Balance Control in Chronic Neck Pain Subjects: a Clinical Assessment.

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Abstract

Title: Balance Control in Chronic Neck Pain Subjects: a Clinical Assessment.

Background: Balance has been found to be decreased in chronic neck pain (CNP) patients of both idiopathic and traumatic onset. Balance has been recommended to be tested in CNP patients. However, there exists no clinical balance test valid for this population.

Purpose: The purpose with this study was to increase knowledge about balance tests that could pick out CNP subjects with balance disturbances.

Aim: To explore if the modified Clinical Test of Sensory Interaction and Balance (mCTSIB) along with adjunct positions can pick out the CNP subjects with balance disturbances.

Methods: A pilot, cross-sectional study was conducted in 10 subjects with CNP (≥3- month duration) and with Neck Disability Index (NDI) ≥10 out of 50, who were recruited from an outpatient clinic in Southwestern Norway. Balance was assessed using the mCTSIB (four test conditions) along with six adjunct test conditions. Each test condition was held for 30 seconds.

Results: The mCTSIB demonstrated a ceiling effect. The adjunct positions with the eyes closed in tandem and especially one-leg standing appear to provide an indication of balance disturbances in CNP subjects. No associations were found between results on balance tests and NDI, pain intensity, or dizziness status. When using a 10-second cut-off score obtained from normative data, there was, in this study, a 20% failure rate for subjects to reach the cut-off score in tandem standing with the eyes closed and 80% in one-leg standing with the eyes-closed.

Conclusion: As a result of a low sample size, limited conclusions can be drawn. The eyes-closed conditions for tandem standing or especially one-leg standing appear to provide an indication of balance disturbances in CNP subjects. No correlations have been found between performance on standing tests and NDI, pain intensity, or dizziness status.

Keywords: balance, chronic neck pain, clinical assessment, mCTSIB, cross-sectional study

Sammendrag

Tittel: Balansekontroll hos pasienter med kroniske nakkesmerter: en klinisk test.

Bakgrunn: Tidligere studier har vist balanseproblemer hos pasienter med kroniske nakkesmerter både av idiopatisk og traumatisk type. Det har blitt anbefalt å teste balansen hos kroniske nakkesmerter pasienter. Det foreligger imidlertig ingen valid klinisk balansetest for denne populasjonen.

Hensikt: Hensikten med denne studien var å øke kunnskap om balansetester som kan fange opp balanseforstyrrelser hos individer med kroniske nakkesmerter.

Mål: Å utforske om den modifiserte Clinical Test of Sensory Interacton and Balance (mCTSIB) sammen med tilleggsposisjoner kan fange opp balanseforstyrrelser hos individer med kroniske nakkesmerter.

Metode: En pilot, tverrsnittsstudie ble gjennomført med 10 individer med kroniske nakkesmerter (≥3 måneders varighet) og Neck Disability Index (NDI) ≥10 av 50, som ble rekrutert fra et institutt på Sørvestlandet i Norge. Balanse ble undersøkt ved bruk av mCTSIB'en (fire situasjoner) sammen med seks tilleggsposisjoner. Hver test situasjon ble holdt i 30 sekund.

Resultat: mCTSIB demonstrert en tak effekt. Tilleggsposisjoner med lukkede øyne for tandem og spesielt stående på ett bein gir indikasjon på balanseforstyrrelser hos individer med kroniske nakkesmerter. Ingen sammenhenger ble funnet mellom resultat fra balansetester og NDI, smerteintensitet, eller svimmelhet status. Ved bruk av en 10-sekund «cut-off score» hentet fra normative data, var det en feilrate av 20% for individer i denne studien, for å nå denne «cut-off scoren» for tandemtest med lukkede øyne og 80% for stående på ett bein med lukkede øyne.

Konklusjon: Som resultat av et lite utvalg, kan kun begrensede konklusjoner trekkes. Stående stilling med øynene lukket i tandem og spesielt på ett bein synes å gi en indikasjon på balanseforstyrrelser hos individer med kroniske nakkesmerter. Ingen sammenhenger har blitt funnet mellom prestasjon på stående tester og NDI, smerteintensitet, eller svimmelhet status.

Nøkkelord: balanse, kroniske nakkesmerter, klinisk test, tverrsnittsundersøkelse, mCTSIB

List of Abbreviations

cm: centimeter

CNP: chronic neck pain

CTSIB: clinical test of sensory integration and balance

DHI: dizziness handicap inventory

m: meter

mCTSIB: modified clinical test of sensory integration and balance

N: sample size

NDI: neck disability index

NPRS: numerical pain rating scale

p: level of significance

r: correlation coefficient

sec: seconds

sd: standard deviation

1. Introduction

Neck pain is one of the most common chronic musculoskeletal disorders. The Global Burden of Disease Study has ranked neck pain fourth in terms of causes of years lived with disability both worldwide and in Norway (Vos, Flaxman et al. 2012). In Norway, the prevalence has been estimated to be between 13.3% and 24.4% of the population (Bovim, Schrader et al. 1994, Björnsdóttir, Jónsson et al. 2013).

Persons suffering from chronic neck pain (CNP) have complained of a variety of symptoms which includes headaches, stiffness, radiating pain, dizziness, visual disturbances, and balance deficits. Over the last 10 years, there has been recognition of the widespread effects that CNP can have on the body. Balance has been found to be one area where CNP patients have shown disturbances. Rubin & al (1995) have reported a 40-70% prevalence of symptoms of unsteadiness and loss of balance in whiplash-associated persistent neck pain. Treleaven & al (2003) have surveyed the complaints of 105 whiplash patients who reported: 90% unsteadiness, 65% lightheadedness, 48% with at least one episode of loss of balance, and 21% had a fall. Another study by the same authors calculated the prevalence of balance abnormalities in 100 subjects with post-whiplash CNP; abnormalities were found in 72% of those with dizziness and 56% of those without dizziness (Treleaven, Jull et al. 2006).

Evidence indicates that poor standing balance can occur in isolation, without dizziness or unsteadiness complaints, and thus may go unnoticed by neck patients (Huxham, Goldie et al. 2001, Treleaven, Jull et al. 2005, Field, Treleaven et al. 2008, Khattar and Hathiram 2012). These authors suggested that rehabilitation of CNP patients should include a thorough evaluation of the sensorimotor system through balance testing among other tests, in addition to the musculoskeletal system.

According to my experience, subjects with CNP have been a challenging population to assess and treat. Moreover, there exist no valid clinical tools to measure balance disturbances in this patient population. It is important that relevant tools are developed to assist clinicians in decision-making, target interventions, and improve treatment outcomes. The focus of this project is on the clinical evaluation of standing balance in this population.

1.1 Theory

In recent years, a spectrum of impairments associated with CNP patients has been more specifically categorized as originating from a sensorimotor disturbance. It can manifest itself as unsteadiness/dizziness, cervical joint proprioception deficits (Heikkilä and Wenngren 1998, Treleaven, Jull et al. 2003), poor oculomotor control (Heikkilä and Wenngren 1998, Tjell, Tenenbaum et al. 2002, Treleaven, Jull et al. 2005, Storaci, Manelli et al. 2006), and/or altered postural stability (Treleaven 2008, Treleaven, Clamaron-Cheers et al. 2011, Talebian, Otadi et al. 2012, Juul-Kristensen, Clausen et al. 2013). The mechanism behind these impairments is often similar, but each patient will present with an individualized combination of symptoms within the spectrum (Treleaven 2008, Juul-Kristensen, Clausen et al. 2013, Malmstrom, Westergren et al. 2013).

1.1.1 Proposed Mechanisms of Balance Disturbances

Many mechanisms have been suggested to balance disturbances, but none has emerged as most prominent. The theories involve local factors, sensory and motor, and global factors, for example, central modulation. The different mechanisms can co-exist as they are closely interrelated.

Sensory Input

For the body to maintain balance, it requires the interaction of sensory inputs, analysis and processing of these inputs, and a coordinated response. These inputs are classified into somatosensory (local and distal), visual, and vestibular systems (Shumway-Cook and Horak 1986, Goble, Coxon et al. 2011, Khattar and Hathiram 2012).

Somatosensory inputs in the cervical spine are considered an important contributor in maintaining oculomotor and postural control (Beinert and Taube 2013). The facets of the cervical spine, especially in the upper neck, are rich with mechanoreceptors and the muscles of the suboccipital area have a high concentration of muscle spindles (Boyd-Clark, Briggs et al. 2002, Treleaven 2008). These play a vital role in mediating reflex connections between sensory inputs from the body, vestibular inputs, visual inputs, and the central and autonomic nervous systems (Karlberg, Johansson et al. 1996, Brandt and Bronstein 2001, Hellstrom, Roatta et al. 2005).

The mechanisms that lead to a disruption of balance and other sensorimotor impairments can be related to the quantity of sensory inputs (excessive or decreased), to a change in the optimal system used for a task, or if the inputs become discordant (sensory mismatch).

Excessive sensory inputs arise from nociceptive afferent activity or increased activity of the muscle spindle system (Falla, Jull et al. 2004). With respect to nociceptive input, pain can primarily drive changes to sensorimotor control, or indirectly via emergence of pathological changes (Malmstrom, Westergren et al. 2013). Cervical pain (experimentally-induced) affects neck proprioception and thus sensorimotor control. These results have been shown to persist long after removal of the painful stimulus (Malmstrom, Westergren et al. 2013). It is debatable whether if, and how much, abnormal cervical afferent sensory input and the resulting balance impairments are proprioceptive and/or nociceptive (Karlberg, Magnusson et al. 1996, Treleaven 2008, Yu, Stokell et al. 2011, Malmstrom, Westergren et al. 2013).

