) or standing (Ylinen & Ruuska 1994, Rezasoltani et al. 2008) have also been reported. Studies using different test devices have reported divergent results for cervical flexion and extension muscle strength, but generally the reliability of these measurements has been shown to be acceptable or good with ICC values ranging from 0.75 to 0.98 (Cagnie et al. 2007, Chiu & Sing 2002, Hogrel et al. 2007, Jordan et al. 1999, Kumar et al. 2001, Peolsson et al. 2001, Ylinen et al. 1999). An association between neck pain and reduced neck strength has been observed in studies using measurement of maximal isometric strength (Chiu & Sing 2002, Jordan et al. 1997, Ylinen et al. 2004a, Ylinen et al. 2003c). The results of isometric neck strength measurements seem to be dependent of the device used and how it is used (Rezasoltani et al. 2008), and thus it is necessary to obtain, for example, the appropriate reference values to the particular device and method used.

Neck strength has commonly been measured for flexion and extension movements, and most researchers have observed the highest isometric cervical strength with the cervical spine in the neutral position (Berg et al. 1994, Pollock et al. 1993). Studies on neck rotation strength are few and the sample sizes have been small (Berg et al. 1994, Mayoux-Benhamou et al. 1989, Vasavada et al. 2001, Ylinen et al. 2003a).

In addition to maximal neck muscle strength, neck muscle endurance strength has been reported quite extensively. Several reports exist on the endurance of the neck flexors (Blizzard et al. 2000, Cleland et al. 2006b, Grimmer 1994, Harris et al. 2005, Kumbhare et al. 2005, Ljungquist et al. 1999, Olson et al. 2006, Wang et al. 2003) and extensors (Ljungquist et al. 1999). In these tests for the flexor muscles the subject was measured in the supine position and was instructed to "tuck in the chin" to perform craniocervical flexion, and then raise their head off the base. In testing the neck extensor muscles, the subject was lying prone on a bench with the head unsupported. The subject was asked to hold the head steady with the chin retracted and the cervical spine in a neutral position. One test procedure also included extra weights attached to test subject's head (Ljungquist et al. 1999). In these endurance tests the time the subject was able to maintain the test position was recorded in seconds with a stopwatch. Some studies have reported that subjects with neck pain had a tendency to demonstrate lower neck muscle endurance than subjects without neck pain (Harris et al. 2005, Ljungquist et al. 1999). The intrarater reliability (ICC) for neck muscle endurance tests has been reported to range from 0.57 to 0.96 (Blizzard et al. 2000, Cleland et al. 2006b, Harris et al. 2005, Olson et al. 2006).

2.2.1.2 Associations between anthropometrical data and neck muscle strength

Males have consistently been reported to have higher maximal neck muscle strength than females. Jordan et al. (1999) reported males to be 20% to 25% stronger than females, whereas Garces et al. (2002) found the difference to be around 30% to 40%. Chiu et al. (2002) reported the widest range for the gender difference, finding males to be 20% to 70% stronger than females. Such an evident gender difference necessitates separate evaluation of neck muscle strength for males and females.

Only a few studies have reported the effect of age on neck muscle strength (Cagnie et al. 2007, Chiu et al. 2002, Garces et al. 2002, Jordan et al. 1999, Peolsson et al. 2001). In general, maximal muscle strength is known to peak between ages 20 to 30, and to decrease thereafter (Keskinen et al. 2004). Maximal isometric neck muscle strength seems to act somewhat differently. Jordan et al. (1999) found no statistical difference in neck strength among females 23 to 70 years of age, while among males neck strength deteriorated after the seventh decade. Chiu et al. (2002) studied females aged 20 to 80 years and reported that age did not affect female cervical muscle strength in flexion or extension. Similarly, Cagnie et al. (2007) found that the isometric strength of the cervical flexor and extensor muscles was not affected by age among males or females aged 20 to 59 years. In contrast, Garces et al. (2002) and Peolsson et al. (2001) found significant age-related decrements in isometric neck muscle strength (Table 1).

TABLE 1 Studies reporting on the effect of age on maximal isometric neck muscle strength in healthy subjects

Authors	Subjects	Measures, ICC (intrarater)	Effect of age
Cagnie et al. 2007	N=96 F=48, M=48, 20 to 59 years, in age groups 20-29, 30-39, 40-49, 50-59 years	Flexion, 0.96 Extension, 0.94	F, no effect of age M, no effect of age
Chiu et al. 2002	N=91 F=46, M=45, 20 to 84 years, in age groups 20-39, 40-59, 60-84 years	Flexion, Extension L lat. flex, R lat. flex Protraction, Retraction ICC ranged 0.92 to 0.99 direction not defined	F, no effect of age M, no effect of age
Garces et al. 2002	N=94 F=43, M=51, 20 to ≥60 years, in age groups 20-40, 41-60, ≥60 years	Flexion, Extension ICC not stated	F, significant decrease in strength with age M, the two older age groups were significantly weaker than the youngest, but did not differ from each other
Peolsson et al. 2001	N=101 F=50, M=51 25 to 64 years, in age groups 25-34, 35-44, 45-54, 55-64 years	Flexion, 0.94 to 0.97 Extension, 0.94 to 0.97 L lat. flex, 0.94 to 0.96 R lat. flex, 0.94 to 0.97	F, significant decrease in strength with age in all directions except lat flex. M, significant decrease in strength with age in all directions
Jordan et al. 1999	N=100 F=50, M=50, 20 to 70 years, in age groups 20-30, 30-40, 40-50, 50-60, 60-70 years	Flexion, 0.57 Extension, 0.94	F, no effect of age M, significant decrease in strength with age after 60 years of age

Abbreviations: ICC=inter correlation coefficient. N=number. F=female. M=male. R=right. L=left. lat. flex=lateral flexion.

The associations reported between height and neck muscle strength are conflicting. Jordan et al. (1999) observed a positive correlation between height and isometric neck muscle strength in flexion and extension in males but not in females, while Garces et al. (2002) reported a correlation between height and strength for both females and males. In contrast, Chiu et al. (2002) found no gender-related association between height and neck muscle strength.

A statistically significant correlation between body mass and neck strength in lateral flexion has been reported in men (Peolsson et al. 2001). Garces et al. (2002) found correlations between body mass and neck muscle strength among both males and females, while Chiu et al. (2002) found no such association.

2.2.1.3 Measurement of range of motion

The literature on measurement of the range of motion (ROM) of the cervical spine is considerable and has appeared during the 21st century. Williams et al. (2010) in their recent review, found 44 reliability studies published after the year 2000 and 22 before. Numerous systems for the assessing the mobility of the cervical spine have been used, such as visual estimation, tape measurement, two-arm goniometry, single inclinometry, dual inclinometry, gravity plus compass goniometry, potentiometry, x-ray, computer tomography, magnetic resonance imaging, optical motion analysis, and electro-, magneto- and ultrasonography-based systems (Antonaci et al. 2000, Chen et al. 1999, Jordan 2000, Prushansky et al. 2010, Viitanen et al. 1998, Williams et al. 2010).

Cervical spine mobility is difficult to assess accurately because of its complex anatomic structure and the tendency to compensatory movements (Bogduk & Mercer 2000). Chen et al. (1999) in their review stated that the variations within each technology used to assess ROM of the cervical spine, were as large as or even larger than those between technologies. This indicates that clinical procedures are as important as the accuracy of the measurement device itself (Chen et al. 1999). So far, none of the equipment measuring ROM of the cervical spine has attained the status of the gold standard (Chen et al. 1999). Some have reported x-ray measurements as a gold standard to assess the validity of the measurement device being studied (Alund & Larsson 1990, Lind et al. 1989, Ordway et al. 1997, Strimpakos et al. 2005, Tousignant et al. 2000, Tousignant et al. 2002). However, the reliability of radiography in this connection has not been shown (Chen et al. 1999). It may be more appropriate to conduct multiple concurrent validation studies with a number of methods to gain a better understanding of the validity of the device under evaluation (Williams et al. 2010). Pair-wise or group comparison of several different methods has been widely reported (Alund & Larsson 1990, Hermann & Reese 2001, Hole et al. 1995, Maksymowych et al. 2006, Malmström et al. 2003, Mayer et al. 1993, Morphett et al. 2003, Peolsson et al. 2000, Reynolds et al. 2009, Strimpakos et al. 2005, Tousignant et al. 2000, Tousignant et al. 2006, Youdas et al. 1991).

Visual estimation of ROM of the cervical spine has been found to be less reliable than two-arm goniometry or the purpose-built Cervical-range-of-motion instrument (CROM) exploiting gravity goniometers and compass goniometry (Youdas et al. 1991). There is a wide consensus that visual estimation is the least reliable and valid method for measuring ROM of the cervical spine (de Koning et al. 2008, Jordan 2000, Williams et al. 2010). Similarly, tape measurement and hand-held goniometry showed low reliability when compared with the CROM instrument (Reynolds et al. 2009). Several studies with similar findings indicate that tape measurement is doubtful for reproducibility and responsiveness (de Koning et al. 2008).

Clinicians commonly use visual estimation, inclinometers, and goniometers, whereas researchers, aiming at optimum accuracy attempt to use more complex methods such as 3-dimensional electromagnetic or audiovisual technologies (Williams et al. 2010). However, through a comprehensive evaluation of studies reporting the reliability of ROM measurement methods, Williams et al. (2010) came to the conclusion that the more "sophisticated" methods that are more likely to be used in research settings do not appear to offer greater reliability than the more "simple" devices commonly used in the clinic.

Several reliability and concurrent validity studies have been published on the CROM instrument among both symptomatic and asymptomatic groups (Audette et al. 2010, Fletcher & Bandy 2008, Hole et al. 1995, Lee et al. 2004, Morphett et al. 2003, Nilsson et al. 1996a, Olson et al. 2000, Peolsson et al. 2000, Rheault et al. 1992, Tousignant et al. 2000, Tousignant et al. 2002, Tousignant et al. 2006, Wang et al. 2005, Youdas et al. 1991, Youdas et al. 1992). Williams et al. (2010) in their systematic review concurred in the conclusion of an earlier systematic review by de Koning et al. (2008) that the CROM instrument had the best results for reliability and validity for passive and/or active movement. In a recent study by Fletcher & Bandy (2008) the intrarater ICC values for the CROM instrument among subjects without neck pain ranged from 0.87 to 0.94 and among subjects with neck pain from 0.88 to 0.96, in measurements conducted in different directions.

Cervical ROM measurements can be performed in different body positions. Measurement in a seated position is the most common and clinically most convenient. In their review, Williams et al. (2010) reported that in 47 studies measurements were done in a sitting position, while 7 studies used mixture of supine and seated, and 10 studies did not report the position. Measurement position may have influence on the mobility values observed, as in the supine position the subject does not have to support the head against gravity, and thus the muscles are more relaxed allowing a greater degree of motion.

Range of motion measurements can be performed to measure the full ROM through a motion plane or as half-cycles. The term "half-cycle" refers to motion observed in one direction (e.g. right or left, flexion or extension) from the anatomical neutral position. Generally, studies using full cycles (Hagen et al. 1997) have reported somewhat higher reliability values than studies using half cycles (Chen et al. 1999). This may be due to the difficulty of precisely defining and repositioning the head in the neutral position (Chen et al. 1999).

Cervical ROM can be assessed by measuring the active range of motion (AROM) and the passive range of motion (PROM). AROM measurement of the cervical spine reflects the individual's ability to move the head with muscular effort while PROM, performed by the examiner, reflects the limits of the range of motion set by passive structures such as the joint capsule, tendons and bony structures. Generally, PROM measurements have been found to show greater values and a smaller standard deviation than AROM measurements (Castro et al. 2000, Chen et al. 1999, Dvorak et al. 1992). Assink et al. (2005) also found PROM values to be greater than AROM values, but higher ICC values with AROM than PROM. Dvorak et al. (1992) reported that cervical AROM values were 4% to 9% lower than PROM values in lateral flexion and axial rotation, but 1% to 14% higher than PROM values in 3 other directions. However, the study comprised only 12 subjects (5 females, 7 males). The amount of difference between PROM and AROM has seldom been reported. In a recent report by Häkkinen et al. (2007), who measured 125 female patients with neck pain, the AROM values of the cervical spine were 12% to 14 % lower than the PROM. Also, in the study by Castro et al. (2000) with 12 subjects, the AROM values were 1% to 9% lower than the PROM values in full ROM movements.

2.2.1.4 Associations between anthropometrical data and cervical spine mobility

Regardless of whether measuring AROM or PROM, full cycles or half-cycles, females tend to show higher ROM values than males (Castro et al. 2000, Chen et al. 1999, Dvorak et al. 1992, Kuhlman 1993), although contradictory findings also exist (Feipel et al. 1999, Lind et al. 1989).

Mobility of the cervical spine, measured as AROM, has been shown to diminish with age in several reports (Chen et al. 1999, Dvorak et al. 1992, Hole et al. 1995, Lind et al. 1989, Peolsson et al. 2000, Sforza et al. 2002, Simpson et al. 2008, Youdas et al. 1992). In a meta-analysis by Chen et al. (1999) consisting of 37 active and 8 passive motion evaluation studies, the ROM of the cervical spine was concluded to diminish by approximately 4° per decade.

Several studies have reported on PROM of the cervical spine, with sample sizes varying from 5 to 150 subjects and consisting of both males and females, but none of them provide data on the effect of aging on the magnitude of PROM of the cervical spine (Assink et al. 2005, Bergman et al. 2005, Dvorak et al. 1992, Glanville & Kreezer 1937, McClure et al. 1998, Morphett et al. 2003, Nilsson et al. 1996b, Sandler et al. 1996, Strimpakos et al. 2005). Nilsson et al. (1996b) with a sample of 90 healthy subjects including males and females, found PROM of the cervical spine to diminish between the ages of 20 and 59 years. Dvorak et al. (1992), studying 150 healthy males and females, found an overall tendency for PROM of the cervical spine to decrease with age. However, the findings of these studies were inconsistent and neither reported the magnitude of the effect of aging on PROM. A summary of studies quantifying the effect of age on ROM in healthy subjects is presented in Table 2.

Studies reporting on the associations between body mass or height and ROM of the cervical spine are few and thus no conclusions can be drawn.