Only a few examples of decreased sensory inputs have been reported. These situations have been artificially created in studies where cervical sensory inputs have been experimentally eliminated (de Jong, de Jong et al. 1977, Palmgren, Lindeberg et al. 2009). A study by de Jong (1977) attempted to demonstrate the effect of limiting sensory inputs by injecting a local anesthetic in cervical facets. This has resulted in impaired standing balance in healthy individuals (de Jong, de Jong et al. 1977).

It has been observed that the optimal source of sensory inputs to control balance changes in subjects with CNP. Since the control of balance involves multiple systems and is redundant, then if one system fails, there are back-up system(s) which can compensate (Winter 1995, Khattar and Hathiram 2012). In healthy adults, the preferred source of inputs in somatosensory from the feet in contact with the supporting surface (Shumway-Cook and Horak 1986, Magnusson, Enbom et al. 1990, Allum, Bloem et al. 2001). On the contrary, visual inputs play a dominant role in limiting the destabilizing effects of altered cervical somatosensory inputs (Rubin, Woolley et al. 1995, Madeleine, Prietzel et al. 2004, Treleaven, Jull et al. 2005, Vuillerme and Pinsault 2009).

Another theory proposes sensory mismatch as a possible cause and occurs when proprioceptive, vestibular, and/or visual systems give inputs that do not concord (Brandt and Bronstein 2001). This has been speculated to be one mechanism behind patients with chronic neck pain and manifestations of sensorimotor disturbances (Karlberg, Magnusson et al. 1996, Heikkilä, Johansson et al. 2000, Brandt and Bronstein 2001, Treleaven, Jull et al. 2003, Wrisley and Whitney 2004, Vuillerme and Pinsault 2009).

Motor Component

The disruption of local structures from pain, disuse, or trauma can have both local and global implications for the control of balance. Locally, adaptations to the muscular structure can arise directly from injury or indirectly via pain and disuse (Uhlig, Weber et al. 1995, Elliott, Jull et al. 2006). Changes in cervical motor control can disrupt global mechanisms of balance control via modulation of reflexes and central processes (Schieppati, Nardone et al. 2003, Sterling, Jull et al. 2003, Malmstrom, Westergren et al. 2013).

Cervical muscles especially in the suboccipital area are highly specialized. Suboccipital muscles are small, non-torque producing, and possess a high density of muscle spindles which are required for proper kinesthesia and proprioception (Elliott, Jull et al. 2006). Structural shifts in neck muscles, both in the flexor and extensor compartments, have been found in subjects with persistent whiplash-associated disorder. More precisely, the rectus capitis posterior minor and major, deep cervical multifidi, and deep neck flexors have shown fatty infiltration (Elliott, Jull et al. 2006). Cervical muscles have also shown a transformation of fiber types from type I to II, modification of motor unit synchronization, and long-lasting activation of muscle spindles (Uhlig, Weber et al. 1995, Thunberg, Ljubisavljevic et al. 2002, Falla, Jull et al. 2004).

Moreover, it was suggested that enhanced muscle spindle activity may develop increased sensitivity and perception of movement resulting in excessive afferent inputs centrally (Malmstrom, Karlberg et al. 2010). Simultaneously, the altered sensory inputs could be the result of activation of free nerve endings from local metabolic changes within the muscles (Schieppati, Nardone et al. 2003). This further reinforces the complex interaction of the sensory and motor components of balance control.

Local changes can lead to a maladaptive shift in motor control. There appears to be painful inhibition of the muscles performing a movement and subsequent complex reorganization of the motor pattern (Sterling, Jull et al. 2003, Falla and Farina 2007) when corrected to fear avoidance (Sterling, Jull et al. 2003). For example, chronic whiplash subjects have shown a high level of superficial cervical muscle activity during simple balance tasks (Juul-Kristensen, Clausen et al. 2013) which could interfere with proprioception (Malmstrom, Westergren et al. 2013). This has also been shown in subjects with idiopathic onset of neck pain. In addition, there is a decreased synergetic activity between longus colli and capitis and overactivation of the sternocleidomastoid (Jull, Kristjansson et al. 2004). Altered motor control been found to negatively affect balance, but also neck muscle fatigue (Schieppati, Nardone et al. 2003, Gosselin, Rassoulian et al. 2004) has been directly implicated in changing the sensory inputs.

Central Modulation

In addition to mechanisms acting locally to affect the control of balance, there are global factors that can result in widespread effects in CNP subjects. Balance control is multifaceted and involves both supraspinal processing and local reflexes.

There is evidence that the frontal and parietal areas play a role in the control of balance (Taubert, Draganski et al. 2010, Goble, Coxon et al. 2011). These areas can respond with a significant increase in gray matter volume as a result of whole body balance tasks. Those same areas are also involved in chronic pain processing and have been shown to atrophy (Apkarian, Sosa et al. 2004, Apkarian, Baliki et al. 2009).

Other factors affecting balance control are changes in the primary somatosensory cortex associated with chronic pain (Flor, Braun et al. 1997), which include enhanced cortical reactivity, shifting of representation on the cortex, and re-sizing of the affected body part on the homunculus.

The autonomic nervous system regulates internal homeostasis. In particular, the sympathetic nervous system can be activated by psychological stresses (Sterling, Kenardy et al. 2003) and can thereby facilitate the development of chronic pain states, whether the onset is traumatic or idiopathic (Hellstrom, Roatta et al. 2005, Passatore and Roatta 2006). More precisely, psychological stresses can facilitate muscle spindle activity via activation of the hypothalamic-pituitary-adrenal axis.

Undiagnosed Pathologies

Other causes of unsteadiness should be considered, such as damage to vertebral artery, pathology to vestibular or central nervous system, psychiatric disorders, and/or use of medications/substances. It is still unknown to what extent the vestibular system could be implicated, especially in CNP of traumatic origin, even in the absence of true vertigo (Rubin, Woolley et al. 1995, Mallinson, Longridge et al. 1996, Lin, Lai et al. 2012).

1.1.2 Measurement Tools

Measuring tools can be developed for specific use in research or targeted to clinical practice. They are essential to reflect a patient’s initial status, monitor changes in the intervention stages, and determine treatment efficacy. Outcome measures are an integral part of evidence-based practice and are important to justify a rehabilitation program in a reliable and credible manner (Sackett, Rosenberg et al. 1996, Domholdt 2005; chapter 17).

Measurement tools are different when they are created for laboratory as opposed to clinical settings. Tools developed for the purpose of research tend to be more sophisticated, technologically-based, and more costly. They could assess impairment or a task more precisely. On the other hand, clinical tools should be affordable, use basic equipment, and take minimal time while maintaining a balance between reliability and validity (El-Kashlan, Shepard et al. 1998).

Measurement tools are described in terms of properties which represent the level of measurement, reliability, validity, and responsiveness (Andresen 2000). Reliability refers to the extent that a tool is reproducible or consistent from one measure to another (Domholdt 2005; chapter 17, Cook and Beckman 2006). It is a reflection of the internal structure of a measuring tool. Validity is the degree to which a result is likely to be true and free from bias and to the extent of measure assesses what it was intended to (Domholdt 2005; chapter 17, Khorsan and Crawford 2014). Cook & al (2006) argues that validity is not a property of the instrument, but of the instrument's scores and their interpretations. It is for this reason that validity must be established for each intended interpretation, for example, assessment of a new target population.

1.1.3 Balance Testing

Balance testing is a generic motor control test. It is specific towards testing of static or dynamic balance, but neither specific towards the system at fault nor to a disease/condition. In the field of CNP, there have been no tools designed to measure balance. Outcome measures developed for other conditions, for example, neurological deficits, vestibular problems, test batteries to assess risk of falls in elderly, have been used in CNP research.

Laboratory Testing of Balance

Computerized posturography was originally developed to evaluate patients with vestibular pathology and has been considered the gold standard to assess balance in patients having balance impairments from neurological and vestibular origin (El-Kashlan, Shepard et al. 1998). It has been the standard for the measurement of balance in CNP research over the last decade.

Using a force platform, the excursion of a subject's center of gravity, direction, and velocity can be measured objectively (Palm, Lang et al. 2014). There are two types of posturography: static or dynamic. Both have been used in CNP research. Static posturography uses a fixed platform whereas dynamic posturography uses a platform that can be unlocked in order to give a sudden perturbation or to be used to change proprioceptive inputs to the lower extremities (Di Fabio 1995). Dynamic posturography was demonstrated to have fair to good test-retest reliability in healthy, elderly population (Ford-Smith, Wyman et al. 1995) and in healthy, young subjects (Wrisley, Stephens et al. 2007). Validity was reported to be moderately high in sensitivity and specificity for vestibular subjects (Cohen and Kimball 2008).

Clinical Testing

In general, clinical testing of balance is semi-quantitative as it uses time measures (objective measure) and some form of scoring (subjective measure) of a subject's ability to perform a static standing position. There are multiple test batteries that exist, but the Clinical Test of Sensory Interaction and Balance (CTSIB) has been principally been involved in CNP research.

The CTSIB was developed to attempt to differentiate between visual, vestibular, and somatosensory inputs in order to design a treatment program for neurological patients having balance deficits. The original version of this test was developed by Shumway-Cook and Horak (1986).

Since the control of balance reflects multiple systems then attempts have been made to separate the systems at fault: visual, vestibular, or somatosensory. The CTSIB attempts differentiation by requiring the patient to stand under a combination of conditions: firm versus foam surface, eyes open with or without conflict dome, or blindfolded which produces six testing conditions. The tester subjectively quantifies sway by using a plumb line or grid on a wall. Each test position is to be held for 30sec. The authors of the test argued that healthy adults should be able to easily maintain each of the six test conditions for a 30-sec period. There exist normative data for healthy individuals of different age groups in relation to different standing conditions (Cohen, Blatchly et al. 1993, Vereeck, Wuyts et al. 2008, Yu, Stokell et al. 2011).

The CTSIB has been studied in different populations as well as in healthy, young community-dwelling population. It has been found to have good test-retest reliability for young and older populations, and high interrater reliability for young adults in a pilot study (Cohen, Blatchly et al. 1993). Moreover, it was able to discriminate at a significant level between healthy population and those who had vestibular impairments. El-Kashlan & al (1998) who evaluated sensitivity of the CTSIB at 87% and specificity at 60% compared to dynamic posturography in a population who suffered from vestibular disorders. It has been found to have an important ceiling effect in stroke patients (Bernhardt, Ellis et al. 1998).

The modified version of the CTSIB (mCTSIB) omits the two conditions with the conflict dome (firm and foam surface). It does not attempt to differentiate the vestibular system from the visual or somatosensory system as the testing conditions with the conflict dome were not found to significantly differ from the results obtained with the eyes closed (Cohen, Blatchly et al. 1993). The mCTSIB was found to moderately correlate to results on dynamic computerized posturography (Weber and Cass 1993, El-Kashlan, Shepard et al. 1998). Weber & al (1993) evaluated that the mCTSIB, as compared to dynamic posturography, had 90% sensitivity and 95% specificity in subjects with complaints of dizziness and imbalance.

Adjunct positions have been integrated in most studies in CNP population. There has been a variety which included: forward reaching, neck torsion, tandem standing, and/or one-legged standing. The battery of standing positions is not uniform throughout the spectrum of studies.

Since the CTSIB was not found to be sensitive enough to differentiate local somatosensory inputs in the neck from vestibular inputs, another test has been proposed. Neck torsion has first been introduced by Tjell & al (1998) and has further been used in evaluating balance control in CNP research (Treleaven, Jull et al. 2005, Yu, Stokell et al. 2011). It is described as body rotation of 45° under a stable head and is thought that cervical afferents would be stimulated without stimulating the vestibular system. It was found to be useful for differentiating dizziness of cervicogenic origin as opposed to vestibular in whiplash-associated CNP with complaints of dizziness (Tjell and Rosenhall 1998) with high specificity and sensitivity in that particular group.

1.2 Balance Studies in Chronic Neck Pain Subjects

Recently, there have been numerous studies highlighting balance deficit as impairment in different CNP populations. These studies have unanimously used computerized posturography to quantify balance deficits while the subjects completed a series of standing tasks.

In whiplash-related CNP, there has been a measured increase in neck muscle activity and measured deficit in standing balance of 10 patients with CNP versus 10 healthy subjects (Juul-Kristensen, Clausen et al. 2013). A study of 21 patients with chronic myofascial neck pain syndrome, without dizziness complaints, demonstrated poor standing balance as compared to 21 healthy controls (Talebian, Otadi et al. 2012). Another study found that 85 cleaning personnel who suffered from neck pain of different origins and were without dizziness, demonstrated perturbed balance as compared to 109 pain free cleaning personnel (Jorgensen, Skotte et al. 2011). Furthermore, a study comparing 20 CNP patients as a result of whiplash versus 20 controls indicates that deficits in balance are significantly greater in subjects with CNP especially when using neck torsion and that somatosensory impairment is the most likely cause of balance disturbances (Yu, Stokell et al. 2011).

In a slightly different study, balance was assessed in 60 non-dizzy CNP patients (30 of idiopathic origin and 30 whiplash-associated) as compared to 30 healthy age-matched controls. The conclusion was that there were balance deficits in both test groups, especially greater in the traumatic onset group (Field, Treleaven et al. 2008). It was demonstrated that balance was disturbed in patients with persistent whiplash-associated neck pain (50 with dizziness and 50 patients without) with respect to 50 healthy controls. The deficits in balance were greater in those experiencing dizziness (Treleaven, Jull et al. 2005).

In trying to differentiate between the populations most at risk of suffering from impaired balance, Treleaven & al (2011) evaluated balance in different patient groups: 21 idiopathic upper cervical pain, 15 idiopathic lower cervical pain, 13 traumatic upper cervical pain, and 15 traumatic lower cervical pain. Even though sample size was low, they were able to identify that the group with the least balance abnormalities: pain of idiopathic onset in the lower cervical spine.

Most of the referred studies looked at patients under 60 years of age in order not to be influenced by a natural age-associated decline in balance (Speers, Ashton-Miller et al. 1998, Vereeck, Wuyts et al. 2008). The intensity of neck pain and associated self-reported disability were varied, but most did not suffer from neck pain of high intensity or were severely disabled. In general, all patients with CNP tended to be associated with balance deficits on testing. The ones that tended to be the most affected were those who had sustained a trauma, experienced dizziness, and had upper cervical pain (Michaelson, Michaelson et al. 2003, Sjostrom, Allum et al. 2003, Treleaven, Jull et al. 2005, Field, Treleaven et al. 2008).

In contrast, there have been a few experimental studies on healthy individuals. Vuillerme & al (2009) experimentally induced pain in 16 young, healthy individuals using electrical stimulation over bilateral upper trapezii. The stimulation was sub-threshold not to cause neck muscle contraction. They repeated trials of pain and no stimulation in four sets. Painful state was associated with a measured decline in standing balance on a force platform. In a study of six healthy subjects, a facet nerve blockade was performed unilaterally at the C5-C6 level. The results were inconclusive as a group, but some individuals appeared to be greatly affected with respect to cervical joint repositioning accuracy and extent of sway in standing balance (Palmgren, Lindeberg et al. 2009).

In trying to establish an association between CNP and balance, Beinert & al (2013) studied the effect of balance as an intervention. In this case, balance was not specifically measured. The study looked at the effect two training programs on 34 subjects with CNP randomly allocated to general physical activity or balance training. It was demonstrated that those who underwent balance training had improved cervical joint positioning accuracy (measured using a cervical goniometer and laser pointer) and significant reduction in neck pain intensity (measured by NPRS) as compared to controls.

2. Purpose and Aim

2.1 Purpose

From research, it has been shown that a range of patients with CNP exhibited balance disturbances on computer posturography, even in the absence of complaints of dizziness or imbalance. Moreover, it has been suggested that balance testing should be part of screening for patients with CNP in order to discern those who have balance impairments and to target intervention. For the assessment of balance, computerized posturography is considered the gold standard. However, it is unreasonable to be used as a clinical tool because it requires specialized equipment and users to be trained, is costly, and is time consuming.

Measurement tools to assess balance that have been used in CNP research and clinical practice have mainly been developed for subjects with vestibular or neurological deficits. There is a need for the development of a clinical test which would be sensitive to determine those CNP patients who have balance disturbances. The purpose with this study was to increase knowledge about balance tests that could facilitate assessment of balance in CNP patients.

2.2 Aim

This was a pilot study with the primary aim to explore, if a clinical assessment of balance previously used to assess balance in vestibular patients, could discriminate CNP subjects with balance disturbances.

Research questions:

- Are the mCTSIB along with adjunct positions able to pick out CNP subjects with balance disturbances?
- How is performance on testing associated with neck disability and pain intensity?
- Do subjects who have reported dizziness have poorer performance on balance testing?
- How do CNP subjects perform on balance tests compared to healthy, age-matched population?

3. Methods

3.1 Research Design

In this study, the research design was cross-sectional. A cross-sectional study is an observation study to document the status of a group or describe a feature of a group of individuals at one particular point in time (Domholdt 2005; chapter 11). This design looks at an association between two variables, but cannot make any inference about a causal relationship since there is no temporal relationship between the variables (Carlson and Morrison 2009). This study evaluated how participants with CNP performed the mCTSIB along with adjunct positions.

3.2 Sample

Subjects were recruited from the caseload of physiotherapists and manual therapists working in a large outpatient clinic in Southwestern Norway. They were patients who were currently undergoing treatment for their CNP.

The inclusion criteria were

- 18-60 years of age
- history of neck pain of more than three months duration, either of idiopathic or traumatic
- pain can extend to the head or down to the upper thoracic area and could peripheralize to the upper extremity
- ability to follow verbal instructions in Norwegian or English
- NDI (Neck Disability Index) score of at least 10 $\geq$ 50, and
- $\geq$ 45° neck rotation in both directions.

The exclusion criteria were

- dizziness of vestibular or vascular origin
- current lower limb injury or pain that could bias the test
- diagnosed vestibular pathology
- diagnosed neurological deficits
- significant visual or hearing impairments, or
- consumption of substances that could affect the processing of sensorimotor inputs, for example, narcotics, sedatives, or alcohol in the previous 24 hours.