TABLE 2 Studies quantifying the effect of age on neck range of motion values in healthy subjects

Authors	Subjects	Technology, Measures, ICC (intrarater)	Magnitude of the effect of age
AROM studies			
Simpson et al. 2008	N=195 F=133, M=62 15 to 93 years	Radiography, Flexion, Extension, no repeated measures	5° decrease in total ROM in flexion/extension per decade
Malmström et al. 2006	N=120 F=60, M=60, 20 to 79 years, in age groups 20-29, 30-39, 40-49, 50-59, 60-69, 70-79 years	Ultrasonography 3-D motion analyzer, Flexion, 0.82* Extension, 0.91* Rot. to R, 0.76* Rot. to L, 0.80* Lat. flex to R, 0.83* Lat. flex to L, 0.83*	No decrease in ROM in flexion, decrease in ROM 5.9° in extension, 3.3° in rot. to R, 4.0° in rot. to L, 3.6° in lat. flex to R, and 3.8° in lat. flex to L per decade
Peolsson et al. 2000	N=101 F=50, M=51 25 to 63 years, in age groups 25-34, 35-44, 45-55, 55-64 years	Gravity/compass goniometer (CROM), Flexion/Extension, 0.90 to 0.94 Rot to R and L, 0.76 to 0.93 Lat. flex to R and L, 0.64 to 0.89	Decrease in ROM in Females/Males 0.3°/0.3° in flexion, 0.5°/5.1° in extension, 0.4°/4.4° in rot. to R, 0.3°/2.2° in rot. to L, 0.3°/2.7° in lat. flex to R, 0.3°/2.0° in lat. flex to L per year
Hole et al. 1995	N=84 F=40, M=44 20 to 69 years, in age groups 20-29, 30-39, 40-49, 50-59, 60-69 years	Gravity/compass goniometer (CROM), Flexion/extension, 0.96 Rot. to R, 0.92 Rot. to L, 0.92 Lat. flex to R, 0.96 Lat. flex to L, 0.96	Decrease in ROM 0.4° in flexion, 0.7° in extension, 0.4° in rot. to R, 0.5° in rot. to L, 0.4° in lat. flex to R, and 0.5° in lat. flex to L per year
Hole et al. 1995	N=84 F=40, M=44 20 to 69 years, in age groups 20-29, 30-39, 40-49, 50-59, 60-69 years	Inclinometer, Flexion/extension, 0.94 Rot. to R, 0.93 Rot. to L, 0.84 Lat. flex to R, 0.94 Lat. flex to L, 0.88	Decrease in ROM 0.4° in flexion, 0.6° in extension, 0.7° in rot. to R, 0.7° in rot. to L, 0.5° in lat. flex to R, and 0.5° in lat. flex to L per year
Youdas et al. 1992	N=337 F=171, M=166 11 to 97 years, in age groups 11-19, 20-29, 30-39, 40-49, 50-59, 60-69, 70-79, 80-89, 90-97 years	Gravity/compass goniometer (CROM), Flexion, 0.23 to 0.88 Extension, 0.89 to 0.96 Rot. to R, 0.58 to 0.99 Rot. to L, 0.81 to 0.95 Lat. flex to R, 0.60 to 0.94 Lat. flex to L, 0.67 to 0.90	Decrease in ROM 0.3° in flexion, 0.5° in extension, 0.4° in rot. to R, 0.3° in rot. to L, 0.3° in lat. flex to R, and 0.3° in lat. flex to L per year
Lind et al. 1989	N=70 F=35, M=35 12 to 79 years	Radiography, rotation by compass goniometer, Flexion, Extension, Rot., Lat. flex ICC not defined	Decrease in ROM 0.1° in flexion, 0.5° in extension, 0.6° in rot., and 0.5° in lat. flex per year
PROM studies			
No studies reported the magnitude of the effect of aging on passive neck range of motion values in healthy subjects			

*ICC values from study Malmström et al. 2003

Abbreviations: ICC=inter correlation coefficient. AROM=active range of motion. N= number. F=female. M=male. ROM=range of motion. 3-D= three dimensional. Rot.=rotation. R=right. L=left. Lat. flex.=lateral flexion. PROM=passive range of motion.

2.2.2 Subjective outcome measurements

In their best evidence synthesis the Neck Pain Task Force (Nordin et al. 2008) stated that patient-completed questionnaires play an important role in understanding patients' experience of disability and prognosis, and that they are useful in monitoring patients' status and response to treatment, and in clinical research. In clinical practice, self-administered questionnaires are commonly used to assess pain, function, disability, and the psychosocial status of patients with neck pain. Other purposes for the use of questionnaires include setting treatment goals, improving physician–patient communication, and standardizing interactions between health care providers and patients (McHorney & Tarlov 1995).

Subjective outcome measures may be broadly classified into generic and specific measures (Resnick 2005). Specific measures can be further classified into condition-specific, region-specific, and patient-specific measures (Resnick 2005). Generic measures assess a multitude of social, psychological and physical parameters. They can be helpful when comparing the health status of patients with different conditions or patients with the general population, or for monitoring patients with multiple conditions (Schaufele & Boden 2003). Specific measures assess factors related directly to the condition, body-region or patient him/herself and may be used in comparing health status between patients with similar complaints or affected body regions (Resnick 2005).

Subjective outcome measures have shown neck pain to be associated with increased disability (Cote et al. 1998) and decreased health-related quality of life (HRQoL) (Cook & Harman 2008, Daffner et al. 2003, Fanuele et al. 2000, Hermann & Reese 2001, Lobbezoo et al. 2004, Luo et al. 2004, Rezai et al. 2009, Saarni et al. 2006).

2.2.2.1 Neck specific questionnaires

According to Resnick et al. (2005) the evolution of questionnaires specific to the cervical spine began with the construction of the neck disability index (NDI), which was a modification of the Oswestry Low Back Pain Disability Questionnaire (Fairbank et al. 1980), by Vernon & Mior (1991). However, in 1988 Viikari-Juntura et al. (1988) had already introduced their Finnish neck pain and disability questionnaire using the Million Visual Analogue Scale, a questionnaire developed for the assessment of low back pain by Million et al. (1982), as a template. Since then, a variety of questionnaires has been introduced. In 2005, Resnick (2005) and in 2008, the Neck Pain Task Force (Nordin et al. 2008) found altogether 13 outcome assessment instruments specific to the cervical spine. Since then, two new measurement tools specific to the cervical spine have been introduced (Leonard et al. 2009, White et al. 2004). Measures specific to the cervical spine are listed according to the year of publication in Table 3.

TABLE 3 Chronology of cervical spine specific questionnaires

Measure	Abbreviation	Authors
modified Neck Pain and Disability Scale	mNPDS	Viikari-Juntura et al. 1988
Neck Disability Index	NDI	Vernon & Mior 1991
Northwick Park Neck Pain Questionnaire	NPQ	Leak et al. 1994
Disability Rating Index	DRI	Salen et al. 1994
Patient-Specific Functional Scale	PSFS	Westaway et al. 1998
Copenhagen Neck Functional Disability Scale	CNFDS	Jordan et al. 1998
Global Assessment of Neck Pain	GANP	Jordan et al. 1998
Neck Pain and Disability Scale	NPDS	Wheeler et al. 1999
Extended Aberdeen Spine Pain Scale	EASPS	Williams et al. 2001
Functional Rating Index	FRI	Feise & Michael Menke 2001
Bournemouth Neck Questionnaire	BNQ	Bolton & Humphreys 2002
Cervical Spine Outcomes Questionnaire	CSOQ	BenDebba et al. 2002
Problem Elicitation Technique	PET	Hoving et al. 2003
The short Core Neck Pain Questionnaire	CNPQ	White et al. 2004
Neck Pain Functional Limitation Scale	NPFLS	Leonard et al. 2009

Despite the accumulation of new neck specific questionnaires, only few of them have gained popularity. After a literature search for the disability questionnaires used as an outcome measure in the 21st century in intervention studies concerning rehabilitation of the neck, the most cited instrument was the NDI. Other instruments cited were NPQ, NPDS, PSFS, and mNPDS (Table 4).

While the NDI is recognized as the most cited instrument, it is also the most frequently evaluated for its psychometric properties. The NDI consists of 10 items concerning pain intensity, personal care, lifting, reading, headache, concentration, work, driving, sleeping, and recreation. Each item is scored from 0 to 5, with higher values representing greater disability. The maximum total raw score is 50, but the outcome is frequently expressed as percentage, as instructed by Fairbank et al. (1980). The NDI has been translated into and validated for several languages (MacDermid et al. 2009). Most of the studies found by MacDermid et al. (2009) in their systematic review, reported the reliability of the NDI to be acceptable, although the ICCs ranged from 0.50 to 0.98. Almost every study considered the NDI to be a one-dimensional measure, as revealed by factor analysis. The reported clinically important difference (CID) varied across different studies with raw scores ranging from 5/50 to 19/50.

TABLE 4 Disability questionnaires reported as an outcome in neck rehabilitation intervention studies in the 21st century.

Instrument	Study
NDI	Ask et al. 2009, Borman et al. 2008, Bronfort et al. 2001, Cleland et al. 2007, Dusunceli et al. 2009, Evans et al. 2002, Fritz & Brennan 2007, Giles & Müller 2003, Gustavsson & von Koch 2006, Gustavsson et al. 2010, Häkkinen et al. 2008, Hoving et al. 2002, Itoh et al. 2007, Jull et al. 2007, Walker et al. 2008, Wood et al. 2001, Ylinen et al. 2003b, Ylinen et al. 2007, Yoon et al. 2009, Young et al. 2009
NPQ	Chiu et al. 2005b, Chow et al. 2006, Gonzalez-Iglesias et al. 2009, Klaber Moffett et al. 2005, Lewis et al. 2007
NPDS	Chow et al. 2006, Griffiths et al. 2009, von Trott et al. 2009
PSFS	Wang et al. 2003, Young et al. 2009
mNPDS	Ylinen et al. 2003b, Ylinen et al. 2007

The NPQ (Leak et al. 1994), like NDI, is based on the Oswestry Questionnaire (Fairbank et al. 1980). Thus, the scales are very similar in format. The NPQ is composed of nine 5-part questions, each scored from 0 to 4 and summated. The ICC has been reported to range from 0.84 to 0.94 (Wlodyka-Demaille et al. 2002, Yeung et al. 2004).

The NPDS is a 20-item questionnaire developed by Wheeler et al. (1999) on the basis of the Million visual analog scale (Million et al. 1981). Each single question has a visual analog scale graded from 0 to 10. Usually three factors have been found to the NPDS. The ICC values for the different factors have been reported to range from 0.45 to 0.98 (Bremerich et al. 2008, Cook et al. 2006, Jorritsma et al. 2010).

The PSFS (Westaway et al. 1998) is based on the concept of a patient-generated list of problematic functions. The activities included in the PSFS are ranked according to severity of dysfunction on a scale from 0 to 10. ICC values of 0.82 to 0.92 have been reported and the minimal detectable difference score varies from 1 to 2 points (Cleland et al. 2006a, Westaway et al. 1998).

The mNPDS was developed by Viikari-Juntura et al. (1988), using the questionnaire reported by Million et al. (1982) as a template. The mNPDS is referred to in the Finnish Current Care Guideline for neck pain (Viikari-Juntura et al. 2009), and also in Fysiatria (a Finnish textbook of physiatrics) (Alaranta et al. 2009). The mNPDS consists of 13 items that measure the intensity of pain and how pain interferes with daily activities and work ability. For each item, a visual analog scale of 100 mm is used. A score of 0 represents no pain or disability and 100 represents the most severe pain or disability. The total score is the mean value of all the items completed. No previous reliability or validity data are available.

2.2.2.2 Generic questionnaires

Several generic instruments have been developed in order to assess a patient's overall health status and to evaluate and describe a patient's ability to function in general life activities. The HRQoL measurement focuses on individuals' own observations on their impairment and health and is thus an indication of the impact of disease on an individual's life (Cook & Harman 2008). Again, no gold standard exists for assessing HRQoL among patients with neck pain and several different instruments have been used: the Short Form-36 Health Survey (SF-36) (Ware & Sherbourne 1992) or subscales of the SF-36, such as the SF-12 (Ware et al. 1996), RAND-36 (Hays et al. 1993), which is identical to the SF-36 except for the recommended scoring algorithm, which is somewhat different, the 15 Dimensional HRQoL instrument (15D) (Sintonen 2001), the EuroQoL Group – 5 dimensional instrument (EQ-5D) (The EuroQol Group 1990), the Healthy Days Measures (Hennessy et al. 1994) and the Nottingham Health Profile (NHP) (Hunt et al. 1985).

In the published 21st century literature, the SF-36 is the most frequently reported instrument in intervention studies related to the neck region and reporting on HRQoL (Bronfort et al. 2001, Evans et al. 2002, Griffiths et al. 2009, Helewa et al. 2007), with 50 hits using as search terms: neck pain [Mesh] and SF-36. A similar search yielded one hit each for the RAND-36, the Healthy Days Measures and the Nottingham Health Profile, but no hits for the 15D. The search yielded five hits for the EQ-5D, of which four were for intervention studies.

The SF-36 was designed for the purposes of clinical practice and research, health policy evaluations, and general population surveys, and was introduced in 1992 by Ware & Sherbourne (1992). The SF-36 is a multi-item scale assessing eight health concepts: 1) limitations in physical activities; 2) limitations in social activities; 3) limitations in usual role activities; 4) bodily pain; 5) general mental health; 6) limitations in usual role activities; 7) vitality; and 8) general health perceptions, with scores for each dimension ranging from 0 (poor health) to 100 (good health) (Ware & Sherbourne 1992). The SF-36 has been frequently re-evaluated ever since by the original authors (McHorney et al. 1993, McHorney et al. 1994, McHorney & Ware 1995, McHorney et al. 1997, Ware 2000) and by several other authors. In a rather recent report by McCarthy et al. (2007) among patients with neck pain, the internal consistency of the SF-36 was 0.88 (Cronbach α) with ICC values ranging from 0.81 to 0.94 for the different dimensions of the SF-36, and the correlation with the NDI ranged from 0.45 to 0.74, $P<.001$.

The Finnish 15D includes the dimensions of mobility, vision, hearing, breathing, sleeping, eating, speech, elimination, usual activities, mental function, discomfort and symptoms, depression, distress, vitality, and sexual activity (Sintonen 2001). Each dimension has five grades of severity and it can be used both to obtain a profile across the 15 dimensions and a single index score ranging from 0 (being dead) to 1 (full health). In calculating the 15D score, valuations elicited from the Finnish population using the multiattribute utility method are used (Sintonen 1995). An ICC value of 0.93 for the total 15D has been reported (Stavem et al. 2001). The 15D and EQ-5D have been compared in a community sample of people with epilepsy to assess construct validity and the Spearman's rank correlations between corresponding items (mobility, usual activities, pain/discomfort, anxiety/depression) were 0.63, 0.77, 0.76, and 0.79, respectively, and 0.78 for the total scores (Stavem et al. 2001).

The EQ-5D addresses mobility, self-care, everyday activities, pain and anxiety/depression. To score, one of the three hierarchical levels is chosen in each dimension. The EQ-5D is commonly used in cost-effectiveness analysis and to derive quality-adjusted-life-year (QALY), including studies of neck pain (Korthals-de Bos et al. 2003, Lewis et al. 2007, Manca et al. 2006). The ICC value for the EQ-5D was 0.93 in the study where 15D and EQ-5D was compared in a community sample of 397 people with epilepsy (Stavem et al. 2001).

The Healthy Days Measures uses four questions for screening self-perceived health and the number of days that the respondents' physical health, mental health, or physical activity was limited or "not good" during the past 30 days (Hennessy et al. 1994). ICC values for the four separate questions have been reported to range from 0.57 to 0.75 among healthy subjects (Andresen et al. 2003).

The NHP is a self-administered questionnaire containing two parts where the first part comprises 38 statements (answered yes or no) that measure six dimensions: energy, pain, physical mobility, emotional reactions, sleep, and social isolation. The second part consists of seven statements concerning: paid employment, jobs around the house, social life, personal relationships, sex life, hobbies and interests, and holidays. Scores for each section can range from 0–100, a higher score indicating more severely compromised HRQoL (Hunt et al. 1985).