3.3 Variables

Background data are age, gender, length of neck pain, onset of neck pain (idiopathic vs traumatic), and presence of other symptoms (headaches, dizziness).

The Numerical Pain Rating Scale (NPRS) is a measure of self-reported pain intensity. It is scored on an 11-point ordinal scale between 0 and 10 where a higher number reflects higher pain intensity. It has been found to have adequate reliability and validity (Grotle, Brox et al. 2004, Cleland, Childs et al. 2008).

The NDI is a simple, reliable, valid tool to measure neck disability (Vernon and Mior 1991). There are 10 categories in which subjects score themselves on an ordinal scale of 0 to 5, with the highest number reflecting a higher disability. The maximum score is 50 or can also be expressed as a percentage. The 10 categories address different aspects: symptoms, ability to perform activities of daily living, and concentration. It has been widely used as a disability assessment questionnaire in neck-related research (Cleland 2005, Cleland, Childs et al. 2008). Its Norwegian version has also been found to be valid (Johansen, Andelic et al. 2013, Breivik 2014).

The mCTSIB was chosen because of it has been widely used in quantitative research in CNP population. Since it has a known ceiling effect, other static positions have been chosen to further challenge balance. The adjunct positions are standing in tandem, on one-leg, and with neck torsion.

In terms of balance testing, the main variables were time and sway measures. Time is a quantitative, ratio variable. Sway is a subjective variable that can be scored on an ordinal scale. Sway was scored as follows: 1 = negligible sway, 2 = minimum sway, 3 = moderate sway, and 4 = excessive sway.

3.4 Procedures

The tester discussed the inclusion and exclusion criteria (with exception of the NDI score) with the referring/treating therapist prior to testing. Testing was done before a scheduled treatment or on a day where no treatment was scheduled.

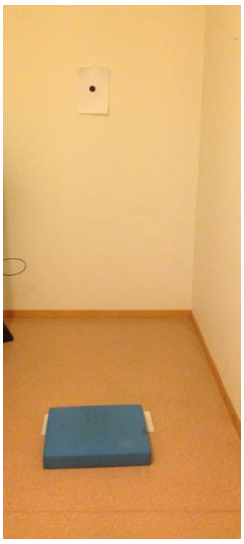
If no was answered to all exclusion criteria, then the subject signed the consent form (Appendix A). While alone in the testing room, the subject then filled out a NDI (Appendix B) and NPRS (Appendix C) according to their status over the last 24 hours. The tester did not look at the results of the questionnaires prior to testing and was therefore blinded to this information. Testing was then performed according to the procedures described below (further testing procedures in Appendix D).

Testing was conducted in a closed room to diminish auditory/visual distractions. A target (black spot) was placed on the wall at 1.5m from a floor target to standardize participant's position. The floor target also had two parallel lines oriented at 45° with respect to the wall. The wall target was placed at about eye level (Pictures1and 2).

The testing positions, as modelled by a colleague, were performed as follows:

- narrow stance on floor with eyes open (Picture 3)
- narrow stance on floor with eyes closed
- narrow stance on foam with eyes open (Picture 4)
- narrow stance on foam with eyes closed
- tandem standing on floor with eyes open (Picture 5)
- tandem standing on floor with eyes closed
- one-leg standing on floor with eyes open (Picture 6)
- one-leg standing on floor with eyes closed
- narrow stance on floor, body rotated 45° under stable head with eyes open (Picture 7), and
- narrow stance on floor, body rotated 45° under stable head with eyes closed.

Picture 1 **Picture 2** **Picture 3** **Picture 4**

Picture 5 **Picture 6** **Picture 7**



The tester stood nearby to assist in case of loss of balance. The test ended when the subject completed a 30-sec trial and was able to maintain the original standing position. On the other hand, the test was stopped and the time was recorded (Appendix F) when one of the following situations occurred:

- one foot or both feet moved from the original position
- one hand or both hands moved away from resting on the shoulders

- one hand or both hands braced against the body in order to stabilize
- opened eyes in the eyes closed testing conditions, and/or
- subject had a near fall or needed to be assisted.

If there was a successful completion of a position, then the subject moved on to the next. If a task failed, the subject attempted completion with one or two more trials to a maximum of three trials (Cohen, Blatchly et al. 1993, Wrisley and Whitney 2004, Vereeck, Wuyts et al. 2008). If a test condition took more than one trial, then the average time of the trials were used in the final calculation.

Once testing was done, the tester calculated the NDI. If the score was ≥ 10, then an interview followed to collect demographical data (Appendix E). If the score was <10, then testing ended, no interview was performed, and results of the test were not included in the study.

3.5 Analysis

The software *Statistical Package for the Social Sciences 22* was used for all analyses. Descriptive analysis of the sample population was performed with respect to gender, age, NPRS score, NDI score, duration of pain, onset of pain, and presence of dizziness or headaches. Other descriptive analyses were done to report the performance of the subjects for each standing conditions and for total time scores. A total score was calculated using the sum of all testing conditions and for the mCTSIB. Finally, failure rates were calculated for the 10 standing conditions using different cut-off scores. All descriptive analyses, sum scores, and failure rates are presented in table format.

Inferential statistics on the sample were performed. Correlation analyses were done using the different total test scores (dependent variable) according to NPRS, NDI, and presence of dizziness (independent variables). Tests of normality were performed on the total test scores. A bivariate correlation was used with Pearson for the scores demonstrating a normal distribution and Spearman for the ones that did not follow a normal distribution. A significance level of $p<0.05$ was selected. The results are presented in table format.

An overview of normative data (Cohen, Blatchly et al. 1993, Vereeck, Wuyts et al. 2008) for different testing conditions and according to different age subgroups are presented as a non-statistical comparison in table format.

3.6 Ethical Considerations

The World Medical Association has developed a set of guidelines and ethical considerations for medical research: the Helsinki declaration. Peripheral professions who wish to study human subjects are invited to follow these guidelines which were last updated in 2003 (World Medical 2013).

With respect to this study, there are some points from the Helsinki declaration that are pertinent. The goal of the study was to gain knowledge of a population suffering from CNP. The testing was performed by a qualified professional: a physiotherapist and manual therapist in training. The intent and the design of the research were clearly defined. The research protocol went through university approval prior to the start of testing. All the subjects needed to be able to give consent and showed ability to follow instructions to be included in the study. The consent and information form is included here as an Appendix A.

If a participant was unwilling to be included in the study, it did not affect their course of treatment. Data in the study were held anonymous. The subjects were assigned a number which was used with respect to data collection**.** Only the primary researcher had a list of names and their corresponding number that were saved on a computer with password protection. No pictures or videos of the participants were taken. The subjects remained dressed and only needed to remove their footwear. Since this project involved only measuring and no intervention was provided, then there was little ethical issue that could arise. The results of the study are to be available to the public via the University of Bergen.

4. Results

Fifteen subjects were initially recruited of which 10 fulfilled all the criteria. Five subjects did not meet the minimum NDI score. Demographical analysis of the sample is shown in Table I. The sample was composed largely of women with a mean age of 39.9+/12.1 years of age. The majority of subjects had associated complaints of dizziness and headaches. The results of the NPRS and NDI were fairly uniform. The subjects rated their pain as 4.8 +/- 1.6 in intensity and their NDI scores were 15.7 +/- 3.7 over 50. The sample was almost equally divided between traumatic and idiopathic-onset of CNP.

Table I

Demographical analysis of the subjects (N=10).

	Mean (sd)
Age	39.9 (12.1)
Female N (%)	8 (80)
NDI (out of 50)	15.7 (3.7)
NPRS	4.8 (1.6)
Duration of symptoms (months)	63.5 (68.2)
Type of onset N (%): Idiopathic Traumatic	 6 (60) 4 (40)
Dizziness N (%)	7 (70)
Headaches N (%)	9 (90)

Table II includes the time measures (sec) recorded for a trial, or the mean of trials if more than one was performed, for each test condition for all 10 subjects. Measures of sway were not included in Table II. There was a wide variation in the strategy that each subject used. It became conceptually difficult to calculate a "mean sway" when one subject failed a trial, and different sway measures were observed in the repeated trials for the same test condition.

Table II

Measured times (sec) for each trial (or mean of >1 trial) for each test condition for each of the 10 subjects.

Sub-jects	mCTSIB				Adjunct Positions					
	Floor		Foam		Tandem		One-leg		Torsion	
	Open	Closed	Open	Closed	Open	Closed	Open	Closed	Open	Closed
1	30	30	30	30	30	19	30	5	30	30
2	30	30	30	30	30	26	30	15	30	30
3	30	30	30	0	30	5	22	2	30	30
4	30	30	30	30	30	29	30	7	30	30
5	30	30	30	30	30	30	30	30	30	30
6	30	30	30	16	30	30	30	9	30	30
7	30	30	30	16	30	7	30	2	30	30
8	30	30	30	30	12	20	17	1	30	30
9	30	30	30	30	30	22	30	7	30	30
10	30	30	30	30	30	30	30	9	30	30

The mean time (sec) and standard deviation (sd) are given for each test condition for all 10 subjects in Table III. The minimal and maximal times encountered in a trial for the whole sample for each test condition are also included. Table IV includes the same statistical analysis by grouping of standing positions. The total test score represents the sum (sec) of all 10 standing conditions and the mCTSIB is the sum (sec) of the first four testing conditions.

Table III

Mean time (sec) and standard deviation (sd) for each test condition for all subjects (N=10).

	Test positions	Mean (sd)	Minimum	Maximum
mCTSIB	Floor with eyes open	30.0 (0.0)	30	30
	Floor with eyes closed	30.0 (0.0)	30	30
	Foam with eyes open	30.0 (0.0)	30	30
	Foam with eyes closed	24.2 (10.3)	0	30
Adjunct Positions	Tandem with eyes open	28.1 (6.0)	11	30
	Tandem with eyes closed	22.2 (8.7)	5	30
	One-leg with eyes open	27.9 (4.6)	17	30
	One-leg with eyes closed	9.2 (9.1)	1	30
	Torsion with eyes open	30.0 (0.0)	30	30
	Torsion with eyes closed	30.0 (0.0)	30	30

Table IV

Mean time (sec) and standard deviation (sd) for groupings of test conditions for all subjects (N=10).

	Mean (sd)	Minimum	Maximum	Maximum theoretical score
Total test score	262.0 (28.9)	209	300	300
mCTSIB	114.2 (10.3)	90	120	120

Tests of normality were done on the different sum scores. The total test score demonstrated a normal distribution (Kolmogorov-Smirnov value > .05). The mCTSIB score did not follow a normal distribution (< .05).

Correlation between reported pain intensity and disability was calculated with respect to the different sum scores. Pearson correlation was used for the total test score and Spearman correlation for the mCTSIB. The results are summarized in Table V. There were no correlations between performance on the balance test and the NPRS or NDI.

Table V

Correlations between test scores and NPRS/ NDI scores reported by coefficient (r) and significant two-tailed value (p).

	NPRS		NDI	
Total test score[1]	p= .625[1]	r= .177[1]	p= .588[1]	r= -.196[1]
mCTSIB[2]	p= .826[2]	r= -.080[2]	p= .333[2]	r= -.342[2]

[1] Pearson correlation.
[2] Spearman correlation.

The results have been listed next to normative data collected by Cohen & al (1993) in Table VI. Their data was only published with means and standard deviations for each testing condition without other descriptive statistics regarding variance.

Table VI

Overview of the mCTSIB mean time (sec) and standard deviation (sd) and those from Cohen & al (1993) in healthy population per age group.

	Sample Mean (sd)	N	Cohen & al (1993) Mean (sd)	N
25-44 years old	117.7 (5.7)	7	120.0 (0.0)	15
45-65 years old	105.3 (15.0)	3	120.0 (0.0)	15

In table VII, the results of the study are listed next to data obtained by Vereeck & al (2008) according to different standing positions and age categories. In their study, they presented data with a 5th percentile cut-off score which represented the 5% lowest scores for each decade of age. This cut-off score was to determine if subjects had a poor performance and hence a test failure. A 10-sec cut-off limit was suggested to indicate poor performance in healthy adults across the four decades. It was considered a simplification for practical purposes.

Table VII

Overview of mean time (sec) and standard deviation (sd) for different standing conditions and those from Vereeck & al (2008) in healthy population per decade of age. Lower 5th percentile score is given (sec) which corresponds to the 5% lowest time score for each population.

		Sample		Vereeck & al (2008)		
Positions	Age	Mean (sd)	N	Mean (sd)	N	5th percentile
Standing on foam with eyes closed	3rd decade	30.0 (0.0)	3	30.0 (0.0)	74	30.0
	4th decade	25.3 (8.1)	3	30.0 (0.0)	43	30.0
	5th decade	30	1	30.0 (0.0)	32	30.0
	6th decade	15.3 (15.0)	3	30.0 (0.0)	30	30.0
Tandem standing with eyes closed	3rd decade	28.7 (2.3)	3	29.9 (0.4)	58	30.0
	4th decade	27.0 (4.4)	3	30.0 (0.0)	42	30.0
	5th decade	19	1	28.8 (4.7)	32	11.5
	6th decade	12.0 (7.6)	3	28.0 (4.9)	28	13.6
One-leg standing with eyes open	3rd decade	30.0 (0.0)	3	30.0 (0.0)	74	30.0
	4th decade	30.0 (0.0)	3	30.0 (0.0)	43	30.0
	5th decade	30	1	29.6 (2.1)	32	25.9
	6th decade	23.0 (6.6)	3	30.0 (0.0)	30	30.0
One-leg standing with eyes closed	3rd decade	19.7 (10.5)	3	27.5 (6.5)	74	9.5
	4th decade	7.7 (1.2)	3	27.5 (6.5)	43	8.5
	5th decade	5	1	21.8 (9.1)	31	3.9
	6th decade	1.7 (0.6)	3	19.9 (9.8)	29	3.8

Table VIII outlines the failure rate for each standing condition according to a 10-sec cut-off suggested by Vereeck & al (2008) and a failure to complete a full 30 sec. In this study, a 10-sec cut-off score yielded the following failure rates in the eyes-closed positions: 10% on foam, 20% in tandem, and 80% in one-leg standing.

Table VIII

Failure rate for each test condition expressed in percentage (%) for all subjects (N=10) using a 10-sec cut-off or failure to complete a testing condition for 30 sec.

	Test Positions	Failure to Reach 10-sec Cut-Off	Failure to Complete Condition	Failure to Complete Condition[1]
mCTSIB	Floor with eyes open	0	0	0
	Floor with eyes closed	0	0	0
	Foam with eyes open	0	0	0
	Foam with eyes closed	10	30	14
Adjunct Positions	Tandem with eyes open	0	10	0
	Tandem with eyes closed	20	70	57
	One-leg with eyes open	0	20	0
	One-leg with eyes closed	80	90	86
	Torsion with eyes open	0	0	0
	Torsion with eyes closed	0	0	0

[1] Includes only subjects 18-45 years of age (N=7).

5. Discussion

The primary aim of this pilot study was to explore a clinical assessment of balance in CNP subjects. As a result of the study, some observations can be drawn, but the sample was too weak to have statistical meaning or reach conclusions.

It was observed that subjects performed well on the mCTSIB and reached a ceiling effect. Adjunct positions had a tendency to be more revealing and subjects tended to have poorer time scores on testing conditions with the eyes closed and with a smaller base of support. There were no correlations found between the performance on the different tests and neck pain intensity, level of disability, or dizziness status. Finally, the subjects in this study performed at a lower level when set next to normative data.

5.1 Results Discussion

The sample had some uniform characteristics with respect to gender, associated symptoms of headaches and dizziness, and in terms of pain and disability ratings. The NDI in this study appeared to be lower than in other studies with matching inclusion/exclusion criteria (Field, Treleaven et al. 2008, Yu, Stokell et al. 2011, Talebian, Otadi et al. 2012, Juul-Kristensen, Clausen et al. 2013).

5.1.1. mCTSIB and Adjunct Positions

The mCTSIB was chosen because it has been widely used in research with CNP population. The adjunct positions were added to further challenge the subjects in static standing and because they have been used in some studies. Adjunct positions were better at picking out subjects with balance disturbances. In general, the performance times decreased with increasing level of difficulty of the testing; narrowing base of support and removal of visual cues. One-leg standing with the eyes closed was noticeably the most difficult test condition followed by tandem standing with the eyes closed.

As previously assumed, the low-challenge test conditions had a perfect success rate in our sample, namely, for standing on the ground with eyes open and eyes closed and standing on the foam with eyes open. It can be argued that these positions did not challenge the sensorimotor system enough to be integrated in clinical balance testing. However, they can be considered as a familiarization to the testing environment as discussed by Juul-Kristensen & al (2013).

In our study, no subject failed the torsion testing conditions. According to Yu & al (2011), neck torsion significantly increased balance deficits on computerized posturography when standing with the eyes closed on a firm surface in subjects with persistent whiplash-associated disorder compared to a control group. However, in that study, all subjects completed the 30-second trial without failure. Results from our study are in accordance with the ones obtained by Yu & al (2011) in terms of completion of the task. Torsion was revealed not sensitive enough to pick out those subjects with perturbed balance.

It could be suggested that neck torsion should be taken to the end of available cervical rotation on the painful side to see if nociceptive afferents would be detrimental to standing balance. If the contribution of cervical rotation in healthy subjects was shown to improve balance on computerized posturography (Yu, Stokell et al. 2011) then it could be suggested that painless and "subthreshold" neck torsion could improve balance and mask the negative impact of nociceptive inputs.

Total Test Scores

The total test and mCTSIB scores were calculated, but offer less observations than the single test conditions. The total scores were needed in order to perform correlation analysis with other variables.

In this experiment, the mCTSIB did not follow a normal distribution and was negatively skewed. This is in accordance with previous observations that the mCTSIB has a strong ceiling effect (Bernhardt, Ellis et al. 1998). This implies that the mCTSIB score cannot register a better performance and that its highest score is too low to register the better performing subjects or to leave room for improvements (Domholdt 2005; chapter 7).

Sway

Sway measures have been estimated and noted during data collection, but have not been analyzed. The subjects in our study used a wide variety of strategies to cope with each testing condition and had a different "tolerance" to disequilibrium. Some subjects had a lower threshold in terms of accepting sway than others. For example, with the eyes-closed positions, a few subjects went from an initial position with minimal sway (grade 2) to "giving up", that is, opening up their eyes or putting their foot down in one-leg standing. Other subjects had a higher threshold to disequilibrium and swayed from minimal (grade 1) progressively to excessive (grade 4) while maintaining the test position before eventually failing the test condition.