2.2.2.3 Measurement of pain

Pain, being a subjective experience, can be only measured through patient self report (Melzack & Katz 1999). Measurement of pain is important in determining the intensity, perceptual qualities and duration of the pain, aiding in diagnosis, helping to decide on the choice of therapy, and in evaluating the relative effectiveness of different therapies (Melzack & Katz 1999).

The most common methods used to assess the intensity of pain include the verbal rating scale (VRS), numerical rating scale (NRS), and visual analogue scale (VAS) (Katz & Melzack 1999). These methods provide simple, efficient, quick, and minimally intrusive measures of pain intensity to which a numerical value can be assigned for clinical and research purposes (Katz & Melzack 1999).

The VRS usually consists of words describing the intensity of pain listed in order from least to most intense pain. From these words the patient chooses the word that best reflects the intensity of pain experienced, the lowest rank scoring 0, the second 1, and so on (Katz & Melzack 1999).

The NRS consists of a series of numbers ranging from 0 to 10 or 0 to 100, where 0 means no pain and 10 or 100 the worst pain and the patient chooses the number best corresponding to the pain experienced (Katz & Melzack 1999).

The VAS consists normally of a 10-cm horizontal line with the two endpoints labeled “no pain” and “worst pain ever”. Patients are required to place a mark on the line at a point indicating the intensity of pain they feel. The result can be measured in mm from the low end of the VAS, ranging from 0 (no pain) to 100 (worst pain ever) (Huskisson 1974, Price et al. 1983). The VAS is sensitive to both pharmacologic and non-pharmacologic procedures that alter the patients’ experience of pain (Belanger et al. 1989, Choiniere et al. 1990, Price et al. 1986). The VAS is conceptually simple and has the advantages of being easy and quick to administer and score (Jensen et al. 1986) and is thus the most preferred of these three measurements when a one-dimensional measurement of pain is required (Katz & Melzack 1999).

The VAS is the most cited pain measure (Nordin et al. 2008) and has frequently been considered as the gold standard against which other questionnaires related to the neck region have been judged (Bicer et al. 2004, Hains et al. 1998, Kim et al. 2005, Mannion et al. 2006, Mousavi et al. 2007, Song et al. 2010, Telci et al. 2009, Wlodyka-Demaille et al. 2002, Wu et al. 2010).

2.3 Summary of the literature

Neck pain is a common condition where the tissue origin is seldom discovered. Its prevalence peaks in middle-age and it is more common among females than males. The etiology of non-serious neck pain appears to be multifactorial. Acute neck pain usually resolves without any special treatment, but neck pain often becomes chronic. Neck pain is associated with limited physical capacity in terms of neck muscle strength and cervical spine mobility. Neck pain may be associated with disability and reduced health-related quality of life. Several objective and subjective measurement instruments have been developed in order to assess phenomena related to neck pain.

The reliability and validity of outcome measures related to neck pain is no longer the key question as several established instruments have been shown to have adequate properties. However, the literature is sparse on the clinical utility of the different measurement instruments related to neck pain. Furthermore, neck-specific subjective outcome instruments have not been validated among Finnish patients with neck pain.

3 PURPOSE OF THE STUDY

The primary aim of this study was to investigate the predictive value, psychometric properties and clinical utility of the instruments commonly used in neck pain. The specific purposes were:

1) To study the effect of age on isometric neck muscle strength and passive range of motion of the cervical spine among healthy females of working age (Studies I and II).

2) To determine whether maximal isometric neck muscle strength or passive range of motion of the cervical spine predict incident neck pain among initially neck pain-free females (Study III).

3) To assess the reliability and validity of the Neck Disability Index (NDI) and the modified Neck Pain and Disability Scale (mNPDS) in Finnish patients with neck pain (Study IV).

4) To study whether generic 15 dimensional questionnaire (15D) is able to detect improvement in health-related quality of life after an effective rehabilitation intervention of neck pain (Study V).

5) To study the responsiveness of the physical capacity and subjective outcome measures commonly used in rehabilitation of neck pain (additional data).

4 MATERIAL AND METHODS

This doctoral dissertation consists of five different studies. These studies were conducted at the Central Finland Central Hospital and the Punkaharju Rehabilitation Centre between the years 2000 and 2008. The studies were approved by the local ethics committees and a written informed consent was obtained from all subjects before entering the study.

4.1 Subjects

For this dissertation, data from three separate subject groups were obtained. Female volunteers (I-III) without neck pain were recruited by sending information about the study to the personnel of large employers in the City of Jyväskylä. The subjects were primarily employees of the City of Jyväskylä, the local hospital and various industrial facilities, and consisted of both blue- and white-collar workers. The youngest age group consisted primarily of students. Out of 241 volunteers, 18 were excluded due to neck-shoulder symptoms and 3 due to failure to supply the information requested. A total of 220 females, aged 20 to 59 years, were enrolled in the study. The data were based on 10-year age ranges (20-29 years, n = 57; 30-39 years, n = 51; 40-49 years, n = 51; 50-59 years, n = 61). The baseline measurements (I and II) were obtained between November 2000 and October 2002 and the final questionnaires of the six-year follow-up study (III) were obtained in December 2008. For the assessment of the predictive value of the physical capacity measures (III), the respondents were categorized into two groups according to whether they had or did not have neck pain for more than a total of 7 days during the preceding year before completing the questionnaire (Figure 2).

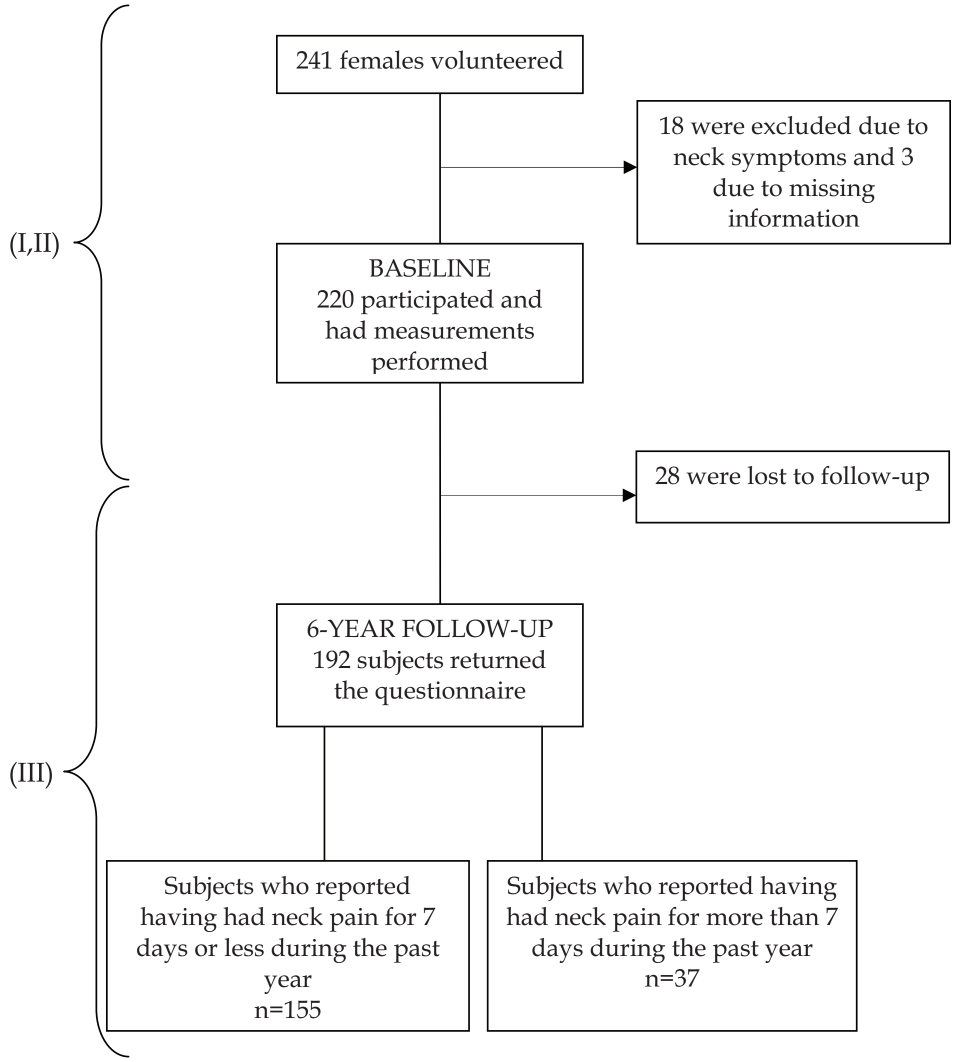


FIGURE 2 Flow chart of the study participants (I, II, and III)

The candidates for report IV, which studied the psychometric properties of the disability questionnaires, included patients with neck pain who were referred for specialist consultation to the physical and rehabilitation outpatient clinic in the Central Finland Central Hospital by their general practitioners and occupational physicians in Jyväskylä. A total of 101 (59 females and 42 males, aged 21 to 82 years) consecutive patients with neck pain entered the study. The trial was conducted between October 2006 and March 2008.

For the intervention report (V) data from the original study by Ylinen et al. (2003b) was used. Female office workers (n=347) with chronic neck pain and from different workplaces in southern and eastern Finland were referred to the study through their occupational health care systems. The candidates completed an application form in their local office of the Social Insurance Institution, which matched the information given on the form against the ordinary criteria for state-financed rehabilitation and sent accepted applications (n=301) to the Punkaharju Rehabilitation Centre. A questionnaire was mailed to these prospective participants to confirm their status regarding the inclusion and exclusion criteria. A total of 180 females, 25 to 53 years of age, met the inclusion criteria and entered the study. The trial was conducted between February 2000 and March 2002 (Figure 3).

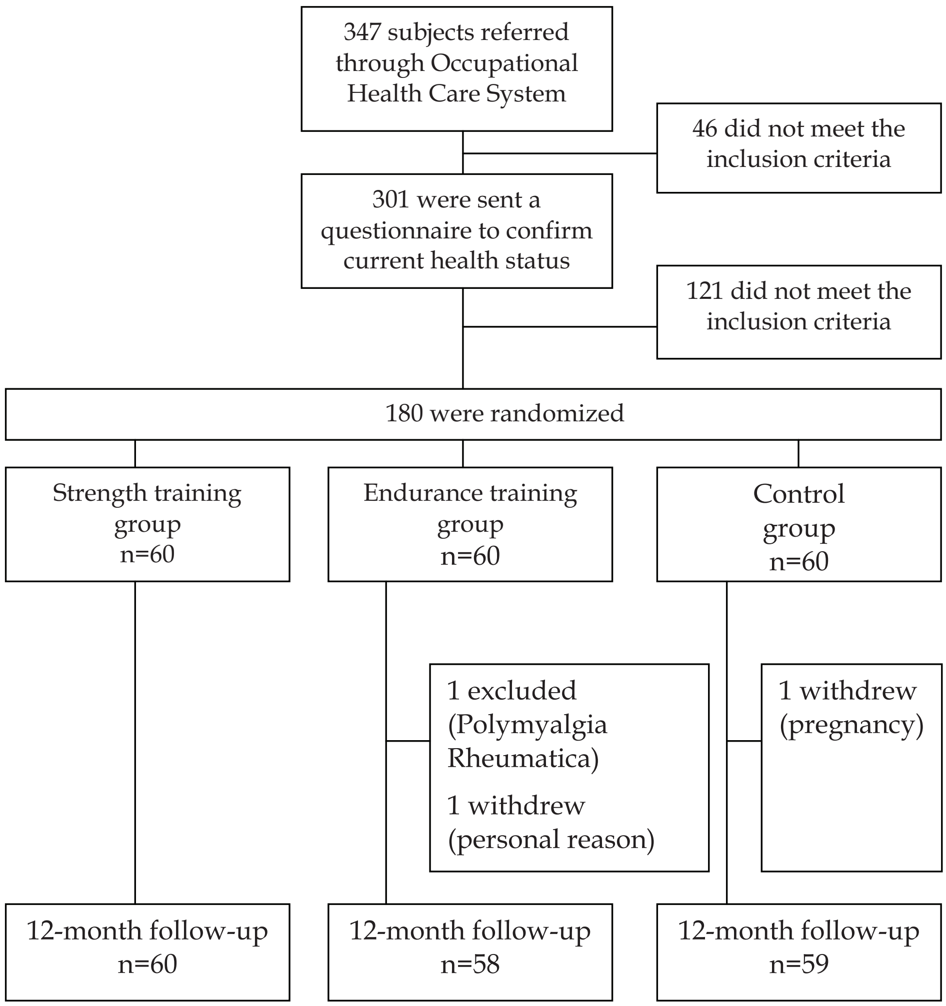


FIGURE 3 Flow chart of the intervention study (V)

4.2 Description of the intervention arms (V)

The subjects were randomized into three groups: a strength training group (STG, *n* = 60), an endurance training group (ETG, *n* = 60), and a control group (CG, *n* = 60). Both of the training groups participated in a 12-day rehabilitation program in a rehabilitation centre; the program was then performed as a home training program for one year.

The STG used a rubber band to train the neck muscles in a single series of 15 repetitions at a resistance level of 80% of the patient's maximum isometric strength as recorded at baseline. The patient sat in an upright position and one end of the rubber band was attached to the patients head and the other end to a sturdy stand. The patient then from the hips bent directly forwards, obliquely toward right and left and directly backwards. The posture of the spine was maintained erect throughout the exercise. The resistance level was checked with a handheld isometric strength testing device (Force-Five, Wagner Instruments, Greenwich, CT) at the baseline and at the 2- and 6-month follow-up visits for monitoring the progress of the training. In addition, a single adjustable dumbbell was used to perform upper body exercises: dumbbell shrugs, presses, curls, bent-over rows, flies, and pullovers. For each exercise, one set of 15 repetitions at the highest load possible was performed. Training was progressive such that if a patient could do 20 or more repetitions, weight was instructed to be added.

The ETG trained their neck muscles by lifting the head up from the supine position in three sets of 20 repetitions. The patients used a pair of dumbbells each weighing 2 kg to perform three sets of 20 repetitions of the same upper body exercises the STG was performing.

Both training groups exercised three times per week and in addition to neck specific exercises, they also performed a single series of squats, sit-ups, and back extension exercises in addition to 20 minutes of stretching exercises for the muscles trained.

The CG received written information and a single guidance session concerning the same neck-specific stretching exercises that the training groups were performing.

In addition, all three groups were encouraged to perform aerobic exercise three times a week for 30 minutes.

4.3 Measurements

4.3.1 Isometric neck muscle strength (I, III, V)

The neck muscle strength measurement system (NSMS, Kuntoväline Ltd., Helsinki, Finland) was used to assess isometric neck muscle strength in three different movement planes. The measurement system consists of a solid frame equipped with 2 adjustable rigid plates to stabilize the subject's trunk. The chest and waist are tightly held against the plates with wide straps at the level of the iliac crest and above the inferior angle of the scapula. The subject is seated with hips and knees at 90 degrees of flexion and the head is held in an upright neutral position.

To measure neck flexor strength, the subject faces the apparatus, and a bar with a force cell attached to it is placed against the forehead (Figure 4, left). To measure neck extension strength, the subject faces away from the apparatus, and the bar with the force cell is placed against the occiput.