In addition, if subjects failed one trial and performed other trials for the same condition, then some subjects used different strategies for each repeated trial. In this case, average time scores can be calculated, but it would be questionable if sway scores could be averaged since they are not a scale variable. Therefore, little extrapolation and correlation could be made between time performance and sway measures.

5.1.2 Associations between Balance Test Results and NDI, NPRS, Dizziness Status

An initial assumption was that subjects with higher pain scores, higher NDI, and/or dizziness would have lower times and exhibit more sway. From our study, no correlations have been found. This is not in accordance to results from several studies (Treleaven, Jull et al. 2003, Treleaven, Jull et al. 2005, Treleaven, Clamaron-Cheers et al. 2011) where greater excursion of center of gravity was measured in subjects with dizziness.

Although most studies in this area have used the NDI and NPRS scales to attempt to represent the subjects' status at the time of the measurement, another questionnaire could have been included. The dizziness handicap inventory (DHI) is a disease-specific questionnaire for individuals with dizziness or balance problems (Jacobson and Newman 1990). Since 70% of the test population had some complaints of dizziness, it could have been important to include a dizziness measure to get an accurate representation of the subjects' status. It is hypothetical whether a correlation would be found between balance and DHI variables. Yu & al (2011) found no correlation in a study between DHI scores and balance scores on static computerized posturography.

5.1.3 Results on Balance Tests in Relation to Normative Data

Normative data are considered secondary data. They can be helpful since they are quick and inexpensive to use, usually involve a large sample, can show general trends (Carlson and Morrison 2009), and therefore, can be used as a frame of reference. On the other hand, normative data may not include all the variables of interest and it may be difficult to understand how there were collected. Consequently, in our study, statistical comparison was not performed. Instead, normative data was used to illustrate the difference performance on standing tests between two populations.

The results of our study point to a difference in time scores when put against normative data from Cohen & al (1993). The subjects had a poorer score on the mCTSIB in both 25-44 years and 45-65 years old categories. Even though there was a difference between the test population and normative data, the mCTSIB might not be the most sensitive clinical assessment for those with CNP because of its strong ceiling effect.

In juxtaposing the single test conditions and normative data from Vereeck & al (2008) according to decades of age, some interesting observations can be made. The major differences were found to be in the eyes-closed standing positions in tandem and especially on one-leg. The difference in the scores was found across the four decades evaluated. This appears to be in line with the previous reports that CNP subjects have an increased reliance on visual inputs in order to control their balance (Rubin, Woolley et al. 1995, Madeleine, Prietzel et al. 2004, Treleaven, Jull et al. 2005, Vuillerme and Pinsault 2009).

Vereeck & al (2008) had reported the lower 5th percentile balancing scores. This reflects approximately twice the standard deviation from the mean value provided that scores are normally distributed (Domholdt 2005; chapter 19) and corresponds to the lower end of normal values. From this, a lower cut-off score was established to determine which subjects had a poor performance on balance testing. A 10-sec cut-off score was proposed as a simplification to the lower 5th percentile rule. According to this cut-off score, the results of our sample in eyes-closed positions yielded a 10% failure in standing on foam, 20% in tandem, and 80% in one-leg standing.

Pass/fail Rate

Most of the studies that look at balance on computer posturography in CNP population publish quantified sway measures for the subjects who can maintain balance according to pre-determined test duration of 20 to 60 seconds. Only a few studies report pass/fail results (Treleaven, Jull et al. 2005, Treleaven, Murison et al. 2005, Field, Treleaven et al. 2008, Jorgensen, Skotte et al. 2011, Juul-Kristensen, Clausen et al. 2013). This leads to limited interpretation of research findings about what is expected of the performance of CNP subjects on a clinical assessment of balance. Reporting of failure rates could be a way to bridge the gap between purely quantitative and semi-quantitative assessments of balance.

The failure rate to hold 30 sec of tandem standing with the eyes closed has been reported to be between 10% and 20% in control groups, 37% in subjects with idiopathic onset of CNP, between 37% and 50% in non-dizzy whiplash subjects with CNP, and between 72-80% in whiplash onset CNP subjects with reported dizziness/unsteadiness (Treleaven, Jull et al. 2005, Treleaven, Murison et al. 2005, Field, Treleaven et al. 2008). Our study is in accordance with those reported failure rates in age-matched subjects (≤45 years of age) where 57% of the subjects failed to reach 30 sec of tandem standing with the eyes closed.

5.2 Methodological Considerations

5.2.1 Threats to Internal Validity

Study Design

A main threat to validity was having the sample size too low. This allows making interesting observations, but limits the ability to reach conclusions. In our study, the sample size was sufficient to explore the use of a clinical assessment of balance in CNP subjects and to gain some knowledge as to which test conditions could pick out those who have balance disturbances. From the results, there was a difference in the performance of the test population especially in the eyes-closed positions with a narrower base of support.

In order to establish the level of sensitivity of a clinical assessment, there needs to be a comparison to a healthy, age-matched population (Carlson and Morrison 2009). In our study, we could not statistically compare our results since there was a lack of a comparison group. We could have chosen to include a healthy, age-matched population of statistically meaningful size, using the same parameters and testing procedures as the ones used in this experiment as opposed to comparing the CNP subjects to normative data.

Tester as a Measurement Tool

The main factor affecting the validity is that the tester was the principal tool of measurement. Steps were taken to standardize the procedures and verbal instructions. The tester was not aware of the results of the NDI and NPRS or any background data before testing in order to minimize biasing the observations/procedures in accordance with pre-testing information.

An important source of error could arise from the tester having to "measure" the extent of sway according to an ordinal scale, look for compensation strategies, and determine a test failure. The tester could not be "calibrated" and could have therefore been inconsistent throughout the testing of all participants. The other source of error could have been when the tester decided when a test failure occurred. Despite standardization and having procedures in place, there was room for interpretation.

In our study, estimating sway was a logistical problem in terms of positioning of the tester with respect to the subject. This study was designed to have only one tester in order to reproduce a more realistic clinical assessment. Sway is not unidirectional and can happen on multiple planes (mediolateral, anterioposterior). As expressed by Cohen & al (1995), the observation of sway needs at least two examiners, one for recording sway in one plane and the other examiner for staying in close proximity of the subject and recording sway in an another plane.

Participants

Since the testing was done once, there was not an expected learning effect from the participants. However, the subjects could familiarize themselves to the testing. It was expected that the first two testing conditions would not be enough to challenge the participants and could be considered trials of familiarization.

The participants might have been influenced by other factors which affect internal validity. In the case of medications, as mentioned in the exclusion criteria, there exists an extensive list of medications that have the potential to affect balance and concentration, or have dizziness as a side-effect, but none of these would have had exactly the same relative effect. For this reason, only a few medications had been selected for the exclusion criteria. In research on balance disturbances in CNP, it has been advocated to exclude medications such as antipsychotics, anti-inflammatories, narcotics, sedatives (Treleaven, Jull et al. 2005, Treleaven, Murison et al. 2005, Field, Treleaven et al. 2008, Yu, Stokell et al. 2011). Other research did not exclude specific medications (Jorgensen, Skotte et al. 2011, Treleaven, Clamaron-Cheers et al. 2011, Juul-Kristensen, Clausen et al. 2013, Otadi, Hadian et al. 2013). Since the goal of this project was to assess a tool usable in the clinic, then medications that are widely used in the population could not all have been excluded. In this manner, there would be a compromise of the factors that influence internal validity in order to improve the external validity of the study.

Standardization

In order to limit threats to internal validity, steps were taken to create a uniform environment and testing procedures so that each subject's performance was consistent within all the trials, and from one subject to the other. In the literature, there exists a wide variation in the equipment and testing procedures. The lack of standardization of measurement tools poses a problem when applying test conditions. The original test by Shumway-Cook & al (1986) by which most of the studies are based on, mentions foam thickness but did not standardize body position.

The foam in our study was 6cm thick. It was chosen because it is widely available in physiotherapy/manual therapy clinics. From the other studies, the thickness greatly varied from 8cm in the original test by Shumway-Cook & al (1986) to18cm for Wrisley & al (2004) and Whitney & al (2004). Since a greater foam thickness diminishes the somatosensory inputs coming from the feet and ankles, it would have been more sensitive to use a thicker foam cushion.

Inconsistencies exist with respect to foot placement and the use of shoes. According to Wrisley & al (2004), there was no difference between the results on computer posturography between narrow and comfortable stances. Furthermore, according to Whitney & al (2004), there was no significant difference between the results on computer posturography with or without shoes.

In our study, the arms-across-the-chest placement was used, the same as in Jorgensen & al (2011), Whitney & al (2004), and Wrisley & al (2004). It was considered to be easier to interpret when the subject was deviating from their original position. On the other hand, this position increased the risk that an individual would use a bracing strategy when experiencing unsteadiness.

With respect to the neck torsion test condition, the difficulty was to ascertain that the subjects had and/or were holding the 45° torsion angle. Even though, foot placement was standardized by parallel lines for the feet at 45° and the tester verified that the sternum and pelvis were in alignment, there could have been rotation coming from the lower extremities and trunk, which would be reducing the torsion angle at the cervical spine. In the absence of a cervical goniometer, this could be a source of error.

5.2.2 Concepts of Balance Testing

In our project, it could be questioned whether the concept of balance was accurately measured by the mCTSIB and adjunct positions in the testing environment, or if it was underrepresented. Construct validity of a measurement tool is concerned with the actual meaning of that variable in a study (Domholdt 2005; chapter 7).

The use of static postures with different testing conditions could have been enough to highlight some of the sensory integration problems. Yet, it could be argued that these conditions were far too limiting to assess motor control strategies and motor planning.

Dynamic balance testing could have been included to explore if it could be more sensitive in discerning CNP subjects with balance impairments.

Moreover, since the theory behind balance disturbances in CNP patients involves disturbances of the sensorimotor system, it could be suggested that multiple systems could be combined to further challenge subjects. For example, static standing condition with active neck or eye movements. In this approach, it could be argued that instead of attempting to differentiate between the different sensory systems, an attempt at augmenting sensory input essentially by giving a sensory overload might represent more accurately a clinical balance test (Reid, Callister et al. 2014).

The concept of imbalance and dizziness could have been further explored. Dizziness could have been measured with the DHI to better represent the sample. In addition, self-reported balance impairments could have been included, for example, questions about imbalance or loss of balance and falls.

From research, it was found that idiopathic origin CNP patients suffer from the same impairments that whiplash-associated CNP patients have, but to a lesser extent. Nevertheless, there has been some extrapolation of research findings that have been extended to idiopathic CNP subjects even though traumatic onset of CNP has been the major focus in literature.

5.2.3 External Validity

External validity refers to whom and in what settings can the results of the study be generalized (Domholdt 2005; chapter 7). For this project, the sample of participants chosen for the study was representative of a more general population of CNP patients seen in a clinical setting. Those included might have different medications that affect balance other than the ones included in the exclusion criteria. Also, those who suffer from dizziness, developed neck pain as a result of a trauma, or those who had a history of lower extremity injury were also included. The NDI results were set to a fairly low level of disability, corresponding to most of the research in this field, but could have been set higher to improve ability to detect balance impairments in this population.

The setting in which the study was conducted would have needed to recreate a natural environment in order to maximize the external validity. Although, in this case, a clinical test was a step towards external validity as opposed to a laboratory test, it lacked in variability. The testing was conducted in a quiet room away from distractions. It was previously described that CNP patients who exhibit sensorimotor disturbances might be more affected by multiple stimuli increasing the challenge of maintaining balance (Huxham, Goldie et al. 2001, Khattar and Hathiram 2012). For example, peripheral visual stimuli, auditory stimuli, other sensory stimuli (wind) were not included in this study; the environment was controlled and non-variable. The testing was also static and had limited ability to generalize to dynamic balance conditions experienced in a “normal, natural” environment. The testing conditions in our study can be considered part of a clinical screening tool, but cannot be considered a functional assessment of balance.

5.3 Recommendations for Further Research

A clinical assessment tool of balance in CNP would need to be further developed and tested to see if it could be sensitive enough to discern those who have balance disturbances. Although establishing sensitivity and validity in this patient population would not be enough since clinical tools need to demonstrate internal consistency, such as, proper reliability.

In terms of the development of a clinical assessment in CNP patients, it would be recommended to challenge balance to a higher level. This could be by either dynamic testing (Stokell, Yu et al. 2011, Reid, Callister et al. 2014) or by challenging multiple sensory systems simultaneously (Sjostrom, Allum et al. 2003).

In order to establish associations between performance on balance testing and background data, it would be recommended to use the DHI (Jacobson and Newman 1990). This could be done in addition to other questionnaires to obtain an accurate representation of subjects with CNP. Furthermore, questions regarding the subjects’ report of unsteadiness and falls could be included in the interview.

5.4 Clinical Implications

A clinical assessment of balance in CNP is not meant to replace computerized posturography. The purpose would be to offer clinicians a rapid, inexpensive, clinical test to assess patients presenting with CNP in order to have a more representative view of the patient and his/her areas of impairments. This allows for a more personalized and targeted intervention.

Being able to assess a CNP patient with balance disturbances or other sensorimotor impairments gives clinicians another approach than a musculoskeletal one for intervention. The treatment of sensorimotor impairments should be an integral part of a rehabilitation program in those patients experiencing chronicity and should be viewed as a parallel line of treatment to manual therapy to the cervico-scapulo-thoracic complex.

6. Conclusion

As a result of the study design and low sample size, limited recommendations can be made. In our study, the mCTSIB demonstrated a ceiling effect and was limited in the ability to pick out subjects with balance impairments. The adjunct positions with the eyes closed, especially of unilateral and tandem standing were better able to challenge the subjects. The performance on static standing tests did not demonstrate association to the subjects' pain intensity, level of disability, or presence of dizziness. The performance results of the subjects appeared to be lower with respect to age-matched normative data especially in more challenging positions of unilateral standing and tandem standing with the eyes closed. It could be recommended that a familiarization period be included in clinical testing incorporating easier testing conditions.

Evaluation and treatment of sensorimotor disturbances within CNP is an emerging field. On the other hand, there is a lack of indexes or test batteries developed especially for this patient population. Moreover, there needs to be more research for the assessment of balance both with respect to clinical cut-off for test conditions and whether alternate forms of assessment of balance should be considered.

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Appendix A – Consent Form

Forespørsel om deltakelse i forskningsprosjekt.

"Balansekontroll hos pasienter med kroniske nakkesmerter: en klinisk test."

Bakgrunn og hensikt

Dette er et spørsmål til deg om å delta i en forskningsstudie for å evaluere balanse. Tidligere forskning har vist at de som har hatt kroniske nakkesmerter har nedsatt kontroll av balanse i stående. Dette prosjektet er en del av masterstudium i manuellterapivitenskap ved universitetet i Bergen.

Hva innebærer studien?

Deltakelse i studien innebærer at du fyller ut et spørreskjema om smerteopplevelse og hvordan nakkesmerter påvirker daglige aktiviteter. En tester i prosjektet skal evaluere din evne å stå ved forskjellige oppgaver: øyene lukket, stå på ett bein, stå med rotert hode, og stå på en skumpute. Etterpå skal testeren spørre deg om dine nakkesmerter. Testeren skal ikke vite om opplysninger fra spørreskjema før testing av balanse.

Mulige fordeler og ulemper

Testingen vil ta circa 20 minutter, inkludert både intervjuet og testing. Det blir ingen behandling, kun testing av hvordan du kan stå ved forskjellige oppgaver. Du må ta av skoene dine når du blir testet, men ikke sokkene. Deltakelse i studien er ikke forbundet med noen helserisiko.

Hva skjer med informasjonen om deg?

Informasjonen som registreres om deg skal kun brukes til denne forskningsstudien på balanse. Alle opplysningene vil bli behandlet uten navn og fødselsnummer eller andre direkte gjenkjennende opplysninger. En kode knytter deg til dine opplysninger og testresultater gjennom en navneliste. Det er kun hovedtesteren som har adgang til navnelisten og som kan finne tilbake til deg. Alle opplysningene blir slettet når prosjektet er avsluttet (circa desember 2014). Det vil da ikke være mulig å identifisere deg i resultatene fra studien når disse publiseres.

Frivillig deltakelse
Det er frivillig å delta i studien. Du kan når som helst og uten å oppgi noen grunn trekke ditt samtykke til å delta i studien. Dette vil ikke få konsekvenser for din videre behandling.
Dersom du ønsker å delta, undertegner du samtykkeerklæringen på siste side. Om du nå sier ja til å delta, kan du senere trekke tilbake ditt samtykke uten at det påvirker din øvrige behandling. Dersom du senere ønsker å trekke deg eller har spørsmål til studien, kan du kontakte prosjektlederen, NAVN, TELEFON NUMBER.
Hvis du vil, kan du gjerne få tilgang til resultater fra studien etter at prosjektet er avsluttet.

Samtykke til deltakelse i studien «Balansekontroll hos pasienter med kroniske nakkesmerter: en klinisk test.»

Jeg er villig til å delta i studien.

(Signert av prosjektdeltaker, dato)

Jeg bekrefter å ha gitt informasjon om studien.

(Signert, prosjektleder, dato)

Appendix B – NDI

SKJEMA OM HEMMENDE NAKKEPLAGER (Norwegian version of the NDI)

☐ (1) IKKE UTFYLT

VEILEDNING: **Dette spørreskjemaet er laget for å gi legen informasjon om hvorledes dine smerter i nakken har påvirket din evne til å klare deg i dagliglivet. Vennligst svar på hver del og kryss av bare den ENE ruta i hver del som passer for deg. Vi er klar over at du kan synes at to av utsagnene i en og samme del kan passe for deg, men vennligst bare kryss av i den ruta som kommer nærmest til å beskrive ditt problem.**

Del 1 - Smerteintensitet

- ☐ Jeg har ingen smerter akkurat nå.
- ☐ Smertene er svært svake akkurat nå.
- ☐ Smertene er moderate akkurat nå.
- ☐ Smertene er nokså sterke akkurat nå.
- ☐ Smertene er meget sterke akkurat nå.
- ☐ Smertene er de verst tenkelige akkurat nå.

Del 2 - Personlig stell (vaske seg, kle på seg, osv.)