FIGURE 4 Measurement of isometric neck flexion and rotation strength

Muscle strength for cervical spine rotation is measured with an overhead component consisting of 4 pads attached on both sides of the head (Figure 4, right). The head is maintained in a neutral position by tightening the pads on both sides simultaneously. The chin is supported with a bar to prevent head movement. The axis of rotation is adjusted by centralizing the overhead component so that it is on the same vertical line as the external auditory canals. The force cell is attached to the axis of the overhead component.

Neck strength was measured first for rotation, followed by flexion and extension. Two warm-up trials were performed, followed by 3 maximal trials in each direction. If the result of the third trial was 5% or more above the highest trial of the 2 previous trials in that direction, additional trials were performed until the improvement remained under 5%. The highest trial in each direction was used in the subsequent analyses. A one-minute rest period was taken between each trial and 2-minute rest period was provided when the direction of measurement was changed. Calibration of the measurement system was done with standard masses (10 kg and 20 kg).

The reliability of the present isometric neck strength measurement system has been shown to be good, with ICC values ranging from 0.94 to 0.98 for measurements conducted by the same tester on different measurement days (Ylinen et al. 1999). The system used here has also been used in several other studies (Häkkinen et al. 2008, Häkkinen et al. 2007, Oksanen et al. 2007, Valkeinen et al. 2002, Ylinen et al. 2003a, Ylinen et al. 2003b, Ylinen et al. 2003c, Ylinen et al. 2004a, Ylinen et al. 2004b). For the present study the intrarater measurements were obtained with 22 subjects at an interval of 1 week.

4.3.2 Passive range of motion of cervical spine (II, III, V)

The cervical measurement system (CMS, Kuntoväline Ltd, Helsinki, Finland) was used to measure PROM of the cervical spine. The CMS includes 2 gravity goniometers, a compass goniometer, and 2 fluid levels attached to a plastic frame. Movement in the three different movement planes is shown by the goniometers and compass in increments of 2 degrees.

For the measurement of PROM of the cervical spine the subject is seated in a chair with a backrest and the subject's chest is fixed with a wide strap to a solid frame to prevent movement of the trunk. The subject is seated with her feet flat on the floor and instructed to keep her lower back firmly against the backrest. The body and head are held in an upright neutral position. The CMS is mounted on the subject’s head and tightened with a screw located on the back of the plastic frame. The fluid levels are used to control the position of the CMS. This starting position is used in all the movement planes measured. The measurements are done in flexion-extension, axial rotation, and lateral flexion with pause of about half a minute between the directions measured (Figure 5).

FIGURE 5 Measurement of passive range of motion in extension (left) and lateral flexion (right)

The reliability of the present cervical spine mobility device on AROM measurements has been reported by Peolsson et al. (2000), with intrarater ICC values ranging from 0.86 to 0.96 and interrater ICC values ranging from 0.61 to 0.95. For validity, concurrent validity with the CROM measurement device has also been reported by Peolsson et al. (2000). The CMS measurement device used in the present study has also been reported to be used in several previous studies (Häkkinen et al. 2007, Ylinen et al. 2003b, Ylinen et al. 2004b, Ylinen et al. 2003c).

In the present study the intrarater reliability measurements for PROM of the cervical spine were performed at an interval of 1 week with 22 subjects.

4.3.3 Disability related to neck region (III, IV, V)

The Neck Disability Index

For this study a Finnish language version of the NDI was constructed according to the guidelines proposed by Beaton et al. (2000). Translation into Finnish was performed independently by 2 persons who produced a synthesized version afterwards. This translation was then compared to the NDI version already in use in Finland to produce a consensus version and was then blindly translated back into English by a native English linguist. The Finnish version of the NDI was finally evaluated by a Finnish linguist (Appendix 1). The reliability and validity of the NDI has been reported in several studies (see page 29), but no previous studies reporting on the psychometric properties of the Finnish version exist.

The modified Neck Pain and Disability Scale

The mNPDS is another neck questionnaire which is in active clinical use in Finland. The Finnish questionnaire consists of 13 items that measure the intensity of pain, and how pain interferes with daily activities and work ability. In the validation of the mNPDS, the same translation procedure as for the NDI was applied to the 13 items of the mNPDS (Appendix 2). No previous studies reporting on the reliability or validity of the mNPDS exist.

4.3.4 Health-Related Quality of Life (V)

To measure HRQoL the generic self-administered questionnaire 15D was used. An ICC value of 0.93 for the total 15D has been reported (Stavem et al. 2001). For construct validity, the 15D has been compared with the EQ-5D with correlation values between corresponding items (mobility, usual activities, pain/discomfort, anxiety/depression) of 0.63, 0.77, 0.76, and 0.79, respectively, and 0.78 for the total scores (Stavem et al. 2001).

4.3.5 Other measurements (I, II, III, IV, V)

Anthropometric measurements, including body height and body mass, were performed for all subjects and the participants completed questionnaires on health status, smoking habits, length of sick leave, work status, physical activity, and physical work load (I, II, and III). Physical work load was categorized as light work (e.g. sitting work), medium work (including standing, walking but not dealing with objects over 5 kg), and heavy work (dealing with heavy objects or tools). A visual analogue scale (Huskisson 1974) was used to assess possible pain in different body parts including the neck area (I, II, III, IV, V).

4.4 Statistical methods

Statistical analyses were performed using STATA (for Windows), version 8 and 10 (Stata Corp, College Station, TX, USA) or SPSS (version 11.0 and 15.0; Inc., Chicago, IL.).

Results are expressed as means with standard deviation (SD) or with 95% confidence intervals (95% CIs) (I-V), and as medians with interquartile ranges (IQRs) (I, II). Statistical comparisons among groups were done by analysis of variance (ANOVA) (I-IV) or by Fisher's exact test (II, III). Intrarater reliability was calculated using the intraclass correlation coefficient (ICC) with 95% CIs (I, II, V, and additional data in the summary). Correlation coefficients were calculated by the Pearson method for continuous variables and the Spearman method for discrete variables (I, II, V). The alpha level was set at 0.05 for all tests.

Study I: In addition to mean and SD values the strength results were also given after normalization to body mass, and the Sidak method was used in the *post hoc* analysis. In assessing the differences between groups, Hommel's method (Hommel 1988) was used to correct levels of significance.

Study II: Analysis of covariance (ANCOVA) with an appropriate contrast for linearity was used in analyzing the relationship between age groups and PROM. Regression analysis with PROM as the dependent variable and age and BMI as continuous predictors was used in estimating the mean annual decrease in PROM.

Study III: In the prediction of incident neck pain, the Receiver Operator Characteristics (ROC) curve and areas under the ROC curve with 95% CIs for maximal isometric neck muscle strength in extension, flexion and rotation and for the passive range of motion of the cervical spine in the sagittal, horizontal, and frontal planes were calculated.

Study IV: The percentage of single and total scores reaching floor or ceiling was calculated. Factor analysis with Varimax rotation was used to analyze the factor structure among the NDI-FI and the mNPDS-FI. Statistical significance for the hypotheses of linearity was evaluated by a bootstrap-type ANOVA, with covariates when appropriate. Kendall's coefficient of concordance was calculated to assess the degree of agreement among the NDI-FI and the mNPDS-FI as ranking raters. Cronbach's alpha was used to estimate internal consistency.

Study V: Due to skewed distributions the bootstrap technique (Efron & Tibshirani 1993) was used in testing the differences between groups in the 15 dimensions and the 15D total score. A bootstrap-type ANOVA was used to test differences at baseline and a bootstrap-type ANCOVA with baseline values as covariates was used to test changes between the groups. The Cohen method (Cohen 1988) was used to calculate the effect sizes and bias-corrected bootstrapping (5,000 replications) to obtain the confidence intervals (95% CIs) for the effect sizes (Algina et al. 2006). An effect size of 0.20 was considered as small, 0.50 as medium, and 0.80 as large.

Additional data (referring to the population of study V): The effect sizes were calculated using the Cohen method. Bias-corrected bootstrapping was used to obtain the confidence intervals (95% CIs) for the effect sizes. Responsiveness was assessed by calculating the ROC curve and areas under the ROC curve with 95% CIs for the mobility, strength, disability, and HRQoL measurements to distinguish patients who were responding the best to treatment (VAS ≤ 10, the lowest tertile) from those responding less well (VAS > 10, the two highest tertiles).

5 RESULTS

5.1 Sample characteristics

Among the neck pain-free volunteers (I, II, III), statistically significant differences were observed in the anthropometrical data among the age groups, with BMI ranging from 22 to 26 kg/m2 ($P<.001$) and body mass ranging from 62 to 70 kg ($P<.001$). Reported physical workload differed also significantly among the age groups ($P=.007$).

In the validation study (IV), the mean (SD) age of the subjects was 50 (12) years and mean (SD) neck pain intensity was 61 (26) mm on the VAS.

In the intervention study (V), the mean (SD) age of the subjects was 46 (6) years and the mean duration of neck pain was 8 (6) years. No statistically significant differences between the strength training, endurance training, and control groups were observed regarding age, body height or weight, BMI, or the duration or intensity of neck pain.

5.2 Effect of age and anthropometrics on physical capacity related to neck region (I, II)

5.2.1 Isometric neck muscle strength (I)

Absolute isometric neck strength values in flexion, extension or rotation did not differ among the four age groups in the healthy females studied. Across all the age groups, mean (SD) maximal isometric neck strength was 73.8 (20.0) N in flexion and 190.8 (31.3) N in extension. Mean (SD) rotation strength was 8.1 (2.3) Nm to the right and 7.9 (2.3) Nm to the left. Large variation within the groups was, however, observed (Table 5).

The flexor muscles of the cervical spine were weaker than the extensor muscles. The mean (95% CI) ratio between the flexion and extension strength values was 1: 2.7 (1:2.6 to 1:2.8).

A small, but significant positive association was observed between body mass and neck flexion strength (r=0.31, P<.01) and extension strength (r=0.25, P<.01). Also, a weak association between height and neck extension strength was found (r=0.19, P<.05). There was no association between rotation strength and height or body mass.

The intrarater ICC values for the isometric neck strength measurements (95% CI) were 0.87 (0.69 to 0.95) in flexion, 0.93 (0.83 to 0.97) in extension, 0.95 (0.87 to 0.98) in rotation to the right, and 0.96 (0.90 to 0.98) in rotation to the left.

TABLE 5 Maximal isometric neck strength of 220 healthy females

Measurement	Age group				P-value†
	20–29 years n=57	30–39 years n=51	40–49 years n=51	50–59 years n=61	
Flexion, N	78 ± 21 (72 to 83)	74± 18 (69 to 79)	72 ± 23 (66 to 78)	72 ± 18 (67 to 76)	0.70
Extension, N	193 ± 28 (185 to 200)	184 ± 30 (175 to 192)	197 ± 38 (187 to 208)	189 ± 27 (182 to 196)	0.55
Rotation Right, Nm	8.1 ± 2.1 (7.6 to 8.7)	7.8 ± 2.2 (7.2 to 8.4)	8.3± 2.6 (7.6 to 9.1)	8.1 ± 2.4 (7.5 to 8.7)	0.71
Rotation Left, Nm	7.9 ± 2.1 (7.4 to 8.4)	7.4 ± 2.2 (6.8 to 8.0)	8.2 ± 2.5 (7.5 to 8.9)	7.9 ± 2.3 (7.3 to 8.5)	0.41

Values are mean ± SD (95% confidence interval)
† P-value adjusted by Hommel´s method.
Abbreviations: N=Newton. Nm=Newton meter.

5.2.2 Passive range of motion of the cervical spine (II)

Passive range of motion of the cervical spine diminished linearly with increasing age in all measured movement planes (*P*<.001 for all movements except for flexion *P* =.018). The BMI-adjusted mean decrease in PROM per one year increase in age was 0.15° (95% CI: 0.04° to 0.27°) in flexion and 0.36° (95% CI: 0.22° to 0.51°) in extension. When flexion and extension were combined the BMI-adjusted mean decrease in PROM per year was 0.52° (95% CI: 0.32° to 0.72°). In lateral flexion, the BMI-adjusted mean decrease per year was 0.51° (95% CI: 0.34° to 0.68°) and in rotation 0.56° (95% CI: 0.33° to 0.78°) (Figure 6).

The passive cervical spine range of motion values in all directions for all four age groups are presented in Table 6.

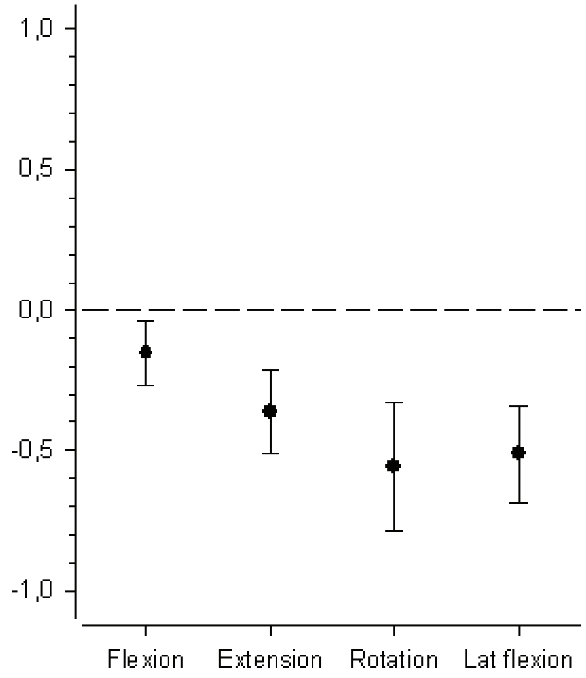


FIGURE 6 Mean change in degrees in passive range of motion per 1-year increment in age in females between 20 to 59 years. Whiskers show 95% confidence intervals.

A moderate positive association was found between PROM and BMI, with the highest value for cervical spine extension (r=0.35, P<.001). A weak association between physical work load and PROM was observed, with the highest value for frontal plane motion (r=0.18, P=.007). PROM values were not associated with height.

The ICC values for the measurement of passive range of motion were (95% Cl) 0.79 (0.49 to 0.91) for flexion, 0.92 (0.81 to 0.97) for extension, 0.84 (0.62 to 0.93) for rotation, and 0.90 (0.77 to 0.96) for lateral flexion.

TABLE 6 Passive cervical spine range of motion in 220 healthy females.

Measurement	Age groups				P-values†	
	20-29 years n=57	30-39 years n=51	40-49 years n=51	50-59 years n=61	Between groups	Linearity
Flexion, °	75 ± 11 (73 to 78)	74 ± 10 (72 to77)	71 ± 9 (69 to 74)	70 ± 9 (68 to73)	0.096	0.018
Extension, °	104 ± 13 (101 to 107)	95 ± 11 (92 to 99)	94 ± 13 (91 to 97)	89 ± 13 (86 to 93)	<0.001	<0.001
Flexion-Extension, °	179 ± 19 (174 to 183)	170 ± 15 (165 to 174)	165 ± 17 (161 to 170)	160 ± 17 (155 to 164)	<0.001	<0.001
Rotation, °	200 ± 19 (196 to 205)	194 ± 18 (189 to 200)	188 ± 20 (183 to 194)	183 ± 18 (178 to 188)	<0.001	<0.001
Lateral Flexion, °	101 ± 16 (97 to 105)	91 ± 13 (87 to 94)	88 ± 15 (84 to 91)	84 ± 12 (80 to 87)	<0.001	<0.001

Values are mean ± SD (95% confidence interval)
† Analysis of covariance, body mass index as a covariate

5.3 Physical capacity measurements in predicting neck pain (III)

Of the 220 volunteers that originally entered the study, 192 (87%) returned the 6-year questionnaire. Of these responders 37 (19%) reported having had neck pain for more than 7 days during the preceding year before completing the questionnaire. There were neck pain cases in every initial age group (20-29 y., n=9; 30-39 y., n=9; 40-49 y., n=6; 50-59 y., n=13). In predicting neck pain, areas under the curve (AUCs) (95% CIs) in different movement planes were 0.52–0.56 (0.41–0.66) for isometric neck strength and 0.54–0.56 (0.44–0.76) for passive mobility of the cervical spine (Figures 7 and 8). The results suggest that neither isometric neck muscle strength nor passive mobility of cervical spine have predictive value for later occurrences of neck pain among originally pain-free females.

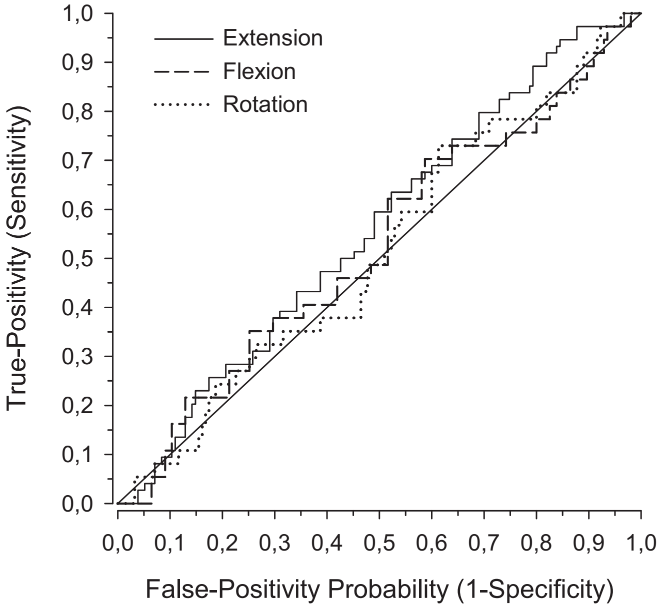


FIGURE 7 Receiver operator characteristics curves for the prediction of neck pain at the six-year follow up based on maximal isometric neck strength for extension, flexion, and rotation at baseline.

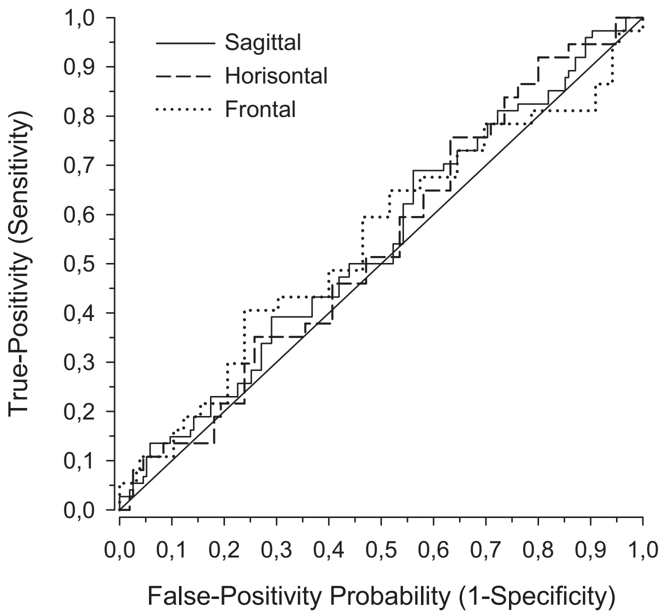


FIGURE 8 Receiver operator characteristics curves for the prediction of neck pain at the six-year follow up based on passive mobility of the cervical spine in the sagittal, horizontal, and frontal planes at baseline.

5.4 Psychometric properties of the NDI-FI and mNPDS-FI (IV)

In the validation study, the mean (SD) total score at the first completion of the questionnaire was 37.6 (15.3) for the NDI-FI and 48.9 (19.0) for the mNPDS-FI. Between the first and second completion of the questionnaires, the mean change (95% CIs) in the NDI-FI total scores among the patients reporting their symptoms to have worsened (n=16) was 3.9 (0.5 to 7.3), among those with stable symptoms (n=65) –3.3 (–4.9 to –1.8), and among those with improvement (n=17) –5.1 (–10.1 to –0.3) (P<.001 for linearity). Between the first and second completion of the questionnaires, the mean change (95% CIs) in the mNPDS-FI total scores among the patients reporting their symptoms to have worsened (n=15) was –0.2 (–3.2 to 2.4), among those with stable symptoms (n=64) –2.9 (–5.8 to –0.4), and among those with improvement (n=17) –11.3 (–2.7 to 0.4) (P<.032 for linearity) (Figure 9). The response rate varied from 81% to 100% on the NDI-FI items and from 80% to 98% on the mNPDS-FI items.

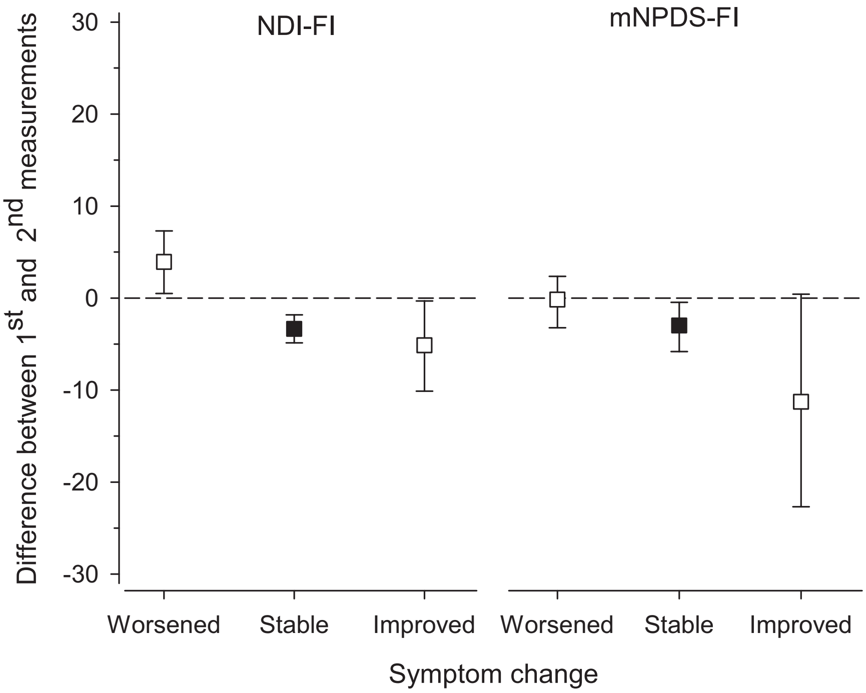


FIGURE 9 Mean change in total score of the Neck Disability Index—Finland (NDI-FI) and the modified Neck Pain and Disability Scale—Finland (mNPDS-FI) between the first and second completion of the questionnaires. Error bars indicate 95% confidence intervals.

Floor and ceiling effect

No values reaching floor or ceiling on total scores of the NDI-FI or the mNPDS-FI were detected. In the NDI-FI items of personal care and concentration 51% and 37% of the responders, respectively, scored at the lower end of the scale.

Validity

Factor analysis identified 1 factor for the NDI-FI and 3 factors for the mNPDS-FI (Table 7). The correlation between neck pain and the NDI-FI was 0.58 (P<.001) and between neck pain and the mNPDS-FI 0.72 (P<.001). A statistically significant linear relationship was observed between self-estimated coping and the outcomes of the NDI-FI and the mNPDS-FI (P<.001). The NDI-FI was associated with neck pain (0.53; P<.001), headache (0.43; P<.001), and upper limb pain (0.36; P<.001). Similarly, the mNPDS-FI was associated with neck pain (0.69; P<.001), headache (0.44; P<.001), and upper limb pain (0.58; P<.001). Kendall's coefficient of concordance between the NDI-FI and the mNPDS-FI was 0.46.

TABLE 7 Explanatory factor analysis with Varimax-rotated factor loadings of the mNPDS-FI* function items. Coefficients with values < 0.40 not shown.

Item	ADL†	Pain	Work ability
1. How severe is your pain?		0.73	
2. How severe is your pain at night?		0.84	
3. Do you get relief from pain killers?		0.41	
4. Do you have any stiffness in the neck?	0.67		
5. Do you have discomfort when looking upwards?	0.70		
6. Do you have discomfort when turning your head to the sides?	0.79		
7. Does your pain interfere with your ability to work with hands overhead?	0.51		
8. Does your pain interfere with your ability to comb your hair?	0.61		
9. Does your pain interfere with your ability to put on your coat?	0.51		
10. How severe is your pain when lying down in bed?		0.81	
11. What is your overall handicap in your complete lifestyle because of your pain?			0.56
12. To what extent does your pain interfere with your work?			0.92
13. To what extent have you had to modify your work in order to be able to do your job?			0.62

* Modified Neck Pain and disability Scale - Finnish
†Activities of daily living

Reliability

The test-retest reliability ICC (95% CIs) among the "stable" patients was 0.94 (0.90 to 0.96) for the NDI-FI total score and 0.91 (0.86 to 0.95) for the mNPDS-FI total score. Cronbach's α, representing internal consistency, was 0.85 for the NDI-FI and 0.90 for the mNPDS-FI. For the 3 factors of the mNPDS-FI, the internal consistency values were 0.84 (activities of daily living), 0.83 (pain), and 0.82 (work ability).

5.5 15D in assessing health-related quality of life (V)

After the 12-month intervention, statistically significant improvement in health-related quality of life was observed for the strength training group and the endurance training group, whereas no change was observed for the control group (P=.012, between groups, ETG vs. CG and STG vs. CG). Statistically significant gains were observed in the dimensions of sleeping, elimination, mental function, distress, and vitality in the strength training group and in the dimensions of sleeping and vitality in the endurance training group. In the control group, statistically significant deterioration was observed in the dimension of mental function. Effect size (95% confidence intervals) for the 15D total score was 0.39 (0.13 to 0.72) for the strength training group, 0.37 (0.08 to 0.67) for the endurance training group, and –0.06 (–0.25 to 0.15) for the control group. The effect sizes of the 15 dimensions and total 15D score are illustrated in figure 10.

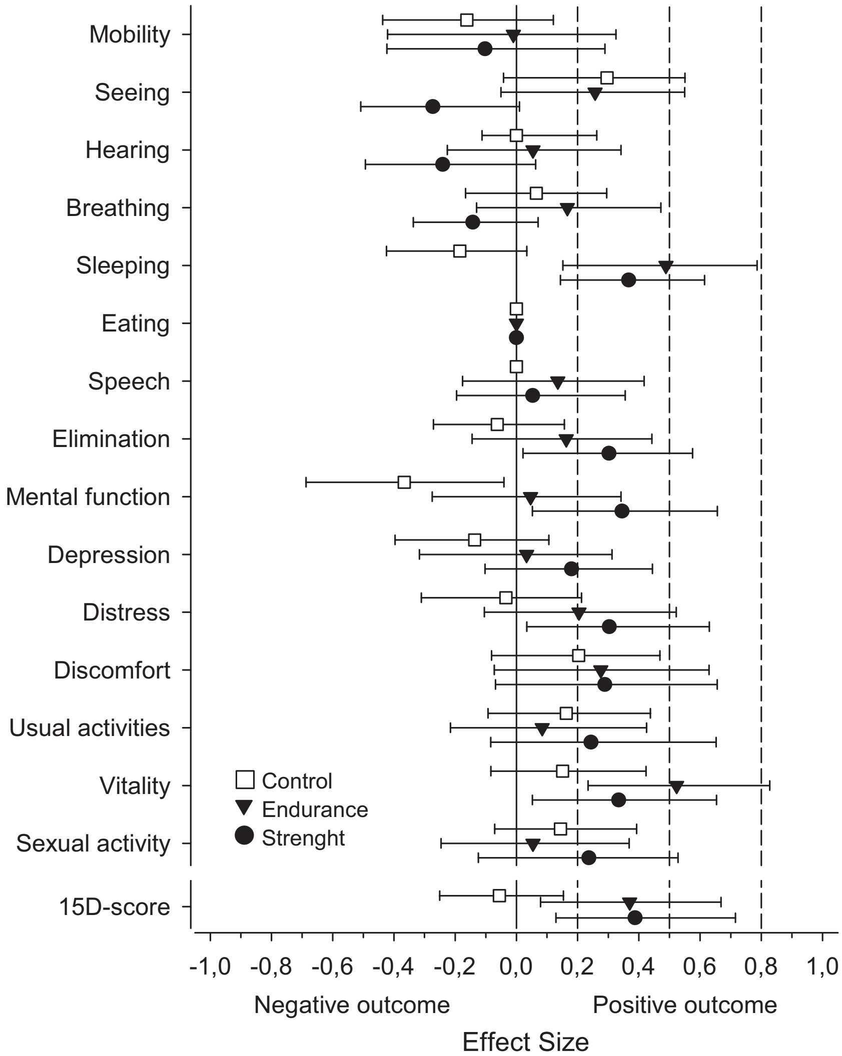


FIGURE 10 Effect sizes of the 15 dimensions and total score of the 15D. Error bars indicate 95% confidence intervals. Small (0.20), medium (0.50), and large (0.80) effect sizes are illustrated with dotted lines.

5.6 Responsiveness of the physical capacity and subjective outcome measurements (additional data)

Of the 179 subjects studied (V), the lowest tertile (58 subjects) assessed their pain to be 10 mm or less (responders) and the two highest tertiles (121 subjects) more than 10 mm (non-responders) on the VAS after the one-year intervention.

Of the mobility measurements lateral flexion showed the largest effect size (95% confidence intervals) of 1.38 (1.09 to 1.76) among responders. However, in the mobility measures, the effect sizes of responders differed from those of non-responders only for rotation, where the effect sizes (95% confidence intervals) were 0.80 (0.58 to 1.01) and 0.29 (0.12 to 0.46) respectively.

In the strength measurements the effect sizes observed among responders differed from those of non-responders in every direction measured. The largest effect size (95% confidence intervals) was observed for rotation strength, which was 1.99 (1.68 to 2.35) for responders.

In both disability questionnaires the effect size of responders differed from that of non-responders. An effect size (95% confidence intervals) of 2.76 (2.30 to 3.28) was found for the mNPDS measurement and 1.44 (0.97 to 1.91) for the NDI-FI among responders.

The effect size (95% confidence intervals) of the health-related quality of life measurement was 0.55 (0.20 to 0.88) for responders and 0.12 (–0.04 to 0.28) for non-responders (Figure 11).

The minimum clinically important difference (MCID) was defined as the amount of change that best distinguishes responders from non-responders. The AUC ranged from 0.51 to 0.68 for the ROM measurements, from 0.68 to 0.76 for the strength measurements, and from 0.62 to 0.72 for the subjective outcomes. Among the subjective outcomes, the optimal cut-off of change defined as MCID was 14 mm for the mNPDS-FI, 5 points for the NDI-FI, and 0.049 points for the 15D score. For the physical capacity measures the MCID was 2 Nm for rotation strength, 18 N for flexion strength and 27 N for extension strength. The MCID values for the PROM values ranged from 1° for flexion to 26° for extension. Sensitivity, specificity, and likelihood ratio for positive result for discriminative ability are presented in table 8.

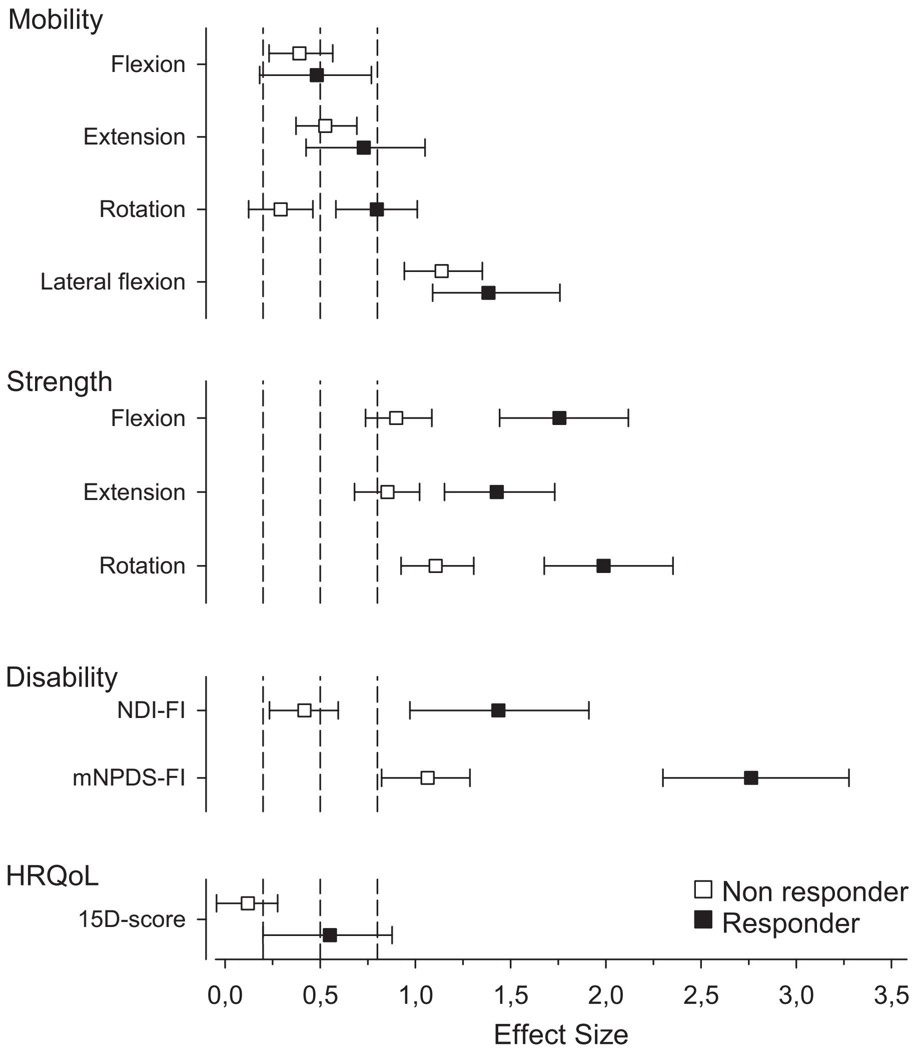


FIGURE 11 Effect sizes of the mobility, strength, disability, and HRQoL measurements for responders to the intervention (neck pain on VAS ≤ 10) and non-responders (neck pain on VAS > 10). Error bars indicate 95% confidence intervals. Small (0.20), medium (0.50), and large (0.80) effect sizes are illustrated with dotted lines.

Abbreviations: NDI-FI=Neck Disability Index - Finnish. mNPDS-FI=modified Neck Pain and Disability Scale - Finnish. HRQoL=Health-related quality of life. VAS=Visual Analog Scale.

TABLE 8 Results for discriminative ability

Measurement	Optimal cut-off of change	AUC (95% CI†)	Sensitivity (95% CI)	Spesificity (95% CI)	LR+ (95% CI)
Mobility					
Flexion, °	1	0.51 (0.42 to 0.60)	0.74 (0.61 to 0.85)	0.31 (0.23 to 0.40)	1.08 (0.89 to 1.31)
Extension, °	26	0.68 (0.60 to 0.77)	0.69 (0.55 to 0.80)	0.64 (0.54 to 0.72)	1.90 (1.42 to 2.54)
Rotation, °	3	0.64 (0.55 to 0.72)	0.72 (0.59 to 0.83)	0.49 (0.39 to 0.58)	1.41 (1.12 to 1.79)
Lateral flexion, °	17	0.54 (0.45 to 0.63)	0.53 (0.40 to 0.67)	0.60 (0.50 to 0.69)	1.33 (0.96 to 1.83)
Strength					
Flexion, N	18	0.76 (0.68 to 0.83)	0.78 (0.65 to 0.87)	0.69 (0.60to 0.77)	2.47 (1.83 to 3.33)
Extension, N	27	0.68 (0.60 to 0.77)	0.69 (0.55 to 0.80)	0.64 (0.55 to 0.73)	1.94 (1.44 to 2.61)
Rotation, Nm	2	0.74 (0.66 to 0.82)	0.78 (0.65 to 0.87)	0.66 (0.56 to 0.74)	2.25 (1.70 to 2.99)
Disability					
NDI-FI	5	0.72 (0.64 to 0.80)	0.77 (0.64 to 0.88)	0.56 (0.47 to 0.66)	1.78 (1.37 to 2.30)
mNPDS-FI	14	0.72 (0.64 to 0.79)	0.88 (0.77 to 0.95)	0.47 (0.38 to 0.56)	1.66 (1.37 to 2.02)
HRQoL					
15D-score	0.049	0.62 (0.53 to 0.71)	0.38 (0.26 to 0.52)	0.87 (0.80 to 0.93)	3.01 (1.69 to 5.36)

† 95% confidence interval (CI) obtained by bias-corrected bootstrapping.

Abbreviations: AUC=Area Under the Curve. LR+=Likelihood Ratio positive. N=Newton. Nm=Newton meter. NDI-FI=Neck Disability Index-Finnish. mNPDS-FI=modified Neck Pain and Disability Scale-Finnish. HRQoL=Health-Related Quality of Life. 15D=15 Dimensional measurement.

6 DISCUSSION

6.1 Physical capacity measurements

Although physical capacity measures – neck muscle strength and cervical spine mobility – have been related to neck pain in several studies, the causality between these phenomena and neck pain has remained obscure. We do not know whether weak neck muscles cause neck pain or whether neck pain results in a weak musculature. Reverse causality may be true for restricted ROM of the cervical spine as well. If there was a causal relationship between weak neck muscles, restricted mobility of cervical spine and onset of neck pain, this would offer us the possibility to take appropriate actions e.g. exercise, to prevent neck pain. However, few longitudinal studies have explored this issue.

6.1.1 Phenomena related to neck muscle strength and mobility of cervical spine

The effect of age on both maximal isometric neck muscle strength and passive range of motion of cervical spine was studied. While neck pain may be a long-standing problem for some, lasting for years or even decades, it is important to be aware of the natural course of the values we frequently use to assess neck pain; we should be able to distinguish between the effect of a disease and the normal processes of aging. Moreover, in addition to the obvious differences between the sexes, we should be aware of the possible influence of individual characteristics such as body height and body mass on physical capacity measures.

Age

Based on the data obtained in the present study, there was no statistically significant difference in absolute neck muscle strength among neck pain-free females between the ages of 20 to 59 years, when subdivided into 10-year age-groups. This is in line with previous findings reporting that among both males and females it may be possible for neck muscle strength levels to be maintained up to the seventh decade (Cagnie et al. 2007, Chiu et al. 2002, Jordan et al. 1999). However, in two other studies a significant decrease in neck muscle strength with aging was found (Garces et al. 2002, Peolsson et al. 2001). These diverse findings may be due to differences in measurement devices and techniques and especially due to the small sample sizes in the age groups. For example, in the study by Peolsson et al. (2001) the subjects' body was not fixed allowing the trunk muscles potentially to affect the measurement. Similarly, in flexion measurement in the same study the cervical spine was in slight flexion, while in other studies the cervical spine was stated to be in a neutral position. Cagnie et al. (2007) performed the measurements in supine and prone while others measured the test subject in the sitting position. An important factor influencing the results may have been that all the above-mentioned studies included both males and females. Thus the number of female participants in those studies varied from 43 to 50, whereas in the present study the number of females studied was 220, thereby increasing the reliability of the results.

In contrast to neck muscle strength, mobility of the cervical spine seems to diminish with age. Chen et al. (1999) in their meta-analysis on AROM and PROM measurement studies concluded that the overall ROM (not specifying the direction or measurement method) of the cervical spine decreases by 4° per decade. The finding of Chen et al. (1999) is more likely to be based on AROM studies, since no studies on the effect of aging on PROM mobility of the cervical spine have been reported. Dvorak et al. (1992) and Nilsson et al. (1996b), with a total sample size of 240 males and females reported PROM of the cervical spine to decrease with increasing age. However, neither of these studies reported the magnitude of the reduction in PROM with aging.

The present study is the first to quantify the effect of age on PROM of cervical spine. The overall PROM of the cervical spine was found to diminish linearly by 6° per decade when adjusted for BMI, which is similar to the decrease in AROM observed in the meta-analysis (Chen et al. 1999). However, one has to keep in mind that AROM and PROM measures somewhat different phenomenon. AROM reflects more the individual's ability to move the head with help of muscular effort while PROM reflects the limits of the range of motion set by passive structures such as the joint capsule, tendons and bony structures. Furthermore, the present sample consisted of females only, while the conclusions of the meta-analysis (Chen et al. 1999) were based on studies combining the results of both males and females despite the fact that cervical mobility has been shown to be greater in females.

Height

In the present study among neck pain-free females, height correlated only weakly ($r=0.19$, $P<.01$) with isometric neck muscle strength and only in extension. An earlier study by Jordan et al. (1999) showed a positive correlation between height and isometric neck muscle strength in flexion (r=0.42, P<.05) and extension (r=0.53, P<.05) in males but not in females. Garces et al. (2002) found correlations (r=0.54 to 0.64, P<.0001) between height and strength for both females and males, but did not report the correlations for different measurement directions. Chiu et al. (2002) found no association in either sex. Studies reporting on the association between height and neck muscle strength are few and inconsistent. Also, in small samples where the variation in height is small it may be difficult to detect the effect of height on strength. Thus on the basis of the literature to date, no definite conclusions on the effect of height on neck muscle strength can be drawn.

In line with Norlander (1995), the present study found a marginal influence of height on mobility values. Due to the limited number of studies no further conclusions can be made.

Body mass and BMI

The present study discovered only small but significant associations between body mass and neck flexion (r=0.31, P<.01) and extension (r=0.25, P<0.1) strength among females. Peolsson et al. (2001) found significant correlations between body mass and neck strength only in lateral flexion to the right (r=0.31, P= 0.03) and left (r=0.31, P= 0.03), and only in men. Garces et al. (2002) found correlations (r=0.46 to 0.54, P<.001) between body mass and neck muscle strength (measured in flexion and extension) among both males and females. Chiu et al. (2002) reported no association in males or females.

Studies reporting an association between body mass or BMI and cervical spine mobility are rare. In the present study, a moderate association between PROM of the cervical spine and BMI was found, with the highest value in extension (r=0.35, P<.001). Malmström et al. (2006) found that BMI had an influence on extension mobility in females, but not in males. Norlander (1995) reported that mobility values were less influenced by individual factors such as the body mass.

Overall, there seems to be wide variation in the results of the different studies reporting on the associations between physical capacity related to the neck region and anthropometric data, the correlations being moderate at best. Differences in the instrumentation and implementation of the physical capacity measurements along with differences between the study populations might explain a great deal of this diversity in results.

Strength ratio

The neck flexor muscles are clearly weaker than the neck extensor muscles. In the present study (I) the ratio between neck flexors and extensors was 0.4. Jordan et al. (1999), in turn reported a flexion/extension strength ratio of 0.6 for both males and females. Kumar et al. (2001) reported the same strength ratio of 0.6 in females. Garces et al. (2002) found the flexion/extension strength ratio to be around 0.6 for both sexes in all angles evaluated. There seems to be no gender difference in the strength ratio between neck flexors and extensors (Garces et al. 2002), although males present roughly 20% to 70% higher neck strength values than females (Chiu et al. 2002, Garces et al. 2002, Jordan et al. 1999). The present study showed a lower strength ratio between the neck flexor and extensor muscles than reported in previous studies. In the instrumentation of the present study a sturdy metal arm pressed against the chest effectively prevented use of the trunk muscles and movement of the torso in flexion. In the previous studies (Chiu et al. 2002, Garces et al. 2002, Kumar et al. 2001), in measuring flexion the body was constrained by a crossed shoulder harness to eliminate contribution to movement of the trunk musculature. It is possible that crossing belts do not restrict the use of trunk muscles as effectively as a metal bar. In extension, in both the previous and present studies, a sturdy support, either a back rest or a metal bar, was used. Jordan et al. (1999) used a device in which the body was not fixed at all during the flexion measurement whereas extension was measured using a back rest. A further explanation to the discrepancies in the results may be that in the studies by Jordan et al. (1999) and Chiu et al. (2002) the measurements were done with the cervical spine held at different angles as compared to the neutral position in the other studies, including the present study.

6.1.2 Neck muscle strength and mobility of the cervical spine in predicting neck pain

Areas under the curve were calculated for the ability of the neck strength measurements and cervical spine mobility measurements to differentiate between subjects with neck pain and without neck pain 6 years after the baseline measurements. The AUC varies theoretically from 0.5 (no accuracy in discriminating subjects with neck pain from those without neck pain) to 1.0 (perfect accuracy) (de Vet et al. 2001). As the values ranged in the present study from 0.52 to 0.56, it was concluded that isometric neck muscle strength or PROM of the cervical spine had no predictive value over incident neck pain. Also Hämäläinen et al. (1994), found no connection between the physical capacity measures and in-flight neck pain. To the present author's knowledge, no other prospective studies on the effect of isometric neck muscle strength and PROM of the cervical spine on incident neck pain have been published.

In addition to weak maximal isometric neck muscle strength, poor endurance of the neck extensor muscles has been associated with neck pain (Jordan et al. 1997). A few studies with somewhat conflicting results have been published on neck muscle endurance and later occurrence of neck pain. One prospective study in 53 healthy office workers found no relationship between neck muscle endurance and the occurrence of neck pain during a one-year surveillance period (Hush et al. 2009). Another study reported that poor neck muscle endurance predicted future neck pain (RR = 1.22; 95% CI 1.00 to 1.49) among 1789 Dutch workers over a 3-year follow-up (Hamberg-van Reenen et al. 2006). However, in that study the participants were allowed to experience some discomfort (feeling of pain, fatigue, tremor etc. scoring less than 4 on a scale from 0 to 10) in the neck region at baseline and this may have caused some bias.

With respect to mobility of the cervical spine, Hush et al. (2009) found some evidence that cervical flexion-extension mobility ≥ 120° was protective towards neck pain. In whiplash-associated disease, Kasch et al. (2001) found that cervical ROM test had high sensitivity in predicting handicap after acute whiplash injury, which is in line with the later findings of Sterling et al. (2006).

The limited number of studies restricts any conclusions on the ability of physical measures to predict neck pain. The current data indicate that isometric neck muscle strength is incapable of predicting future neck pain among neck pain-free subjects, while the findings for neck muscle endurance are more conflicting. Among patients, ROM measurements of the cervical spine might have relevance in predicting future conditions, especially among WAD patients.

In a recent systematic review, Hamberg-van Reenen et al. (2007) found strong evidence for no relationship between trunk muscle endurance and the risk for low back pain. Evidence for a relationship between trunk muscle strength, or mobility of the lumbar spine and the risk of low back pain was as inconclusive as between physical capacity measures and the risk for neck/shoulder pain (Hamberg-van Reenen et al. 2007).

6.2 Psychometric properties of the NDI-FI and mNPDS-FI

To avoid multiplication of outcome measures and to enhance cohesion in neck pain research, translation and adaptation of an instrument that has gained popularity and acceptance in the scientific community, is recommended rather than the creation of a new questionnaire. Further, to be able to make reliable comparisons between different patient populations with different languages and cultural backgrounds, an adequate translation procedure and a cross-cultural adaptation of the questionnaire of interest are required (Beaton et al. 2000).

For the present study a Finnish language version of the NDI was constructed according to the guidelines proposed by Beaton et al. (2000). The measurement properties of the original NDI seemed to be well retained in the NDI-FI, and the mNPDS-FI also demonstrated good psychometric properties.

To meet the standards for individual patient-monitoring in clinical practice, floor or ceiling effects up to 15% have been suggested (McHorney & Tarlov 1995). Only two items in the NDI-FI and none in the mNPDS-FI questionnaires reached the floor value of 15%. Therefore, it can be reasonably concluded that both instruments can be used to assess the full range of severity related to neck pain. Floor and ceiling effects have seldom been reported in studies utilizing the NDI. When the 15% limit was applied, a floor effect was observed in only four items of the Korean version of the NDI (Lee et al. 2006).

Test-retest reliability was high for the NDI-FI questionnaire with an ICC value comparable to that obtained in other similar studies. In studies with over

50 subjects and 7 days or more between the completion of the questionnaires, the ICC values ranged from 0.88 to 0.95 (Ackelman & Lindgren 2002, Kovacs et al. 2008, Vos et al. 2006). Similarly, the mNPDS-FI showed high test-retest reliability. As the mNPDS-FI is used only in Finland, no comparative data are available.

Internal consistency proved to be high for both questionnaires, the NDI-FI again showing values comparable to those of previous studies, with Cronbach alphas ranging from 0.74 to 0.92 (Cook et al. 2006, Hains et al. 1998, Lee et al. 2006, McCarthy et al. 2007, Mousavi et al. 2007, Trouli et al. 2008).

In evaluating construct validity, only one factor, explaining 41% of the variance, was identified for the NDI-FI. In most of the previous studies (Cook et al. 2006, Hains et al. 1998, Trouli et al. 2008), one factor has explained 45% to 59% of the total variance. One previous study has suggested 2 factors for the NDI (Wlodyka-Demaille et al. 2002). However, these 2 factors explained no more than 55% of the total variance. Thus a one-factor structure for the NDI is supported by the present data. For the mNPDS-FI, 3 factors, explaining 60% of the variance, were identified.

Both questionnaires, the NDI-FI and mNPDS-FI, showed a linear association with patient perceptions of coping. In addition, the NDI-FI and mNPDS-FI were both positively associated with the intensity of neck pain on the VAS. Thus, by showing a good convergent validity, the construct validity of both scales was reinforced. As might have been expected, the association between both of the instruments and the headache measurement was clearly weaker than that with neck pain, suggesting good discriminative validity.

6.3 15D in assessing health-related quality of life

The 15D instrument was able to detect improvements in HRQoL after a 12-month rehabilitation process that was effective in reducing neck pain. Changes in the 15D total score and in the dimension of sleeping between intervention groups were significant. Furthermore, the strength training group improved significantly in five of the 15 dimensions, whereas the endurance training group improved in two of the 15 dimensions. The effect sizes for the 15D and its dimensions seemed, however, to be modest.

In addition to the present study, a HRQoL measurement instrument has been applied in two exercise intervention studies on rehabilitation of neck pain. Bronfort et al. (2001) compared the effectiveness of spinal manipulation combined with neck exercises to either alone. Helewa et al. (2007) investigated the effects of therapeutic exercises and sleeping with neck support pillows. In these two short-term intervention studies the SF-36 instrument was used, but no statistically significant changes in HRQoL were observed.

6.4 Responsiveness of physical capacity and subjective outcome measurements

To interpret treatment effects, it is important not only to know if the results are statistically significant, but also if they are relevant for patients and clinicians (Pool et al. 2007). Consequently, insight into clinical utility, for example, through assessing the responsiveness of an instrument, is needed.

To study the clinical utility of the physical capacity measurements and subjective outcome measurements discussed in the present study, the responsiveness of each of the measures was assessed in a randomized controlled study.

In this sample of 180 female office workers with chronic neck pain, the subjects were categorized into responders and non-responders on the basis of neck pain intensity on the VAS after the 12-month intervention. Subjects in the lowest tertile rated their neck pain as 10 mm or less and were defined as responders, while those in the two higher tertiles scoring over 10 mm were defined as non-responders. Against this criterion the responsiveness of the physical capacity measurements and subjective outcome measurements was assessed.

Physical capacity measurements

Of the mobility measurements, lateral flexion showed the largest effect size but there was no significant difference between responders and non-responders. For a diagnostic test, the area under the curve is considered to be satisfactory when it exceeds 0.70 (Childs et al. 2005). The AUC values for all the directions of mobility measured were under 0.70, and therefore the ability of these measurements to discriminate between responders and non-responders in this setting can be questioned.

The isometric neck strength measurement showed large effect sizes, exceeding the value 0.80, in each direction measured with significant differences between responders and non-responders. The AUC values exceeded 0.70 for flexion and rotation measurements, but for extension the AUC was 0.68. Thus, isometric neck strength measurements present good discriminative ability between responders and nonresponders in this clinical setting of working age women.

No previous reports on the responsiveness of physical capacity measures related to neck region exists and thus there are no comparative data. Therefore, the present findings are novel and need to be replicated in other studies. Our present findings indicate that isometric neck muscle strength measurements, but not PROM measurements, may have discriminative ability.

Subjective outcome measurements

The neck specific disability questionnaires NDI-FI and mNPDS-FI both showed large effect sizes, values over 0.80, for responders. Because the AUC values for both indices also exceeded 0.70, they seem to be useful instruments in discriminating between responders and non-responders. Although comparison of effect sizes between different studies is not methodologically recommended, it can be mentioned that effect sizes ranging from 0.55 to 1.35 for the NDI instrument have been presented in previous studies (Vernon 2008). A minimum clinically important difference (MCID) or minimum clinically important change (MCIC) in NDI has been reported in 3 studies (Cleland et al. 2006a, Pool et al. 2007, Stratford et al. 1999) with values ranging from 3.5 to 10, which is in concordance with the value found in the present study. As the mNPDS-FI is a unique instrument, no previous data on MCID or MCIC exist.

The effect sizes of the generic 15D instrument did not differ between responders and non-responders, and the AUC value was below 0.70. Therefore, the responsiveness of 15D is questionable.

In this thesis, the HRQoL measurements were less sensitive to change in the patient's status than the disability measurements. This is in accordance with a systematic review stating that patients' impairments in a variety of conditions are better reflected in disability measures than in HRQL instruments (Weisscher et al. 2007).

The highest AUC values were shown with the disability questionnaires and isometric neck muscle strength measurements. As these measurements also showed large effect sizes, it is suggested that of the measures studied, these instruments are the most responsive to change.

6.5 Methodological considerations

For this thesis data from 3 different subject groups were used. The samples for reports I, II, III, and V intentionally consisted of females only. There were several reasons for this decision. First, neck pain is more prevalent among females. Secondly, many individual characteristics such as muscle strength and joint mobility differ between the sexes. Men are known to be stronger than females whereas females tend to be more flexible than males. Therefore, reference values for neck muscle strength and cervical spine mobility should be obtained separately for males and females. Targeting the resources available at females only enabled us to include a substantial number of subjects in the measurements. Inclusion of males would have decreased the statistical power as gender stratification would have been needed. Naturally, studying females only also means that the conclusions are applicable only to females. The psychometric properties of disability questionnaires have generally been tested with both sexes, and this was also done in the present research (IV).

The isometric neck muscle strength measurements (I, III, V) and PROM measurements of the cervical spine (II, III, V) were performed with instruments that have been reported to be reliable (Ylinen et al. 1999, Peolsson et al. 2000). All the measurements were conducted by experienced physical therapists following a strict protocol. Thus, the physical capacity measurement values presented can be considered an accurate evaluation of the phenomenon measured.

In the present study the strength of the cervical flexor muscles was measured using a conventional method where the subject's head and neck are flexed together on the thorax in a sitting position. Another method is cranio-cervical flexion (CCF) where the head is flexed on the cervical spine in a lying position (O'Leary et al. 2007b). The latter method is designed to assess the performance of a further isolated group of neck flexors, the upper deep neck flexor muscles (DNF). However, it is difficult to isolate the contribution of DNFs from that of the more superficial muscles both of which work in concert to produce a cervical flexion moment (Conley et al. 1995). EMG measurements where the electrode has been inserted via the nose to the posterior oropharyngeal wall have been conducted to study the performance of the DNFs (O'Leary et al. 2007b). However, the EMG activity of the DNFs did not differ between the conventional method and CCF (O'Leary et al. 2007b). Consequently, as the aim of this thesis was to study the properties of measurements commonly used to measure parameters in the neck region, the conventional method of assessing cervical flexion strength was preferred.

The disability questionnaires NDI-FI and mNPDS-FI are referred to in the Finnish Current Care Guideline for neck pain (Viikari-Juntura et al. 2009) and in the Finnish textbook of physiatrics (Alaranta et al. 2009) and hence they can be considered key instruments for assessing disability among Finnish patients with neck pain. Thus their selection for the reliability and validity analysis (IV) was justified. The cultural adaptation of these instruments was done according to published guidelines and their psychometric properties were evaluated among a representative group of diagnosed patients with neck pain.

The use of data (V, additional data) from a high-quality RCT study offered an excellent possibility to observe the responsiveness of the measurements presented in this thesis. Neck pain assessed with the VAS was used as an outcome against which the responsiveness of the physical capacity and subjective outcome measurements was evaluated. Although the ROC method applied is widely used in assessing responsiveness it has one disadvantage. The external clinical change score must be dichotomized (e.g., improved *vs.* unimproved or responder *vs.* non-responder, as in this thesis). The literature does not give a straight answer on how to determine an appropriate cut-off point for dichotomization when using VAS-assessed pain. Most studies have reported on the VAS-assessed change that patients have felt to be adequate. A meaningful change has been reported to be 20 to 30 mm or 30 to 55% in several studies (Emshoff et al. 2010, Grilo et al. 2007, Lee et al. 2003, Mesrian et al. 2007, Ostelo et al. 2005, Peolsson et al. 2007, ten Klooster et al. 2006, Wolfe & Michaud

2007); however, especially in acute pain, a change of 35 mm has been required to be considered meaningful (Ostelo et al. 2005). Only in one previous study has neck pain been reported separately (Peolsson et al. 2007). One study reported absolute values, stating that values lower than 5 mm represent a painless situation among postoperative patients (Jensen et al. 2003). In the present study dichotomization was done on the basis of tertiles, with the lowest tertile representing responders and the two highest tertiles non-responders. This gave a cut-off point of 10 mm which is rather close to the value reported by Jensen et al. (2003).

Limitations

The findings of the studies reporting on the effect of age on neck muscle strength and cervical spine mobility (I, II) were based on cross-sectional data; this is an obvious limitation. Performing a longitudinal study with the same subjects followed up over several decades and measuring neck muscle strength and ROM of the cervical spine at specific intervals would give more reliable answers to the effect of age on these parameters. Furthermore, the sample for studies I–III was volunteers, which may have bias the results. However, as stated earlier, the results of studies I and II are in line with the findings of several other studies using both cross-sectional data and volunteers.

The results of study III, investigating the ability of isometric neck muscle strength and PROM of the cervical spine to predict future neck pain, might have been stronger if the sample had been screened regularly for neck pain throughout the six-year period. Instead, data from the last past year was used, which may have biased the results.

Strengths

The strengths of this study include the relatively large datasets in all studies with practically no missing data. In addition, this study contributes new and important information to the research on rehabilitation of the neck: the magnitude that ageing has on the PROM of the cervical spine, the psychometric properties of the NDI-FI and mNPDS-FI, and the utility of the commonly used measurement instruments in rehabilitation of the neck region. In particular, analyzing the responsiveness of the physical capacity measurements and subjective outcome measurements within a single high-quality RCT study yielded a good estimate of the utility of these instruments. However, it is important to bear in mind that in this RCT study the emphasis was on strength training, which may have highlighted the responsiveness of the isometric neck muscle strength measurements.

6.6 Clinical implications and future directions

Since the results of the present study revealed that age did not affect isometric neck muscle strength, the mean strength values obtained here can be used as reference values for females of working age. Likewise the PROM values observed can be used as reference values but only if it is taken into account that PROM of the cervical spine diminished with aging. Thus reference values corresponding to patients' age should be used. The variation between individuals was large in both the strength and mobility values. Therefore using mean values presented as a norm should be avoided. Rather, it is the change over time in these parameters which is of interest, as this reflects the change in the patient's status. The analysis of the additional data showed that physical capacity measures, in particular isometric neck muscle strength measurement are responsive means of assessing change in patient status. In addition, the neck-specific disability questionnaires showed high responsiveness. Thus the clinical utility of these physical capacity and subjective outcome measurements is confirmed and their use in assessing the effectiveness of rehabilitation can be encouraged. As stated above, the findings of the present thesis are based on data gathered solely among females, except for study III on the reliability and validity of the NDI-FI and mNPDS-FI, and thus studies including men, with random samples and in a prospective setting would be of interest. Further, the literature on the effect of neck rehabilitation on HRQoL is very sparse. While different HRQoL instruments differ markedly for some conditions and may systematically emphasize different conditions (Saarni et al. 2006), it would be interesting to find out if HRQoL instruments other than the 15D would differ in responsiveness in relation to the rehabilitation of neck pain.

7 MAIN FINDINGS AND CONCLUSIONS

The main findings of the present study can be summarized as follows:

1) Age did not affect isometric neck muscle strength in neck pain-free females of working age; however mobility of the cervical spine diminished with increasing age.
2) Isometric neck muscle strength and passive range of motion of the cervical spine were not able to predict future neck pain among working age females without neck pain.
3) Both the neck-specific disability questionnaires, the NDI-FI and mNPDS-FI, showed good reliability and validity among Finnish patients with neck pain.
4) The generic 15D questionnaire was able to detect improvements in health-related quality of life after effective rehabilitation of neck pain. However, the effect sizes were modest.
5) Both the physical capacity and subjective outcome measures were responsive tools in monitoring patients’ status and evaluating the effectiveness of the rehabilitation process. In particular, the measurement of isometric neck muscle strength and the neck specific disability questionnaires proved to be sensitive to change in patients' condition.

In conclusion, the results of the present study showed that highly reliable and valid instruments are available for the evaluation of Finnish patients with neck pain. Although the screening of healthy female subjects for prospective neck pain, using physical capacity measures targeted at the neck region, is not recommended, physical capacity measures and subjective outcome measures are useful instruments in assessing patient status and the effects of neck pain-related interventions. The observations of the present thesis can be applied in planning, conducting and evaluating rehabilitative processes among patients with neck pain.

YHTEENVETO

Jopa yli 70 % ihmisistä kokee niskakipua jossain elämänsä vaiheessa. Naiset kokevat niskakipua jonkin verran miehiä yleisemmin. Terveys 2000 -tutkimuksen mukaan viimeisen kuukauden aikana 26 % yli 30 –vuotiaista suomalaisista miehistä ja 40 % saman ikäisistä naisista oli kokenut niskakipua. Niskakivun yksilölle ja yhteiskunnalle aiheuttamat kustannukset ovat merkittävät johtuen mm. tutkimus- ja hoitokuluista, työstä poissaoloista sekä toimintakyvyn heikkenemisestä. Niskakipu aiheuttaa myös merkittävää inhimillistä kärsimystä sekä heikentää elämänlaatua.

Niskakivun syy jää useimmiten epäselväksi huolimatta kuvastamistutkimuksista. Niskapotilaan tilaa voidaan arvioida mittaamalla esimerkiksi lihasvoimaa, liikkuvuutta, koettua kipua, toimintakykyä sekä terveyteen liittyvää elämänlaatua. Saadaksemme luotettavaa tietoa potilaan tilasta ja hoitotoimenpiteiden vaikutuksesta mm. terveydenhuollon päätöksentekoprosessien tueksi, tulee käytettävien mittareiden olla toistettavia ja luotettavia ja niiden tulee pystyä reagoimaan herkästi potilaan tilassa tapahtuviin muutoksiin.

Tässä väitöskirjassa selvitettiin niskakipupotilaiden hoidossa käytettävien keskeisten mittareiden kykyä ennustaa niskakipua, mittareiden toistettavuutta ja luotettavuutta sekä kliinistä käyttökelpoisuutta. Näiden kysymysten selvittämiseksi väitöskirjassa tutkittiin kolmea eri otosjoukkoa.

Iän vaikutusta niskan maksimaaliseen isometriseen lihasvoimaan sekä kaularangan passiiviseen liikkuvuuteen selvitettiin 20–59-vuotiailla naisilla (n=220) joilla ei ollut niskakipua. Samalla aineistolla selvitettiin myös, voidaanko oireettomille henkilöille tehdyillä niskan lihasvoimamittaus- tai kaularangan liikkuvuusmittaustuloksilla ennustaa myöhemmin ilmenevää niskakipua.

Kansainvälisesti käytetyn niskan haittaindeksin suomenkielisen version (NDI-FI) sekä suomalaisen niskan haittakyselyn (mNPDS-FI) toistettavuutta ja luotettavuutta tutkittiin niskakivuista kärsivillä 21–82-vuotiailla miehillä ja naisilla (n=101).

Niskan isometrisen lihasvoima- ja kaularangan passiivisen liikkuvuusmittausten, niskan haittakyselyiden (NDI-FI ja mNPDS-FI) sekä terveyteen liittyvän elämänlaatumittarin (15D) herkkyyttä havaita niskakipupotilaan tilassa tapahtunutta muutosta tutkittiin satunnaistetussa kontrolloidussa harjoitteluinterventiossa. Tähän tutkimukseen osallistui 180 niskakivuista kärsivää 25–53 -vuotiasta toimistotyötä tekevää naista.

Niskakivuttomilla tehdyn poikkileikkaustutkimuksen keskeisimmät tulokset osoittivat, ettei ikä vaikuttanut niskalihasten isometriseen maksimivoimaan. Sen sijaan kaularangan passiivinen liikkuvuus aleni lineaarisesti ikävuosien 20 ja 59 välillä. Kuusi vuotta alkumittausten jälkeen näille samoille henkilöille tehdyssä kyselyssä 19 % oli kokenut niskakipua yli 7 päivänä viimeksi kuluneen vuoden aikana. Alkutilanteessa tehtyjen niskavoimamittausten tai kaularangan liikkuvuusmittausten tuloksilla ei kuitenkaan ollut yhteyttä niskakipujen ilmenemiseen.

Molempien tutkittujen niskan haittaindeksien, NDI-FI ja mNPDS-FI, psykometriset ominaisuudet osoittautuivat hyviksi. Mittarit olivat hyvin toistettavia ICC arvojen ollessa 0.94 (NDI-FI) ja 0.91 (mNPDS-FI). Lisäksi mittareiden sisäinen johdonmukaisuus oli hyvä Cronbahin alpha arvojen vaihdellessa välillä 0.82 ja 0.90. Molemmat haittaindeksit olivat yhteydessä sekä kipujanalla arvioituun niskakipuun että potilaiden omaan kokemukseen haitan asteesta, mikä osoittaa haittaindeksien rakenteellista luotettavuutta.

Tutkittaessa objektiivisten niskan toimintakykymittausten sekä subjektiivisten toimintakyvyn haitta- ja elämänlaatukyselyiden herkkyyttä havaita muutosta harjoitteluinterventiotutkimuksessa, todettiin erityisesti niskan haittakyselyiden (NDI-FI ja mNPDS-FI) sekä niskan isometristen lihasvoimamittausten olevan herkkiä havaitsemaan muutosta potilaan tilassa.

Tutkimuksen tulosten perusteella todetaan, että niskan isometrisen lihasvoiman tai kaularangan passiivisen liikkuvuuden mittauksilla ei voida seuloa niskakivulle alttiita henkilöitä oireettomien työikäisten naisten keskuudesta. Näin ollen terveiden henkilöiden seulontaa näillä niskan fyysisen toimintakyvyn mittareilla ei suositella käytettäväksi niskakipujen ennaltaehkäisemiseksi.

Tässä tutkimuksessa suomeen validoitu kansainvälisen niskan haittaindeksin (NDI-FI) ja kotimaisen haittakyselyn (mNPDS-FI) psykometriset ominaisuudet olivat hyvät. Siten suomalaisten niskakipupotilaiden hoitoon, kliiniseen arviointiin ja tutkimuskäyttöön on nyt ”tuotu” kaksi niskapotilaille spesifistä haittakyselyä, joiden toistettavuus ja luotettavuus ovat hyvät.

Tämän väitöskirjatutkimuksen yhteenvetona voidaan todeta, että sekä objektiivisemmat niskan fyysisen toimintakyvyn mittaukset että subjektiiviset niskaspesifit kyselylomakkeet ovat kliinisesti käyttökelpoisia mittareita arvioitaessa niskakipupotilaan tilan muutosta sekä kuntoutustoimenpiteiden vaikutuksia ja niitä voidaan suositella käytettäväksi niskakipupotilaiden hoidon tavoitteita asetettaessa ja vaikuttavuutta arvioitaessa.

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Appendix 1 NISKAKIPUINDEKSI (NDI-FI)

Kyselyn tarkoituksena on antaa tietoa siitä, kuinka kipu on vaikuttanut kykyynne suoriutua jokapäiväisistä toimistanne. Rastittakaa joka kohdasta vain se ruutu, joka parhaiten kuvaa tilannettanne tänään.

1. Kivun voimakkuus

☐ Minulla ei ole kipua tällä hetkellä.
☐ Kipu on hyvin lievä tällä hetkellä.
☐ Kipu on kohtalainen tällä hetkellä.
☐ Kipu on melko voimakas tällä hetkellä.
☐ Kipu on hyvin voimakas tällä hetkellä.
☐ Kipu on pahin mahdollinen tällä hetkellä.

2. Itsestä huolehtiminen (peseytyminen, pukeutuminen jne.)

☐ Selviydyn näistä toimista normaalisti, eikä niistä aiheudu lisää kipua.
☐ Selviydyn näistä toimista normaalisti, mutta niistä aiheutuu lisää kipua.
☐ Näistä toimista selviytyminen on kivuliasta vaatien aikaa ja varovaisuutta.
☐ Tarvitsen hieman apua, mutta selviydyn useimmista toimista itsenäisesti.
☐ Tarvitsen apua päivittäin useimmissa näistä toimista.
☐ En pukeudu, peseydyn vaivalloisesti ja pysyttelen vuoteessa.

3. Nostaminen

☐ Voin nostaa raskaita taakkoja, eikä se lisää kipua.
☐ Voin nostaa raskaita taakkoja, mutta se lisää kipua.
☐ Kipu estää minua nostamasta raskaita taakkoja lattialta, mutta voin nostaa niitä, jos ne on sijoitettu sopivasti, esim. pöydälle.
☐ Kipu estää minua nostamasta raskaita taakkoja, mutta voin nostaa kevyitä tai kohtalaisia taakkoja, jos ne on sijoitettu sopivasti.
☐ Voin nostaa vain hyvin kevyitä taakkoja.
☐ En voi nostaa tai kantaa mitään.

4. Lukeminen

☐ Voin lukea niin pitkään kuin haluan ilman niskakipua.
☐ Voin lukea niin pitkään kuin haluan tuntien lievää niskakipua.
☐ Voin lukea niin pitkään kuin haluan tuntien kohtalaista niskakipua.
☐ En voi lukea niin pitkään kuin haluan, mikä johtuu kohtalaisesta niskakivusta.
☐ En voi lukea juuri lainkaan, mikä johtuu voimakkaasta niskakivusta.
☐ En voi lukea lainkaan.

5. Päänsärky

☐ Minulla ei ole lainkaan päänsärkyä.
☐ Minulla on ajoittain lievää päänsärkyä.
☐ Minulla on ajoittain kohtalaista päänsärkyä.
☐ Minulla on usein kohtalaista päänsärkyä.
☐ Minulla on usein voimakasta päänsärkyä.
☐ Minulla on lähes koko ajan päänsärkyä.

6. Keskittymiskyky

- ☐ Halutessani voin keskittyä täydellisesti ilman vaikeuksia.
- ☐ Halutessani voin keskittyä täydellisesti, mutta siinä on hieman vaikeuksia.
- ☐ Minun on kohtalaisen vaikeaa keskittyä silloin kun haluan.
- ☐ Minun on vaikeaa keskittyä silloin kun haluan.
- ☐ Minun on erittäin vaikeaa keskittyä silloin kun haluan.
- ☐ En voi keskittyä lainkaan.

7. Työ

- ☐ Voin tehdä työtä niin paljon kuin haluan.
- ☐ Voin tehdä vain tavallisen työni mutta en enempää.
- ☐ Voin tehdä suurimman osan tavallisesta työstäni mutta en enempää.
- ☐ En voi tehdä tavallista työtäni.
- ☐ En voi tehdä juuri mitään työtä.
- ☐ En voi tehdä mitään työtä.

8. Autolla ajaminen

- ☐ Voin ajaa autolla ilman niskakipua.
- ☐ Voin ajaa autolla niin pitkään kuin haluan tuntien lievää niskakipua.
- ☐ Voin ajaa autolla niin pitkään kuin haluan tuntien kohtalaista niskakipua.
- ☐ En voi ajaa autolla niin pitkään kuin haluan, mikä johtuu kohtalaisesta niskakivusta.
- ☐ En voi ajaa autolla juuri lainkaan, mikä johtuu voimakkaasta niskakivusta.
- ☐ En voi ajaa autolla lainkaan.

9. Nukkuminen

- ☐ Minulla ei ole univaikeuksia.
- ☐ Uneni on hyvin vähän häiriintynyt (alle tunnin unettomuus).
- ☐ Uneni on vähän häiriintynyt (1-2 tunnin unettomuus).
- ☐ Uneni on kohtalaisesti häiriintynyt (2-3 tunnin unettomuus).
- ☐ Uneni on voimakkaasti häiriintynyt (3-5 tunnin unettomuus).
- ☐ Uneni on täysin häiriintynyt (5-7 tunnin unettomuus).

10. Vapaa-aika

- ☐ Voin osallistua kaikkiin vapaa-ajan toimiin ilman niskakipua.
- ☐ Voin osallistua kaikkiin vapaa-ajan toimiin tuntien lievää niskakipua.
- ☐ Voin osallistua useimpiin mutta en kaikkiin tavallisiin vapaa-ajan toimiin niskakivun takia.
- ☐ Voin osallistua vain muutamiin tavallisiin vapaa-ajan toimiin niskakivun takia.
- ☐ En voi osallistua juuri mihinkään vapaa-ajan toimiin niskakivun takia.
- ☐ En voi osallistua mihinkään vapaa-ajan toimiin.

Appendix 2

NISKA-HARTIAVAIVOIHIN LIITTYVÄN HAITAN ARVIOINTI (mNPDS-FI)

Merkitkää alla oleville viivoille pystyviiva sille kohdalle, mikä parhaiten vastaa kokemaanne kipua tai toiminnan rajoitusta viimeisen viikon aikana.

1. Kuinka paha kipunne on?

|—————————————————|

ei lainkaan kipua pahin mahdollinen kipu

2. Kuinka paha kipunne on yöllä?

|—————————————————|

ei lainkaan kipua pahin mahdollinen kipu

3. Kuinka hyvin kipulääkkeet vaikuttavat kipuunne?

|—————————————————|

vievät kivun täydellisesti eivät lievitä lainkaan

4. Kuinka jäykkä niskanne on?

|—————————————————|

ei lainkaan jäykkyyttä täysin jäykkä

5. Vaikeuttaako kipunne ylöspäin katsomista?

|—————————————————|

ei lainkaan estää täysin

6. Vaikeuttaako kipunne pään kääntämistä sivusuuntiin?

|—————————————————|

ei lainkaan estää täysin

7. Vaikeuttaako kipunne työskentelyä yläraajat kohoasennossa (kädet hartiatason yläpuolella)?

ei lainkaan — estää täysin

8. Vaikeuttaako kipunne tukan kampaamista?

ei lainkaan — estää täysin

9. Vaikeuttaako kipunne takin pukemista päälle?

ei lainkaan — estää täysin

10. Onko teillä kipua, kun makaatte vuoteessa?

ei lainkaan — pahin mahdollinen kipu

11. Kuinka paljon kipu rajoittaa normaalia elämäntapaanne?

ei lainkaan — en voi tehdä mitään

12. Rajoittaako kipu työntekoanne?

ei lainkaan — estää täysin

13. Kuinka paljon olette joutunut muuttamaan työtänne kivun vuoksi?

en lainkaan — erittäin paljon (olen joutunut vaihtamaan työtäni)

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