- ☐ Jeg kan stelle meg selv som normalt, uten at det gir ekstra smerter.
- ☐ Jeg kan stelle meg selv som normalt, men det gir ekstra smerter.
- ☐ Det er smertefullt å stelle seg, og jeg er langsom og forsiktig.
- ☐ Jeg trenger noe hjelp, men klarer mesteparten av mitt personlige stell.
- ☐ Jeg trenger hjelp hver dag med mesteparten av mitt personlige stell.
- ☐ Jeg klarer ikke å kle på meg, har vansker med å vaske meg og holder meg i senga.

Del 3 - Løfting

- ☐ Jeg kan løfte noe tungt uten at det gir ekstra smerter.
- ☐ Jeg kan løfte noe tungt, men det gir ekstra smerter.
- ☐ Smerter hindrer meg i å løfte noe tungt opp fra gulvet, men jeg kan klare det hvis det er gunstig plassert, for eksempel på et bord.
- ☐ Smerter hindrer meg i å løfte noe tungt, men jeg kan klare noe lett eller middels tungt hvis det er gunstig plassert.
- ☐ Jeg kan bare løfte noe meget lett.
- ☐ Jeg kan ikke løfte eller bære noe i det hele tatt.

Del 4 - Lesing

- ☐ Jeg kan lese så mye som jeg ønsker, uten at det gir smerter i nakken.
- ☐ Jeg kan lese så mye som jeg ønsker, men med svake smerter i nakken.
- ☐ Jeg kan lese så mye som jeg ønsker, men med moderate smerter i nakken.
- ☐ Jeg kan ikke lese så mye som jeg ønsker, på grunn av nokså sterke smerter i nakken.
- ☐ Jeg kan omtrent ikke lese i det hele tatt, på grunn av meget sterke smerter i nakken.
- ☐ Jeg kan ikke lese i det hele tatt, på grunn av smerter i nakken.

Del 5 - Hodepine

- ☐ Jeg har ikke hodepine i det hele tatt.
- ☐ Jeg har svak hodepine som kommer nå og da.
- ☐ Jeg har moderat hodepine som kommer nå og da.
- ☐ Jeg har moderat hodepine som kommer jevnlig.
- ☐ Jeg har sterk hodepine som kommer jevnlig.
- ☐ Jeg har hodepine nesten hele tiden.

Vernon,H., & Mior,S.(1991). The Neck Disability Index: A Study of Reliability and Validity. J. Manipulative and Physiological Therapeutics,14(7),409-415.

[illegible]

SKJEMA OM HEMMENDE NAKKEPLAGER - forts.

Del 6 - Konsentrasjon

- ☐ Jeg kan konsentrere meg uten vansker.
- ☐ Jeg kan konsentrere meg med små vansker.
- ☐ Jeg har nokså store vansker med å konsentrere meg.
- ☐ Jeg har store vansker med å konsentrere meg.
- ☐ Jeg har svært store vansker med å konsentrere meg.
- ☐ Jeg kan ikke konsentrere meg i det hele tatt.

Del 7 - Arbeid (eller daglige gjøremål)

- ☐ Jeg kan gjøre så mye arbeid som jeg ønsker.
- ☐ Jeg kan gjøre mitt vanlige arbeid, men ikke mer.
- ☐ Jeg kan gjøre mesteparten av mitt vanlige arbeid, men ikke mer.
- ☐ Jeg kan ikke gjøre mitt vanlige arbeid.
- ☐ Jeg kan omtrent ikke gjøre noe arbeid i det hele tatt.
- ☐ Jeg kan ikke gjøre noe arbeid i det hele tatt.

Del 8 - Bilkjøring

- ☐ Jeg kan kjøre en bil uten at det gir smerter i nakken.
- ☐ Jeg kan kjøre en bil så lenge som jeg ønsker, men med svake smerter i nakken.
- ☐ Jeg kan kjøre en bil så lenge som jeg ønsker, men med moderate smerter i nakken.
- ☐ Jeg kan ikke kjøre en bil så lenge som jeg ønsker, på grunn av nokså sterke smerter i nakken.
- ☐ Jeg kan omtrent ikke kjøre en bil i det hele tatt, på grunn av meget sterke smerter i nakken.
- ☐ Jeg kan ikke kjøre en bil i det hele tatt, på grunn av smerter i nakken.

Del 9 - Søvn

- ☐ Jeg har ikke problemer med å sove.
- ☐ Søvnen min er litt forstyrret (mindre enn 1 times søvnløshet).
- ☐ Søvnen min er noe forstyrret (1-2 timers søvnløshet).
- ☐ Søvnen min er moderat forstyrret (2-3 timers søvnløshet).
- ☐ Søvnen min er sterkt forstyrret (3-5 timers søvnløshet).
- ☐ Søvnen min er fullstendig forstyrret (5-7 timers søvnløshet).

Del 10 - Fritid

- ☐ Jeg er i stand til å drive med alle mine fritidsaktiviteter uten at det gir smerter i nakken overhodet.
- ☐ Jeg er i stand til å drive med alle mine fritidsaktiviteter, men med noe smerter i nakken.
- ☐ Jeg er i stand til å drive med de fleste av, men ikke alle, mine vanlige fritidsaktiviteter på grunn av smerter i nakken.
- ☐ Jeg er bare i stand til å drive med noen få av mine vanlige fritidsaktiviteter, på grunn av smerter i nakken.
- ☐ Jeg kan omtrent ikke drive med noen fritidsaktiviteter, på grunn av smerter i nakken.
- ☐ Jeg kan ikke drive med fritidsaktiviteter i det hele tatt.

Vernon,H., & Mior,S.(1991). The Neck Disability Index: A Study of Reliability and Validity. J. Manipulative and Physiological Therapeutics,14(7),409-415.

[illegible] 30/01/04

Appendix C – NPRS

Numerisk smerteskala

Hvordan vil du gradere de smertene du har hatt i løpet av den siste uke. Sett ring rundt ett tall.

0 1 2 3 4 5 6 7 8 9 10

ingen smerter *så vondt som det går an å ha*

Subjects were informed to fill out the NPRS according to the pain intensity which represents best the last 24 hours.

Appendix D – Testing Procedures

For the purpose of this study, narrow stance was defined as feet together: medial malleoli, first tarsometatarsal joints, and/or heels in as much contact as possible. The arm position was defined as arms crossed over the chest with the hands resting on the shoulders and was used in all testing conditions (Picture 8). Tandem standing had the dominant foot directly in front of the non-dominant foot (with toes touching the back of the heel). One-leg stance was standing on the dominant foot with a slight space between the legs at knee level. Foot dominance was determined as the leg most likely to be kicking a ball (Riemann and Guskiewicz 2000).

Picture 1

The foam was turned over between each condition so as to not be influenced by uneven wear. The foam was an Airex with dimensions of 41cm x 50cm x 6cm. Although it has been found that there was no significant in testing individuals with or without their shoes (Whitney and Wrisley 2004), for purpose of standardization, the test was conducted with socked or bare feet.

The tester demonstrated the task and instructed the subject to “stand with your feet together and your arms across your chest with the hands resting on the shoulders in a relaxed manner and do this until I tell you to stop”. For the eyes open testing, the instruction was “look at the black spot on the wall” as opposed to the eyes closed testing: “keep your eyes closed until I tell you to stop”. For the tandem position, instruction was “stand with one front in front of the other so that the toes of the back foot touch the heel of the front foot”. For the unilateral stance test, the tester said: “stand on one leg keeping a space between your knees”.

For the last test condition, the tester held the head while the subject rotated his/her body until reaching marks on the ground at 45°. The direction of the rotation was chosen according to the least painful. The instructions was “keep your body in this position with your eyes open (or closed) until I tell you to stop”.

Appendix E – Background Data Collection

SUMMARY INFORMATION

GENDER	MALE	FEMALE
AGE	YEARS	
NDI SCORE	/50	
NPRS SCORE	/10	
DURATION OF SYMPTOMS		
CERVICOGENIC DIZZINESS	YES	NO
CERVICOGENIC HEADACHES	YES	NO
EXTENSIVE PAIN PATTERN	YES	NO
ONSET	TRAUMATIC	IDIOPATHIC
PAIN IN LEGS	YES	NO
MEDICATIONS/ALCOHOL		

Appendix F – Scoring Grid

SCORING

POSTURES	TRIAL 1	TRIAL 2	TRIAL 3
FLOOR, EYES OPEN	/sec Sway:	/sec Sway:	/sec Sway:
FLOOR, EYES CLOSED	/sec Sway:	/sec Sway:	/sec Sway:
FOAM, EYES OPEN	/sec Sway:	/sec Sway:	/sec Sway:
FOAM, EYES CLOSED	/sec Sway:	/sec Sway:	/sec Sway:
TANDEM, EYES OPEN	/sec Sway:	/sec Sway:	/sec Sway:
TANDEM, EYES CLOSED	/sec Sway:	/sec Sway:	/sec Sway:
ONE-LEG, EYES OPEN	/sec Sway:	/sec Sway:	/sec Sway:
ONE-LEG, EYES CLOSED	/sec Sway:	/sec Sway:	/sec Sway:
BODY ROT, EYES OPEN	/sec Sway:	/sec Sway:	/sec Sway:
BODY ROT, EYES CLOSED	/sec Sway:	/sec Sway:	/sec Sway: