A clinical study of patients with concurrent dizziness and neck pain

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Abbreviations

ACR – American College of Rheumatology

BPPV – benign paroxysmal positional vertigo

CCAT - Crowe Critical Appraisal Tool

CCR – cervicocollic reflex

CD – cervicogenic dizziness

CI – confidence interval

CNS – central nervous system

COM – center of mass

COP – center of pressure

COR – cervical-ocular reflex

CROM – cervical range of motion

DHI – Dizziness Handicap Inventory

DO – dizziness only

DN – dizziness and neck pain

ENT – ear, nose and throat

GPE – global physiotherapy examination

ICD – International Classification of Diseases

kPA – kilopascal

OR – odds ratio

ND – neck pain and dizziness

NDI – Neck Disability Index

PPT – pressure pain threshold

SD – standard deviation

TNR – tonic neck reflex

VCR – vestibulocollic reflex

VOR – vestibulo-ocular reflex

VSR − vestibulospinal reflex

VSSsf – Vertigo Symptoms Scale short form

WAD – whiplash-associated disorders

Abstract

Dizziness is a relatively common complaint with a heterogeneous group of patients with several plausible causes. There has long been a controversy regarding the role of the cervical spine in dizziness and balance issues, even though there are well-established physiological connections between the vestibular, visual and cervical proprioceptive systems In addition, previous studies have shown that concurrent dizziness and neck pain exist in both patients with primary dizziness and patients with primary neck pain, resulting in a common clinical issue. However, there is little knowledge about the prevalence of patients with concurrent dizziness and neck pain and how neck pain influences patients with dizziness and balance.

This project was a cross-sectional study of patients referred for either dizziness or neck pain to one of two outpatient clinics − an ear, nose and throat clinic or a spine clinic − both at Haukeland University Hospital in Bergen. The overall object of this thesis was to examine to what extent and how neck pain influences dizziness in terms of physical and dizziness characteristics, dizziness severity, postural control and quality of life.

Our findings are presented in four papers. Paper I was a systematic review of the clinical characteristics of patients with cervicogenic dizziness. Only eight out of 2161 articles met our inclusion criteria. We found that reduced postural control measured with posturography was the most common clinical finding in patients with cervicogenic dizziness compared with other populations.

Paper II examined differences in dizziness disability and quality of life in patients with and without neck pain, referred for dizziness to the ear, nose and throat clinic. Additionally, we examined whether neck pain was associated with a nonvestibular or vestibular diagnosis. We found that patients with additional neck pain reported higher dizziness disability and lower quality of life. In addition, there was no association between neck pain and the presence or absence of a vestibular disorder.

Paper III explored the relationship between the pressure pain threshold in the neck and postural control in patients referred to both clinics. The patients were divided according

to their referred clinic and thus their primary complaint. In the patients referred for dizziness as the main complaint, we found a small, inverse relationship between pressure pain thresholds and sway area with eyes closed, after adjusting for age, sex and generalized pain. The same inverse relationship was found between pressure pain thresholds in the neck and the Romberg ratio on a bare platform after adjusting for age, sex and generalized pain. Neither of these relationships were present in the neck pain group.

In Paper IV, we explored clinical symptoms and physical findings in patients with concurrent neck pain and dizziness from both centers and examined whether they differed from patients with dizziness alone. Both neck pain groups were associated with certain dizziness characteristics and increased physical impairment. The neck pain group, having dizziness as their primary complaint, had the highest symptom severity score.

The overall findings of this thesis indicate that neck pain may affect postural control, dizziness symptoms, physical impairments and quality of life. As the relationship between dizziness and neck pain is a controversial topic, these finding may be helpful and should be considered when examining patients with concurrent complaints, regardless of diagnosis.

List of publications

Paper I

Knapstad MK, Nordahl SHG, Goplen FK. Clinical characteristics in patients with cervicogenic dizziness: A systematic review. Health Science Reports. 2019;2(9):e134.

Paper II

Knapstad MK, Goplen F, Skouen JS, Ask T, Nordahl SHG. Symptom severity and quality of life in patients with concurrent neck pain and dizziness. Disability & Rehabilitation. 2019:1-4.

Paper III

Knapstad MK, Goplen FK, Ask T, Skouen JS, Nordahl SHG. Associations between pressure pain threshold in the neck and postural control in patients with dizziness or neck pain - a cross-sectional study. BMC Musculoskeletal Disorders. 2019;20(1):528.

Paper IV

Knapstad MK, Nordahl SHG, Skouen JS, Ask T, Goplen FK. Neck pain associated with clinical symptoms in dizzy patients-A cross-sectional study. Physiotherapy Research International. 2019:e1815

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Contents

1. Introduction

1.1 Background

Both dizziness and neck pain are relatively common complaints in the Norwegian population. Surveys show that 14% of the Norwegian population have reported an experience of dizziness and balance problems during the last 3 months [1]. Aside from low back pain, neck pain is the most common complaint from the musculoskeletal system with a 1-week prevalence of 34% in the Norwegian population [2]. Individually, each of these complaints is associated with impaired physical function and quality of life and causes a financial burden on patients as well as healthcare systems [3-6]. The coexistence of both symptoms has been reported in patients either with dizziness as the primary complaint [7, 8] or in patients primarily seeking help for neck symptoms [9, 10], indicating that concurrent complaints may be a common clinical issue. Dizziness is a complex symptom and there are theories suggesting neck pain as a cause of dizziness and balance issues in the absence of other explanations of diagnosis [11], commonly known as cervicogenic dizziness (CD). The theory is based on the known physiological connections between the vestibular, visual and cervical proprioceptive afferents throughout the central nervous system (CNS) [12]. However, the notion of dizziness due to neck pain is controversial since there is a lack of clinical tests for the condition and gap in the knowledge about neck pain's contribution to dizziness symptoms [11-13]. Additionally, research has tended to focus only on CD patients, and not investigated how neck pain influences dizziness in larger groups with both symptoms, regardless of diagnosis. There is little knowledge about the prevalence and the consequences of concurrent dizziness and neck pain, and how neck pain influences dizziness characteristics, physical impairment and quality of life in dizzy patients. This thesis will explore the clinical interrelations between dizziness and neck pain in both patients with primary dizziness and primary neck pain.

The first paper is a systematic review examining clinical characteristics in patients with CD. Previous studies have found postural instability during posturography in patients with neck pain [14] and CD [15, 16]. Thus, Paper III explores the relationship between pain sensitivity in the cervical region and posturography in a population with dizziness and in a population with neck pain. Last, as there is little knowledge about how neck pain influences patients with dizziness, Papers II and IV examine how neck pain associates with symptom severity, quality of life, physical characteristics and dizziness characteristics in dizzy patients. The results of the papers are presented and followed by a discussion of the main results. Methodical considerations and limitations of this thesis are discussed, followed by a consideration of implications and need for future research in the field of dizziness and neck pain.

1.2 Dizziness

Dizziness is a field that is in constant development, but still has areas which are unclear and in need of updated evidence. Dizziness is a relatively common complaint and affects about 15%−20% of the adult population annually [17]. Patients with dizziness make up a heterogeneous group of patients with several plausible causes of their problems. It is one of the most common symptoms leading to referral to neurologists and otolaryngologists [18]. Dizziness is usually divided into subgroups: vertigo (a false sensation of self or surroundings moving, often spinning); disequilibrium (a sense of imbalance); and presyncope / "lightheadedness," which is usually described as a vague feeling of being disconnected from the environment [19, 20]. Vertigo is the symptom that most often points to a vestibular origin of the dizziness [21]. The prognosis for patients with dizziness is usually good, with as many as three quarters of patients reporting no impairment due to dizziness 3 months after consulting a physician [21]. However, the final cause of dizziness is not always identified [18, 22] and there are patients who do not recover properly and suffer with severe impairment due to dizziness, causing interference with daily activities [4, 23].

The term "vertigo" has long been discussed and the Barany society's committee for the classification of vestibular disorders describes "vertigo" and "dizziness" as non-hierarchal. They argue that they are two different sets of symptoms. They define vertigo as the false sense of self-motion without any motion, or the feeling of distorted self-motion with normal movement. Whereas dizziness is defined as a sense of disturbed or impaired spatial orientation without a false or distorted sense of motion [24]. In this thesis, however, the term “dizziness” will be used as an umbrella term for all types of dizziness descriptions, as patients often have difficulties describing their feeling of dizziness in a consistent manner [25].

1.2.1 The vestibular system

The vestibular system has important sensory functions, which are involved in and contribute to the perception of head position and acceleration, self-motion and spatial orientation [26]. The system consists of a continuous series of tubes and sacs, located in the inner ear in the temporal bone of the skull, the vestibular nuclear complex, the cerebellum and neural pathways [27] [28]. The vestibular system is a very precise and rapid system, and the only system able to detect head movements at very high velocity, acceleration and frequencies [28]. It receives input from the inner ear, proprioception from the somatosensory system, visual signals and input from motor commands. The inputs are integrated by the vestibular nuclear complex which generates motor commands to the eyes and body. The cerebellum monitors and calibrates the vestibular system so that it can produce accurate responses [29].

The peripheral vestibular system

The peripheral portion of the vestibular system includes the structures of the inner ear and the vestibular part of the eight cranial nerves, which is constantly providing information about the motion and position of the head to integrating centers in the brain stem, cerebellum and somatosensory cortex [26]. The peripheral vestibular system consists of five receptors: three semicircular canals, the saccule and the utricle. The semicircular canals (the anterior, posterior and horizontal canal) are responsible for input of angular acceleration, and are positioned at approximately right angles to each other [26]. The semicircular canals are filled with endolymph with a density slightly higher than water. During head movement, the flow of endolymph stimulates hair cells within the canals, leading to excitation or inhibition of signals from that canal. The utricle and saccule make up the otolith organs of the membranous labyrinth. Sensory hair cells project into a gelatinous membrane that has calcium carbonate crystals on top (otoconia) [28]. The hair cells of the utricle are positioned in the horizontal plane and in the vertical plane in the sacculus. These organs provide information about the head position relative to gravity and linear acceleration, i.e. head accelerations along a straight line [27, 28]. Neurons from the semicircular canals, the saccule and utricle go through the vestibular nerve and enter the brain in the pons and pass to the vestibular nuclei [27].

The central vestibular system

There are two main targets for peripheral vestibular input: the vestibular nuclear complex and the cerebellum [29]. The vestibular nuclei have extensive connections to cerebellar and brainstem structures and are the primary processors of vestibular input, with fast connections between afferent information and motor output neurons [26, 29]. The vestibular nuclear complex integrates input from the opposite vestibular nuclei, cerebellum, visual and somatosensory system. Further, they directly innervate motor neurons controlling postural, extraocular and cervical muscles, vital for the stabilization of gaze, posture and head orientation during movement [26]. The main function of the cerebellum in the vestibular system is to monitor the information and readjust and adapt the central processing of the information, if necessary. Although not required for vestibular reflexes, the cerebellum calibrates and makes the reflexes effective [29]. Studies using functional magnetic resonance imaging suggest that vestibular pathways terminate in the insular and parietal regions of the cortex.

Vestibular reflexes

The vestibular system participates in three important and rapid reflexes: stabilization of gaze during movement, maintaining posture and maintaining muscle tone. The vestibulo-ocular reflex's (VOR) main purpose is to generate rapid eye movements that counter the head movement, making a person able to stabilize their gaze on an object during head movement. The reflex is generated through stimulation of the semicircular canals [26, 28]. Loss or reduced function of the VOR can have severe consequences, with reduced or loss of the ability to stabilize gaze on a visual target during head movements [26]. Postural adjustment of the head and body are mediated by the vestibulocollic reflex (VCR) and the vestibulospinal reflex (VSR). The VCR regulates head position to maintain the head in a horizontal gaze orientation relative to gravity [26, 28] and activates the neck muscles to maintain head position and limit unintentional head rotation displacement [30]. The VSR's main purpose is to maintain posture and center of mass over the base of support. The reflex helps maintain the upright posture by generating output to extensor muscles in the trunk and limbs in response to stimuli from the labyrinthine receptors [26, 28]. As with the VOR, damage to the vestibular system causes reduced function in the VCR and VSR, leading to patients exhibiting reduced head and postural control [26].

1.2.2 Vestibular lesions

There are several different disorders that can cause abnormalities of the vestibular function [31]. Peripheral vestibular dysfunction or damage, involving the vestibular organs and/or the vestibular nerve, may produce a variety of symptoms [32]. If the vestibular system is damaged on one side, this results in asymmetric input to the vestibular nuclei. This can cause disturbances in perception (vertigo/dizziness), gaze stabilization (nystagmus), postural control (impaired balance or tendency to fall) and vegetative systems (vomiting/nausea) [26, 33]. The symptoms of vestibular damage can be divided into two groups: static and dynamic symptoms. The static symptoms are present when the head is still and is commonly associated with sudden unilateral disturbances or loss of function and include vertigo, nystagmus, imbalance, nausea and vomiting. Other static symptoms often include imbalance and tilting of the head and body to one side. The dynamic symptoms are only present when moving the head and include blurry vision, loss of visual acuity and disorientation in complex sensory environments and may appear a while after the onset of vestibular loss [34]. A unilateral lesion is the most common type of peripheral vestibular abnormality. The loss of signals on one side results in a neural asymmetry, which is perceived as if the head is moving away from the damaged side. As a result of the reduced function on one side, nystagmus is generated by the VOR, which moves the eyes slowly toward the damaged side follow by the saccadic system resetting the eyes in the opposite direction. As the perception of head movement is contradicted by the visual and somatosensory systems, the patients experience the static symptoms of vertigo and the autonomic symptoms. When moving the head, the asymmetry and sensory mismatch causes loss of coordination between head and eye movement and results in the dynamic symptoms of vision disturbances and disorientation [34, 35]. While peripheral disorders are usually characterized by a combination of perceptual, ocular motor and postural signs, central vestibular disorders may manifest as a more "complete syndrome" or with single components [32]. Lastly, some patients present without a clear vestibular disorder. These patients are often challenging to treat as dizziness is a subjective sensation and refers to a variety of symptoms with many potential contributory factors [22, 36, 37].

1.2.3 Vestibular compensation

When patients experience acute unilateral vestibular loss, most of their symptoms resolve within a few weeks. Most patients return to normal activity, and it appears that their vestibular function has returned. However, only in a few patients is the vestibular function fully restored and, in many patients, there is little or no restoration of the peripheral vestibular function. Thus, there must exist some mechanism that causes most patients to still feel recovered. This type of general recovery is called "vestibular compensation" and is the process whereby the patient achieves functional recovery after vestibular lesions. This is a complex process where different vestibular-controlled responses recover at different rates, while some do not recover at all. However, changes in afferent input causes a change in neural activity in the vestibular nuclei, however; after some time, the neural resting activity is approaching normal, and some of the symptoms are resolved [34, 38]. This is possible due to the high degree of plasticity of the vestibular pathways. These mechanisms participate in the vestibular compensation process, so that the patients can recover after vestibular lesions [34].

Several mechanisms are involved in the recovery of vestibular function, such as cellular recovery, spontaneous reestablishment of residual vestibular function, substitution of alternative strategies for the loss of vestibular function, and habitation of unpleasant sensations [39]. The first step of compensation is called *static compensation* and begins almost immediately after the onset of the vestibular lesion. It reduces the most stressing symptoms that are present in the absence of head movements, such as vertigo, autonomic symptoms and nystagmus and head tilt. It is a spontaneous compensation and considered to be a robust process that restores symmetric activity in the vestibular nuclei [38]. After static compensation, the patients do not experience symptoms when the head is at rest but may still experience blurry vision and loss of visual acuity when moving the head. This is handled by the *dynamic compensation*, which occurs later and works over a longer time period to reduce the long-term negative effect of damage to the vestibular system. This is a complex process, and the patient's symptoms may never completely resolve as the vestibular function may never be fully restored [34]. The dynamic compensation is associated with VOR function, for instance the drop in VOR gain and oscillopsia experienced after vestibular dysfunction. This can be compensated via new eye−head coordination strategies and the use of other triggering signals [40]. Visual cues can, for example, substitute for vestibular input to produce near normal VOR in low-frequencies ranges of head movement, while the occurrence of saccades can be considered as a behavioral substitute for gaze stabilization at higher frequencies. This will further decrease oscillopsia and postural instability during head and body movements. In addition, neural networks in the brain can reorganize and mimic the lost functions [41]. The dynamic compensation is thought to be dependent on active input from the visual, vestibular and somatosensory systems [38].

1.3 Postural Control

Postural control is the ability to control the body's position in space for both orientation and stability and results from an extremely complex simultaneous interaction of different systems [42].

1.3.1 Definitions

Postural orientation is the process of controlling and maintaining an appropriate relationship between the body segments and the body in relation to the task of the environment. Postural stability is the ability to control the center of mass (COM) over the base of support. The COM is a hypothetical point, thought to be the center of the body mass. The base of support is the area of the body that is in contact with the support surface. The center of pressure (COP) is the center of the distribution of force applied to the supporting surface. The COM and COP are thus strongly connected, and the COP moves continuously around the COM to keep the COM within the support base. To keep balance in relation to quiet stance, a person needs to keep the COM within the limits of the base of support, referred to as the "limit of stability" [42].

1.3.2 Physiology of postural control

To maintain postural orientation, stability and thus control, the CNS is dependent on correct information from all the sensorimotor components. The somatosensory, vestibular and visual systems provide important information about the body's position and movement in space in relation to both gravity and the environment [42]. The somatosensory system generates information to the CNS regarding the position and motion of the body with reference to the supporting surface. The system provides input from muscle spindles, Golgi tendon organs, cutaneous receptors and joint receptors. This information contributes to spinal reflex control, modulating descending commands and contributes to perception and control of movement through ascending pathways [27].

The vestibular system, activated by head movements, alters the distribution of postural tone in the trunk and limb to maintain overall balance during posture and locomotion [42, 43]. The visual system provides information of the position and motion of the head with respect to the surrounding environment. In addition, vision provide references for verticality and enables us to identify objects in space to determine their movement. [27]. Information from the sensory system is increasingly processed as it ascends the neural hierarchy. Every level of hierarchy has the ability to modulate the information coming from lower centers. First in the association cortex, the transition from perception to actions starts. The motor cortex interacts with sensory areas in the parietal lobe, basal ganglia and cerebellar areas to identify where we want to move, plan the movement, and then execute the movement needed to maintain balance [27].

1.4 The cervical spine

1.4.1 Anatomy and function

The cervical spine is often divided into four units: the atlas; the axis; the C2-3 junction; and the remaining vertebrae [44]. The atlas serves as a cradle to the occiput and the atlanto-occipital joint only allows for nodding movements. Apart from weight bearing, the atlantoaxial junction is constructed to allow a large range of axial rotation with seemingly flat facet joints. In the C2-3 junction, the body of the axis “anchors” the atlas and the head into the rest of the cervical spine and functions as a socket [44]. The movement of the atlanto-occipital and atlantoaxial junction is coupled, so that rotation is accompanied with lateral flexion to the other side in each segment [45]. The other vertebral segments are stacked on one another, separated with an intervertebral disc. The surfaces of these vertebras are not flat as in the lumbar region, but slightly curved in the sagittal plane. The anterior inferior border of each vertebral body forms a lip that hangs downwards like a slight hook towards the anterior superior edge of the vertebra below. Meanwhile, the superior surface of each vertebral body slopes greatly downwards and forwards. The articulating surfaces of the inferior and superior intervertebral joints are similar to a saddle joint, maintaining anterior–posterior and medially and laterally directed concavities. These structures, in addition to the facet joints, make flexion–extension the cardinal movement of these segments, simultaneously allowing for rotation [44]. The cervical spine demands both stability and mobility to control movement in the sagittal, transversal and medial planes. There are several muscles that work collectively to control and execute movement [46]. Muscles in the cervical region are arranged so that some muscles only work in the upper cervical region, others only in the mid and lower regions, and others that work over the entire cervical spine. The cervical muscles can further be divided according to their functional role. The larger superficial muscles have better capacity to generate large torque movements, due to larger lever arms and cross-sectional areas, compared to the deeper muscles. The deeper segmental muscles have direct attachments to the vertebrae, with small lever arms and a higher density of muscle spindles. The suboccipital muscles have the highest density of muscle spindles in the entire human body [43, 46]. Together with the multifidus, longus colli and longus capitis the suboccipital muscles generate fine-tuned control of head movement in addition to generating support for the cervical segments [46].

1.4.2 Cervical reflexes

The cervicocollic reflex (CCR) function is to activate the neck muscles that are stretched by head movement in relation to the body. It works in conjunction with the VCR to maintain head position, limit unintentional head rotation [30] [47, 48] and control body posture [49]. The reflex is activated by slower movements than the VCR [30]. The cervical-ocular reflex (COR) is activated by the stretching of the neck muscles and works together with the VOR and optokinetic reflex to control extraocular muscles and create clear vision when moving the head. In low-frequency movements, the COR assists in creating opposite movements of the eyes compared to the movement of the head [12, 30, 43]. The tonic neck reflex (TNR) works to achieve postural stability and is responsible for alteration in limb muscle activity as a response to body movements relative to the head [30], and this is integrated with the VSR [43].

1.4.3 Neck pain

Neck pain is a common and heterogeneous symptom with various presentations. It is defined as "arising from anywhere within the region bounded superiorly by the superior nuchal line, inferiorly by an imaginary transverse line through the tip of the first thoracic spinous process, and laterally by sagittal planes tangential to the lateral borders of the neck" [50]. The intensity can range from mild to disabling and the recurrence rate is high. There are several proposed ways of classifying neck pain, such as mechanism of onset, pathoanatomy, duration, predictors or subgrouping patients with similar clinical characteristics. There are additional classifications that categorize neck pain by its location [46, 51]. Neck pain can have various origins but musculoskeletal causes are the most common. Pain from the musculoskeletal system is most often felt in the posterior neck. Depending on the segment and structure, the pain may refer to the head, shoulder, arm or the thoracic region. Neck pain of musculoskeletal origin is initially caused by a nociceptive source, such as mechanical stress or local injury, inflammation or from irritation of nerve structures. However, neck pain may arise from many other causes such as infection, vascular disorders, metabolic bone disease, neurological, inflammatory and visceral disease [46]. Pain and injury in the cervical region may have major effects on the neuromuscular system, with changes in both muscle behavior and structure. In addition, there is no evidence that the function will automatically return to normal after the resolving of a pain event [46].

1.5 Neurophysiological connections with the cervical spine

In order to maintain postural control, the human body is dependent on afferent input from the somatosensory, vestibular and visual systems [43]. There is an established physiological connection between the cervical proprioceptive afferents and the visual and vestibular system throughout the spinal cord, brainstem, cerebral cortex and cerebellum [12]. Due to high demands of both stability and mobility, the deep segmental muscles of the cervical spine have one of the highest densities of muscle spindles in the human body, which, together with joint and tendon receptors, constitute a well-developed proprioceptive system [12, 43, 52]. The proprioceptive system of the cervical spine has direct connections to the several areas of the spinal cord and CNS to integrate and create appropriate efferent neuromuscular responses. In addition to connections with the central cervical nucleus, cerebellum, thalamus and the somatosensory cortex, it has connections to the medial and lateral vestibular nuclei and the superior colliculus, which is a reflex center for coordination between eye and neck movement [30, 43]. The cervical afferents are involved in three cervical reflexes influencing head, vision and postural control [48]. The COR, CCR and TNR are generated by afferents from the cervical spine and work with the vestibular and visual reflexes to maintain posture, head and eye movement control [43]. The vestibular system only provides information about head movements and not the position or movement of the head on the trunk, or any other body segments [53]. Thus, the vestibular apparatus cannot distinguish whether or not it is just the head or the whole body that is moving during head movements. In order to achieve optimal head orientation and perception it is necessary to perceive the head movements and position in relation to the lower body segments. A large portion of this information is provided from cervical afferents [13, 49]. Integration of symmetrical afferent input from the cervical, vestibular and visual systems in the vestibular nuclei complex is vital for normal head perception, balance and to provide responses resulting in precise motor commands to the eyes and body. Thus, it is theorized that an asymmetry in inputs, caused by a disturbance of the afferent from the cervical spine, may lead to a sensation of imbalance or dizziness [12, 19, 43]. The mechanism by which distorted cervical proprioception could lead to sensory disturbances and dizziness symptoms is still uncertain; however, theories exist. Pain, either as primary or secondary event may lead to altered sensitivity of mechanoreceptors and the muscles spindles because of ischemic or inflammatory events. Conditions leading to impairment of the muscles, such as increased fatigability, fatty infiltrations, degenerative changes, atrophy or trauma may cause altered muscle spindle and mechanoreceptor sensitivity in the cervical spine and cause a disturbance of the afferent input from the cervical spine [43, 48]. Neck pain may additionally cause maladaptive strategies and change the neck muscle coordination and reduce specificity of neck muscle activation, for instance with reduced activation of the deep segmental muscles and increased activation of superficial muscles [46]. Lastly, psychosocial distress may additionally lead to altered muscle spindle activity, due to activation of the sympathetic nervous system [43]. However, it is likely that a combination of such processes is causing disturbances in the tuning and integration of cervical input in the CNS [48].

Some of the criticism to the theory of a sensory mismatch between cervical, visual and vestibular inputs, is that the CNS should be able to adapt to these altered inputs just as the system is capable of adapting to erroneous vestibular inputs [12]. However, although many patients recover spontaneously fromvestibular disorders, there are still many of these patients who show maladaptation and who develop persistent dizziness [35].

1.6 Previous research on cervical contribution to dizziness and balance

Although the research on the condition of CD is scarce, there are several studies examining the connection between the cervical, vestibular and visual systems, both in animals and humans. Animal studies have shown that local injections, nerve blockades and dissection of neck muscle in the upper cervical region led to decreased balance, coordination, ataxia and even nystagmus [54-56]. Both in humans and in monkeys, there has been found an increase in the COR after vestibular loss, possibly explained as a compensation for the loss of VOR [57-61]. In humans, injecting hyperosmotic saline into deep cervical muscles caused decreased orientation and impaired ability to sense head-on-trunk movements [62]. Vibration on the dorsal neck muscle has been shown to reduce spatial orientation via displacement of the body during a stepping test [63]. Further, stimulus to the cervical neck muscles has shown to give an illusion of either head movement or the illusion of objects moving and to shift the subjective "straight ahead" towards the stimulated side [64, 65] and increase body sway [66]. Studies on patients with whiplash-associated disorders (WAD) show that the patients with dizziness had greater impairment or deficit in terms of joint position error [67] postural control [68] and smooth pursuit during neck torsion [69] compared to patients with WAD without dizziness. Additionally, studies have found that patients with idiopathic neck pain have impaired balance when compared with healthy controls [70].

1.7 Cervicogenic dizziness

Even though there are several different origins or causes of dizziness [22], there is not always a clear cause of the symptoms. In some of these cases, after excluding other possible reasons for a patient's dizziness, the dizziness symptoms have been proposed to have cervical origin [11]. Dizziness due to neck pain or neck dysfunction is a relatively new clinical concept. CD was first described in 1955 [71] and has since been a topic of controversy and disagreement among researchers and clinicians. To this day, there is still no consensus as to whether or not the condition actually exists. In the International Classification of Diseases (ICD), CD is not included. The term is defined as "a non-specific sensation of altered orientation in space and disequilibrium originating from abnormal afferent activity from the neck" [72].

One of the main problems with the conditions is the lack of objective tests that are both specific and sensitive for this entity [12]. There is no clear consensus on the criteria for the condition except for the exclusion of other causes of dizziness [13, 19]. In addition, the clinical characteristics of the conditions are uncertain. However, there seems to be a consensus that patients with CD rarely experience true vertigo. Their dizziness is more often described as disorientation, imbalance, unsteadiness, lightheadedness or disequilibrium accompanied with limited range of motion and cervical pain [11, 19]. The theory behind CD is mainly based on physiological evidence, which suggest that cervical input to the CNS may play a role in dizziness. It is theorized that a disturbance of the afferent input from the cervical region may be a possible cause of dizziness [13, 43].

2. Objectives

2.1 Main objective

The main objective for this thesis was to explore the relationships between neck pain, dizziness symptoms, quality of life and postural control.

2.2 Specific objectives

2.2.1 Paper I

In this study, we first conducted a systematic review of clinical findings of patients with diagnosed CD and aimed to explore how they differed from other populations. Secondly, we aimed to compare the diagnostic criteria in the included studies.

2.2.2 Paper II

The aim of this paper was to examine differences in dizziness handicap, quality of life and demographics in patients with and without neck pain, referred to an ear, nose and throat (ENT) clinic for dizziness. Additionally, we examined whether neck pain was associated with a nonvestibular or vestibular diagnosis.

2.2.3 Paper III

The main aim of this study was to examine whether there is an association between the pressure pain threshold (PPT) and postural sway in patients with dizziness and in patients with neck pain. In addition, we wanted to examine the upper and lower regions of the cervical spine separately due to their differences in mechanical properties and distribution of mechanoreceptors.

2.2.4 Paper IV

The aim of this study was to explore and describe the clinical symptoms and physical findings in patients with concurrent neck pain and dizziness and to examine whether they differ from patients with dizziness alone.

3. Material and Methods

3.1 Design and settings

With the exception of the systematic review, the papers (II, III & IV) presented in this thesis are cross-sectional trials conducted at an outpatient ENT clinic and an outpatient spine clinic at Haukeland University Hospital, Bergen, Norway. We included patients prospectively from both clinics who were referred from general practice and other specialist care units during a 1-year period (2017−2018). Data were entered into SPSS and stored on a secure database. At both centers, a study nurse recruited the patients on the same day as they appeared for their appointment at the clinic. The physical examination of the participants was performed by experienced physiotherapists who were familiar with the tests. The participants filled out survey data before or after the physical examination depending on time. The patients filled in the questionnaires confidentially and handed it to a study nurse so that the examiner was blinded to their answers. At both clinics, all patients were examined and diagnosed by a physician.

3.2 Subjects

Local patients referred for dizziness were included from the ENT clinic and patients referred for persistent neck pain were included from the outpatient spine clinic. Thus, we included one population with dizziness as their primary complaint and one population with neck pain as their primary complaint. At both centers, patients had to be between 18 and 67 years old. Exclusion criteria were insufficient language skills or severe orthopedic or neurological diseases affecting balance. As the ENT clinic is a quaternary referral center for special cases of vestibular problems, such as inner ear barotraumas or vestibular schwannomas, and examines acute hospitalized patients, people with these conditions were not invited to participate to avoid overrepresentation. Paper II included patients from the ENT clinic only, whereas Papers III and IV included patients from both centers. An overview of the different clinics and subgroups used in the different papers is displayed in Figure 1. Healthy controls were included and recruited among the hospital staff for the physical tests. They had to be between 18 and 67 years old, without neck pain and not suffer from any known vestibular pathology, orthopedic or neurological diseases affecting balance during the previous three months. A flow chart of the recruitment is displayed in Figure 2.

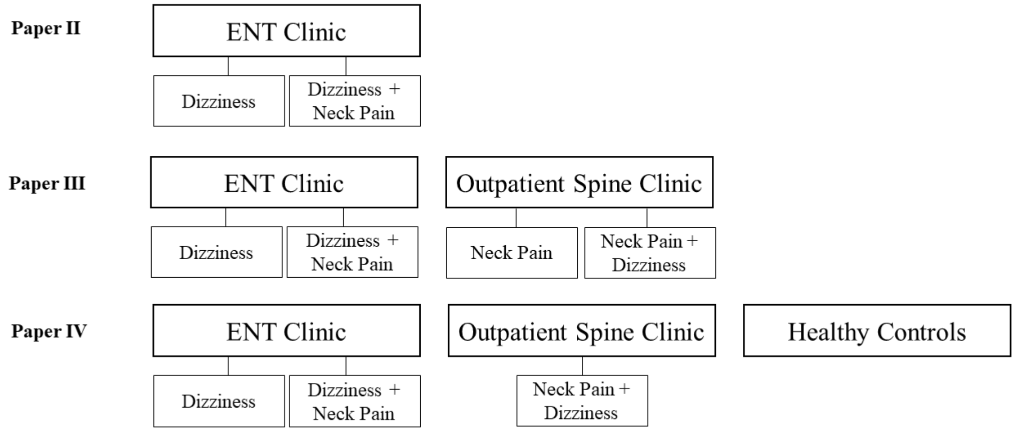

Figure 1. Overview over different clinics and subgroups in the different papers.

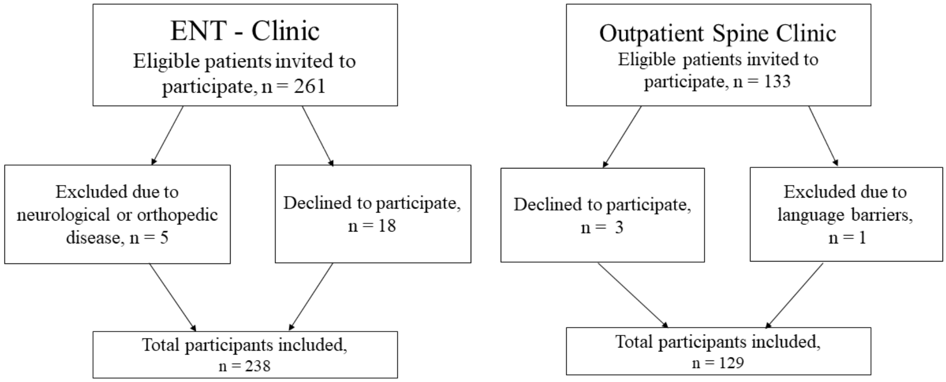

Figure 2. Illustration of the different clinics and groups

When assessing the data for Papers III and IV, two missing participants were located from the ENT clinic and included in the dataset. In addition, one participant from the ENT clinic was wrongly coded with “neck pain.” These mistakes were corrected in paper III and IV.

3.3 Outcomes

An overview over papers, design, sample and outcomes is provided in Table 1.

Table 1. Description of design, population and outcomes in the different studies

Paper	Design	Populations and groups	Data collection	Outcomes
I	Systematic review	Patients with CD, other vestibular diagnosis, only neck pain and healthy controls	Sept 2017–Sept 2018	Clinical characteristics & diagnostic criteria
II	Cross-sectional study	Patients referred for dizziness to the ENT clinic (n=236) Divided into two groups: with (n = 139) and without (n = 97) neck pain	July 2017–Aug 2018	Neck pain, vestibular diagnosis, DHI, NDI & RAND-12
III	Cross-sectional study	Patients referred for dizziness to the ENT clinic (n=238) and patients referred for neck pain at the outpatient spine clinic (n=129) Divided into two groups according to referral center	July 2017–Aug 2018	PPT, posturography & ACR-tender points
IV	Cross-sectional study	Patients referred for dizziness to the ENT clinic (n=238), patients referred for neck pain at the outpatient spine clinic (n=129) and healthy controls (n=47) Divided into four groups: - Healthy controls - Patients from the ENT clinic with dizziness only (DO) (n = 100) - Patients from the ENT clinic with predominately dizziness and neck pain (DN) (n=138) - Patients from the outpatient spine clinic with predominately neck pain that reported additional dizziness (ND) (n = 55).	July 2017–Aug 2018	Dizziness characteristics, VSS-sf, PPT, ACR-tender points, GPE-52 flexibility, CROM

CD, cervicogenic dizziness; ENT, ear nose and throat; PPT, pressure pain threshold, DHI, Dizziness Handicap Inventory; NDI, Neck Disability Index; VSSsf, Vertigo Symptom Scale short form; GPE, global physiotherapy examination; CROM, cervical range of motion; ACR, American College of Rheumatology.

3.3.1 Physical tests

The physical tests were chosen for evaluating the degree of pain and function both locally in the neck area, and globally for the entire body. The following tests were used in this project.

Pressure pain threshold (PPT)

The neck PPT is defined as the minimal amount of pressure that first becomes one of pain [73] and is usually measured with a pressure algometer. Even though self-reported pain intensity is the most common approach to pain measurement, it will be mediated by biopsychosocial aspects [74] that can make interpretation difficult. The PPT is thus a tool of both self-reported pain, but additionally a more objective technique than other pain measures such as visual analog scales [75] which are used to quantify mechanical pain or pain sensitivity [76, 77]. Thus, PPT was chosen as a measure of neck pain in order to study the relationship between neck pain, dizziness and balance issues (Papers III & IV). Previous studies of the intra-rater reliability of handheld algometers measuring PPT in patients with neck pain, have reported conflicting results [78, 79]. However, the device used in our project has proven reliable in patients with and without neck pain [78]. Prior to the project, the reliability and validity of the held algometer (Wagner FDX-25 digital force gage (Wagner Instruments, Greenwich, CT)) used in this project was examined in patients with dizziness. This study found that the algometer showed concurrent validity and was reliable in both the intrarater and t test–retest conditions [80]. The PPT was measured in kilopascal (kPa).

American College of Rheumatology (ACR) − tenderpoints

As neck pain is rarely isolated and usually a part of a wider pain pattern [2], we included the American College of Rheumatology (ACR) – tender points to provide a measure of generalized, not just localized neck pain. The ACR tender points are nine bilaterally defined points for testing muscular–skeletal pressure pressure sensitivity in different body regions. The tester provides a gradually increasing pressure, stopping at approximately 4kg. The patient was told to say “yes” if they experienced pain or “no” if they experienced only discomfort at each point after pressure is applied. The pressured was applied once time for each of the different points. This is a well-known and validated clinical examination used in patients with widespread pain conditions [81-83] In Papers III and IV, all the nine bilateral points were used to assess the level of generalized pain.

Posturography

Posturography is a widely used tool to gain a measure of postural sway [84-88]. The main drawbacks of other clinically based balance examinations are the subjective nature of the scoring systems and the lack of ability to examine underlying pathophysiology in patients. With posturography, it is possible to introduce manipulation of certain elements, such as visual and proprioceptive feedback, and in such, examine underlying mechanisms for reduced balance. Posturography may thus serve as a more objective tool of posture and balance and is deemed a useful tool to gain a better understanding of the patient’s balance disorders [84]. Even though the diagnostic ability of posturography is uncertain [84], it is indicated to be a reliable tool [89]. The relationship between PPT and posturography was evaluated with Synapys Posturography System® (SPS®, SYNAPSYS, Marseille, France) in Paper III. Total sway area (mm^2) was recorded. Additionally, we examined the Romberg ratio (sway area with eyes closed / sway area with eyes open) [90] as an indicator of the proprioceptive contribution to postural stability. A higher ratio, and thus greater difference between eyes closed and eyes open, indicates greater proprioceptive deficit and greater reliance on vision in maintaining postural control.

Cervical range of motion (CROM)

As reduced cervical range of motion (CROM) has previously been thought to be a characteristic in patients with CD [11] and in patients with neck pain [91, 92], we chose to include the total amount of cervical range of motion as one of the physical tests. In addition, it is theorized that dizziness may lead to reduced neck movements to avoid moving the head [93]. In Paper IV, cervical active range of motion was measured using the cervical range-of-motion device CROM Performance Attainment Associates 3. The instrument has shown good reliability and validity in previous studies [94, 95]. It was reported as the total of amount of CROM (degrees) by adding the degrees of flexion, extension, right and left lateral flexion and right and left rotation.

Global physotherapy examination 52 (GPE) – flexibility

As a measure of global impairment, we used the flexibility subscale of the global physiotherapy examination (GPE) 52 in Paper IV, to reflect the flexibility of the spine as well as the patient's ability to relax, especially in the shoulder and head region. The scores range from 0−9.2 and a higher score indicates a reduced flexibility and ability to relax. Reduced flexibility has previously been found to be reduced in patients with dizziness [96]. In addition, this subscale has been shown to differentiate healthy participants from patients with generalized and localized pain [97].

3.3.2 Patient-reported outcomes

Dizziness Handicap Inventory (DHI)

In Paper II, the severity of dizziness handicap was evaluated using a Norwegian version of the Dizziness Handicap Inventory (DHI) [98]. This questionnaire aims to quantify the handicap experienced by dizziness. It contains 25 items with a maximum score of 100. A score > 29 indicates disability. The DHI was originally developed to measure and quantify the self-perceived handicapping effect of dizziness caused by the vestibular disorders [99]. However, the questionnaire has been widely used in various diagnoses [100, 101]. Initially, the questionnaire was developed to examine different dimensions of self-perceived handicap due to dizziness and unsteadiness: physical, functional and emotional. However, these subscales of the DHI have been questioned as they are not consistent through different studies [102-104], suggesting the use of the full scale. The Norwegian version of the questionnaire has been validated and the sum score demonstrates satisfactory measurement properties [98].

Neck Disability Index (NDI)

In Paper II, the degree of neck disability was measured with the Neck Disability Index (NDI) [105]. The NDI consists of 10 items with each score on a 0 to 5 rating scale and a total range of 0 – 50. Scores between 0–and 4 indicate no disability, 5–14 mild disability, 15–24 moderate disability, 25–34 severe disability and 35–50 complete disability [105]. The index has been validated in the evaluation of pain and disability in acute and chronic conditions [105]. The Norwegian version has shown good test−retest reliability [106].

RAND - 12

In Paper II, quality of life was measured with the RAND-12 health status inventory. RAND-12 measures physical and mental dimensions of health. Scores > 50 indicate that persons are well, a score of 40−49 indicate mild disability, 30−39 moderate disability and scores <30, severe disability [107]. This survey contains the same 12 items as the 12-item short form survey (SF-12), taken from the eight scales of the SF-36/RAND-36. The RAND-12 has minor differences compared to SF-12, which has been validated in Norwegian [108, 109]. RAND-12 is based on an item response theory based on scaling procedures and oblique (correlated) factor rotations to generate the subscale scores. SF-12 is based on principle component factor analysis with orthogonal factor rotation. RAND-12 has shown to better discriminate between known groups, is more sensitive to change [110, 111] and has shown adequate construct validity in diverse chronic conditions [112].

Vertigo Symptom Scale – short form (VSSsf)

In Paper IV, as a measure of degree of dizziness symptom severity, the patients filled out the Vertigo Symptom Scale – short form (VSSsf) consisting of 15 items. The patients answer how frequently they have experienced symptoms in the past month on a scale from 0–4 and thus there is a possible range of score from 0 to 60. A higher score indicates increased symptom severity. A score ≥ 12 points on the total scale indicates severe dizziness. The form consists of 15 items with two subscores. One subscore measures severity of automatic symptoms, such as sweating, heart pounding and nausea, and the other measures severity of symptoms of vertigo and balance. The questionnaire with its subscales has been validated and translated into Norwegian [113].

Other survey data

The participants also filled out a self-reporting survey regarding their dizziness, such as questions of onset of dizziness, triggering events, time-course, type of dizziness, accompanying symptoms, age and gender.

3.4 Systematic review

3.4.1 Literature search and eligibility criteria

The literature search was carried out through PubMed and MEDLINE from inception of the database to September 2018. The eligibility criteria were restricted to published, peer-reviewed original studies in English. Unpublished studies, case reports, conference abstracts, editorials and reviews were excluded. The included studies had to compare clinical characteristics in patients with CD to a reference group who either had another diagnosis or were healthy controls. To gain higher comparability between studies, they had to state whether other possible causes of dizziness had been ruled out and the diagnostic process had to be accounted for. The Rayyan systematic review web application [114] was used by two reviewers to facilitate the study selection process and adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement [115].

3.4.2 Data extraction and assessment of methodological quality

Data extracted were population (age, sex and sample size), study design diagnostic criteria, and clinical findings compared to other diagnosis. Due to the heterogeneous nature of study design and outcome in the included studies a pooling of the study's results was not possible. Thus, a meta-analysis was not possible and a qualitatively analysis of the included studies was performed. We used the Crowe Critical Appraisal Tool version 1.4 (CCAT) for assessment of the methodological quality of the studies as it allows for a variety of research designs to be evaluated using the same tool [116].

3.5 Statistics papers II−IV

In this thesis, participant characteristics were described with either mean values and standard deviation (SD), median values and interquartile range, or percentages. Parametric tests were performed when assumptions were met, if not, data were transformed or non-parametric tests were used. The alpha level was set at <0.05. Data were analyzed using SPSS version 24 for Windows (Statistical Package for the Social Sciences, SPSS Inc., Chicago, IL) and Stata 15, StataCorp LLC 2017 (*Stata Statistical Software Release 15*. College Station, TX: StataCorp LP).

3.5.1 Paper II

Age, DHI and both RAND-12 dimensions were compared with *t*-tests between the two groups (Figure 1). Linear regression was performed to adjust for age and sex. Within the neck pain group, association between DHI and NDI was examined by linear regression, with age and sex as adjusting variables. The Mann−Whitney test was used in order to examine between-group differences in dizziness duration. The Wilcoxon signed-rank test was used to examine differences in duration of dizziness and neck pain in the neck pain group. Sex differences and association between neck pain and diagnosis were examined using the Pearson's chi-squared (x^2) test, as were associations between onset of neck pain prior to dizziness and diagnoses. The onset of neck pain prior to dizziness was treated as a binary variable.

3.5.2 Paper III

Sway area and Romberg ratio were positively skewed and logarithmically transformed prior to regression analysis. Linear regression was used to estimate the relationship between postural sway (sway area and Romberg ratio) and PPT after adjusting for age, sex, and generalized pain (number of ACR tender points). Sway area was used as the dependent variable and PPT as the independent variable. Three regression models were generated, including the unadjusted model (Model 1), the age and sex-adjusted model (Model 2), and the age, sex, and generalized pain-adjusted model (Model 3). PPT in the upper and lower neck was highly correlated and thus assessed in separate analyses to avoid multicollinearity. To facilitate interpretation of the coefficients, they were back-transformed after analysis.

3.5.3 Paper IV

Initial examination of the variables (binary) association to the different groups (Figure 1) were done by the chi-square tests (X^2). Cramérs V test was used as a measure of strength of association. Follow-up comparison between groups of statistically significant variables from the X^2-test was conducted with a univariate logistic regression with groups as the dependent variable. Differences between groups in the physical tests and the VSSsf were examined with multinomial logistic regression where the “dizziness only” group was used as reference category. Age and sex were used as adjustment variables.

4. Results

4.1 Paper I

The search resulted in 2161 articles and a total of eight studies met the inclusion criteria and were thus included in the review. The included studies included a total of 225 patients classified as CD. They were compared to healthy controls (*n* = 140) [10, 15, 117-120], benign paroxysmal positional vertigo (BPPV) (*n* = 25) [121], “general dizziness” (*n* = 86) [122], one vestibular neuritis (*n* = 18) [119] and to patients with only neck pain (*n* = 40) [10, 117].

4.1.1 Clinical findings

Altered postural control measured with posturography was the most common clinical finding. Kalberg et al. [119] found that vibratory stimulation of the calf muscles could distinguish patients with dizziness of suspected cervical origin from patients with vestibular neuritis and healthy controls. Two studies found altered postural control compared to both patients with only neck pain and healthy controls [10, 117] and two studies found reduced postural control in patients with CD compared to healthy controls [15, 120]. The second most consistent finding was altered neck proprioception examined in two studies using a cervical relocation test. These studies found patients with CD to have higher position errors compared to patients with BPPV [121] and to healthy controls [118].

Regarding certain dizziness characteristics or dizziness triggers, this was investigated in two of the studies. CD patients were more likely to report a sensation of drunkenness/lightheadedness and cervical movement as a precipitating factor, and less vertiginous symptoms compared to patients with BPPV [121]. The other study found certain question from the DHI to be discriminatory between CD and patients with general dizziness (Question 1: Does looking up increase your problem? Question 9: Because of your problem, are you afraid to leave your home without having someone accompany you? Question 11: Does quick movement of your head increase your problem?)[122].

Other clinical characteristics examined in the included studies were cervical range of motion, duration of dizziness, neck pain intensity, psychometric measures, headache, smooth pursuit/nystagmus during neck torsion and video head impulse test. However, the results were inconsistent or there was no difference between CD and other populations.

4.1.2 Diagnostic criteria

Exclusion of other possible causes of dizziness were reported by all the included studies. The second most consistent criterion were the coexistence of neck pain and dizziness and was found in all but one study [118]. The other criteria varied across all studies and included dizziness characteristics, aggravating symptoms, triggers, reduced cervical ROM, timing and duration of neck symptoms and dizziness.

4.2 Paper II

During a one-year period, 59% of the patients included from the ENT clinic (Figure 1) for dizziness and balance issue, reported neck pain. Women were overrepresented in the neck pain group ($p = 0.004$). Using linear regression to adjust for age and sex, neck pain was associated with a higher DHI score ($\beta = 11.5$, 95% confidence interval (CI): 5.90, 17.0, $p < 0.001$), a lower Rand-12 – physical score ($\beta = -6.24$, 95% CI: −9.0, −3.04, $p < 0.001$) and a lower RAND-12 – mental score ($\beta = -5.21$, 95% CI: −8.00, −2.30, $p < 0.001$). There was no difference in dizziness duration or age between the group with or without neck pain.

Within the neck pain group, we found a significant association between NDI and DHI ($\beta = 1.06$, 95% CI: 0.65, 1.47, $p < 0.001$) adjusted for age and sex. The neck pain group had a significantly longer duration of neck pain compared to duration of dizziness ($p < 0.001$) examined with Wilcoxon signed-rank test and 58% reported that the neck pain started prior to the dizziness.

In patients diagnosed with a peripheral vestibular diagnosis, 55% reported neck pain, whereas in the patients with a nonvestibular diagnosis, 64% reported neck pain. Using the chi-square test, there was no association between neck pain and whether the patients had a vestibular or a nonvestibular diagnosis ($p = 0.29$). Neither was there any association between those reporting neck symptoms prior or after the onset of dizziness and diagnosis group (vestibular or nonvestibular ($p = 0.51$)).

4.3 Paper III

In this paper we examined the relationship between the PPT in the neck and postural control in a total of 235 patients from the ENT clinic (dizziness group) and 125 patients from the outpatient spine clinic (neck pain group) (Figure 1). There were minor differences in age and sex between the two patient groups (ENT clinic: mean age 45.7 & 73.5% females. Outpatient spine clinic: mean age 41.0 & 79.2 % female).

4.3.1 Association between sway area and PPT

After adjusting for age, sex, and generalized pain, there was an inverse relationship between PPT and sway area in both the eyes closed conditions (with and without standing on rubber foam) in the lower neck in the dizziness group. An increase of 10 kPa was associated with a 3.1% reduction of sway in the eyes closed condition (95% CI, −5.0% to −1.1 %, $p = 0.002$) and a 1.8% reduction of sway in the eyes closed on foam condition (95% CI, −3.3% to −0.4%, $p = 0.014$). In the upper neck, there was an inverse relationship between PPT and sway area in the third model, when standing with eyes closed on a bare platform and an increase of 10 kPa was associated with a 1.6% reduction of sway in the eyes closed condition (95% CI, −3.1% to −0.1%, $p = 0.038$). In the patients with neck pain, PPT was not associated with postural sway in any of the models

4.3.2 Association between Romberg ratio and PPT

Regression analysis adjusted for age, sex, and generalized pain found an inverse relationship between PPT and Romberg ratio in both the upper and lower neck on the bare platform in the dizziness group. A 10 kPa increase in PPT in the upper neck was associated with a 1.1% decrease in Romberg ratio (95% CI: −2.0% to −0.2%, $p = 0.015$) and a 1.8% decrease in PPT in the lower neck (95% CI: −3.0% to −0.7%, $p = 0.002$). On foam rubber, the PPT was only associated with the Romberg ratio in the age and sex-adjusted model. No relationship was found in the neck pain group in either of the conditions.

4.4 Paper IV

In this study we examined the association between neck pain and characteristics of dizziness and physical impairment in patients with dizziness from both the ENT clinic and the outpatient spine clinic (Figure 1). They were divided into the following groups: the dizzy subjects at the ENT clinic were divided into dizzy patients with complaints of neck pain (DN, n = 138, mean age 45.7 (SD: 12.4), 80.3% female) and patients with dizziness only (DO, n = 100, mean age 45.5 (SD: 11.9), 64% female) and no neck complaints. The third group consisted of consecutive patients from the outpatient spine clinic whose primary complaint was neck pain, but who also reported complaints of dizziness (ND, n = 55, mean age 42.5 (SD: 11.8), 83.6% female). In addition, 47 healthy controls (mean age 40.5 (SD: 13.7), 65.9% female) were included.

4.4.1 Associations between groups and dizziness characteristics

We found several associations between the neck pain groups and certain dizziness characteristics. Both neck pain groups were more likely to have a gradual onset of dizziness (DN: Odds ratio (OR) = 2.44, 95% CI: 1.37–4.35, $p = 0.002$; ND: OR = 4.68, 95% CI: 2.27–9.62, $p < 0.001$), dizziness resembling presyncope/lightheadedness (DN: OR = 4.48, 95% CI: 1.64–12.23, $p = 0.003$; ND: OR = 4.09, 95% CI: 1.31–12.71, $p = 0.015$) and visual disturbances (DN: OR = 3.47, 95% CI: 1.25–9.65, $p = 0.017$; ND: OR = 5.50, 95% CI: 1.47–13.80, $p = 0.008$), compared to the DO group. In addition, the DN group was more likely to report a rocking sensation of dizziness (OR = 2.17, 95% CI: 1.25–3.78, $p = 0.006$) compared to the DO group.

The ND group was more likely to report headache (ND vs DO: OR = 8.35, 95% CI: 3.81–18.28, $p < 0.001$; ND vs DN: OR = 5.33, 95% CI: 2.55–11.17, $p = 0.001$) and less likely to report spinning dizziness (ND vs DO: OR = 0.27, 95% CI: 0.13–0.56, $p <$ 0.001; ND vs DN: OR = 0.35, 95% CI: 0.17–0.69, $p = 0.003$), vomiting (ND vs DO: OR = 0.09, 95% CI: 0.01–0.71, $p = 0.022$; ND vs DN: OR = 0.10, 95% CI: 0.01–0.80, $p = 0.030$), and having a constant dizziness (ND vs DO: OR = 0.10, 95% CI: 0.02–0.47, $p = 0.003$; ND vs DN: OR = 0.12, 95% CI: 0.02–0.54, $p = 0.006$), compared to the two other groups.

Compared to the DO group, there was a significant association between the DN group and an increase in the total score of VSSsf (OR = 1.03, 95% CI: 1.00–1.06, $p = 0.034$) and a higher autonomic-anxiety subscore was significantly associated with both neck pain groups (DN: OR = 1.12, 95% CI: 1.05−1.19, $p = <0.001$. ND: OR = 1.11, 95% CI: 1.03–1.19, $p = 0.006$). $p = 0.006$).

4.4.2 Associations between groups and physical characteristics

There were several associations between neck pain and the physical tests. We found that both neck pain groups were significantly associated with a lower total CROM (DN: OR = 0.985, 95% CI: 0.978–0.992, $p < 0.001$; ND: OR = 0.979, 95% CI: 0.971–0.988, $p < 0.001$), a higher ACR-tender point count (DN: OR = 1.208, 95% CI: 1.015–1.156, $p < 0.001$; ND: OR = 1.083, 95% CI: 1.015–1.156, $p = 0.015$) and higher GPE-flexibility score (DN: OR = 1.273, 95% CI: 1.078–1.505, $p = 0.005$; ND: OR = 1.688, 95% CI: 1.346–2.116, $p < 0.001$) compared to the DO group. A decrease in PPT in both upper and lower regions of the neck was associated with the DN group (upper neck: OR = 0.94, 95% CI: 0.02 – 0.097, $p < 0.001$; lower neck: OR = 0.94, 95%CI: 0.91–0.97, $p < 0.001$) compared to the DO group.

When comparing the healthy controls to the DO group, we found that a higher CROM (OR = 1.015, 95% CI: 1.004–1.025, $p = 0.005$), a higher PPT in the lower neck (OR = 1.07, 95% CI: 1.03–1.12, $p = 0.001$) and a lower score on the GPE flexibility (OR = 0.783, 95% CI: 0.624–0.983, $p = 0.035$) was associated with the control group.

5. Discussion

This thesis investigated relationships between dizziness and neck pain in patients with both symptom complexes. To gain insight into this controversial field we conducted a systematic review. The review highlighted the lack of knowledge and research on patients with CD. With the exception of reduced postural control, the review found a few consistent clinical findings and criteria for diagnosing the condition in this patient group. The three cross-sectional trials found interesting associations between neck pain and dizziness. Patients with concurrent dizziness and neck pain reported higher severity of their dizziness and lower quality of life compared to those with only dizziness. In addition, neck pain was not associated with a nonvestibular origin of their dizziness and was common in both vestibular and nonvestibular diagnosis. We found linear relationships between PPT in the neck and postural sway in certain conditions in patients with dizziness. Lastly, we found an association between neck pain and certain dizziness characteristics and adverse physical characteristics in patients with dizziness, both in patients with neck pain as their primary complaint and in patients with dizziness as their primary complaint. These novel findings indicate that relationships between the two complaints exist and raises questions for future research that require further examination and verifications. In the following chapter, the main findings and issues raised in this thesis will be compared and discussed in light of current knowledge on the field, in addition to methodological considerations across the studies.

5.1 Discussion of the main findings

Even though dizziness of cervical origin is a controversial topic, the known connections and integrations of cervical, visual and vestibular signals in the CNS have made it difficult to dismiss the idea of the cervical contribution to dizziness. As a correct perception of head position in relation to the body and space is dependent on integration of input from the visual, vestibular and the proprioceptive system in the cervical region [12, 13, 43], it is reasonable to theorize that a disruption or alteration of the cervical input could cause spatial disorientation. However, what kind of symptoms this would yield is not well explored and lacks scientific evidence. In addition, if the disruption or alteration of afferent input from the cervical spine is a cause of dizziness, this could in theory also affect patients with other known extracervical causes of dizziness when they experience neck issues. Research on this topic has tended to focus on cervical contribution to dizziness, only when all other possible causes are ruled out, thus, not considering the possible synergistic interaction of both neck pain and vestibular disorders on dizziness, or the consequences of having concurrent complaints. In light of this, we aimed to further investigate relationships between neck pain and dizziness and the following section will discuss the main findings of our study.

5.1.1 Current knowledge on clinical characteristics in patients with cervicogenic dizziness

In the systematic review (Paper I), the most consistent clinical finding seemed to be altered postural stability with posturography, when comparing CD to other populations. This finding is supported and interesting in light of previous research, as CD is often described as a sensation of imbalance [11, 19] thought to arise from an alteration in the input from cervical afferent information leading to a sensory mismatch between the visual, vestibular and somatosensory system [12, 19]. In addition, reduced postural control has been found in patients with WAD reporting dizziness, when compared to those without dizziness [123]. One of the studies in this review [121] found that the two most frequently reported dizziness symptoms in patients with CD were a sensation of “drunkenness” (92%) and imbalance (76%). Also, the results from Paper III found associations between the degree of neck sensitivity of pain and postural control in a population with dizziness. L’Heureux-Lebeau et al. [121] found that 32% of patients with CD reported a rotatory sensation compared to 76% in a group with BPPV, indicating less vertiginous dizziness symptom characteristics in the patients with CD. This is coherent with the fact that CD is commonly reported as a more vague clinical picture than peripheral vestibular disorders, which at least in the acute phase can be recognized by a clear spinning vertigo, spontaneous nystagmus and lateropulsion [11, 19, 33, 124]. In addition, the findings in Paper IV indicated less vertiginous symptoms in dizzy patients with neck pain. Interestingly, as both CROM and neck pain are thought to be associated with CD [11], the results from the review varied when compared to other populations. However, two studies implicated neck movements as a precipitating or aggravating factor [121, 122].

Comparison of the different studies in the systematic review should be made with caution as the test procedures, equipment and parameters differed across the studies. In addition, most of the other clinical findings from the included studies were inconsistent when compared to each other or found no differences between patients with CD and other populations. This was also the case regarding the diagnostic criteria used in the included studies. We found a lack of agreement on objective criteria for CD, emphasizing the lack of clinical hallmarks of the condition.

5.1.2 Concurrent complaints, dizziness handicap and quality of life

In patients from the ENT – clinic (Paper II) we found that the prevalence of neck pain was higher (59%) in a dizzy population compared to what has previously been found in the general population [125], thus, implying an overrepresentation of neck pain in patients with dizziness. This overrepresentation could be caused by several reasons. Theoretically, it is possible that issues in the neck can cause sensory disturbances, resulting in a sensory mismatch causing dizziness [48, 126]. Conversely, as discussed by Wilhelmsen and Kvaale [93], dizziness may cause a “head-trunk” locking. This would probably be a conscious behavior at first, due to avoidance of provocative movements of the head that are generating dizziness. However, it may become an automatic behavior over time causing a rigid movement pattern leading to both an increase in neck pain, and to reduced vestibular compensation [93] as provoking movements and head movements are deemed important for the recovery of dizziness [127]. The results from Paper II showed that 58% of the patients with neck pain from the ENT clinic reported the onset of neck pain prior to the onset of dizziness which means that almost 50% reported dizziness as their first symptom. However, a discussion of what comes first, dizziness or neck pain, is perhaps somewhat redundant as both symptoms may have a mutually preserving effect on each other.

Neck pain was approximately evenly distributed between the patients diagnosed with a vestibular (55%) or a nonvestibular diagnosis (64%) and the group with both neck pain and dizziness reported higher disability due to their dizziness (measured with DHI). The higher dizziness disability score together with a similar prevalence of neck pain in both diagnosis groups are interesting, as most research tends to focus on cervical contribution to dizziness, only when all other possible causes are ruled out, thus not considering how or if neck pain affects dizziness regardless of diagnosis. One explanation of these findings may simply be that more symptoms add to the total burden, resulting in higher disability scores for the patients. However, considering the neurophysiological connections between cervical afferents and the vestibular system and the relationship found between PPT in the neck and sway in Paper III, the higher DHI score in the neck pain group may additionally indicate neck pain as a possible amplifier for dizziness symptoms in dizzy patients. In addition, the association between higher DHI score and neck pain may be of importance as a higher DHI score has been found to be associated with more frequent episodes of dizziness and longer dizziness duration [128].

Previous research has shown that both patients with nonvestibular and vestibular dizziness [4, 129, 130] have reduced quality of life compared to the healthy population. Our study indicated mild to moderate disability in both physical and mental quality of life (measure with RAND-12) in both groups. However, the patients with additional neck pain had significantly lower mental and physical quality of life compared to the group with only dizziness (Paper II). Thus, the burden of neck pain seems to influence both the perceived handicap of dizziness and the patient's quality of life. These findings are perhaps not surprising. Both self-reported health and functional status is associated with numbers of symptoms [131, 132] and neck pain is often a part of a more widespread pain complex [2]. It would be reasonable for additional neck pain to add to the burden of dizziness and affect quality of life in dizzy patients.

5.1.3 Association between postural sway and PPT in the cervical region

Both sway area and Romberg ratio had an inverse relationship with PPT in the neck, after adjusting for age, sex, and generalized pain (Paper III). However, this association was only found with eyes closed and only in patients referred for dizziness and not in patients referred for neck pain. The results suggested that dizzy patients with a higher tolerance for pain were more stable on the platform, indicating that a lower pain tolerance was associated with increased sway. A possible explanation for these findings is that in the eyes closed condition, the CNS has to rely on accurate vestibular and somatosensory feedback, including important information about head-on-body position from proprioceptive afferents in the neck [13, 49]. A low PPT may indicate neck pathology, which may include alteration in the proprioception afferent information in the neck, affecting postural control. The inverse relationship between Romberg ratio and PPT is supports this explanation as the Romberg ratio is an indication of visual dependency due to proprioceptive deficit [90]. As there was less difference in sway area between eyes closed and eyes open with increased PPT, this may imply that a higher tolerance for pain is associated with better proprioceptive function of the neck. A lower tolerance for pain in the cervical region may cause sensory disturbances, making the patient rely more on visual feedback to keep stable.

Postural control relies on several sensory systems, and a deficit in one of these may be compensated by the others. Thus, it is possible that an existing vestibular deficit could unmask a sensory mismatch caused by a disorder in neck proprioception when measuring postural balance with eyes closed. In the ENT, clinic approximately 50% were diagnosed with a vestibular problem. A possible explanation for some of our findings may be that there was a synergistic interaction between neck pathology and vestibular deficit. Neck pain alone may not be sufficient to cause postural imbalance. However, 45% of the neck pain patients from the spine clinic reported dizziness. It may be speculated that dizziness in most of these patients was nonvestibular.

The importance of the presence of dizziness is coherent with other studies finding that patients with WAD have altered postural control only when they report dizziness [68]. In addition, the most consistent findings from the systematic review (Paper I) were altered postural control when comparing CD to other populations. However, it is important to emphasize that PPT had a small explanatory power for both sway area and the Romberg ratio. The coefficients of the associations were small with small changes in percentage of sway. Thus, interpretation must be done with caution. In addition, it is difficult to evaluate the clinical implication of the association. Previous studies examining PPT in the neck area found a minimal detectable change ranging from 69 to 113 kPa [78, 80]. Thus, larger differences in PPT would be associate with a larger percentage of sway. Dizziness with a suspected cervical origin is often characterized with descriptions of dizziness such as a feeling of unsteadiness, disequilibrium, or lightheadedness [19, 124]. It is perhaps possible to speculate whether the association found in this study, however small, might influence a patient's symptoms.

5.1.4 Association between neck pain, dizziness and physical characteristics

In Paper IV we further explored the relations between neck pain and dizziness symptoms in terms of both clinical symptoms and physical characteristics. This paper included one group of healthy controls and three groups with dizzy patients: one group had neck pain as their primary complaint; one group with neck pain as a secondary complaint; and one group had only dizziness. In line with Paper II and III, this paper found that neck pain was associated with certain characteristics. The two neck pain groups were more likely to report a gradual onset of their dizziness, lightheadedness and visual disturbances compared to the group with only dizziness. These findings are coherent with some of the reports from the systematic review and the understanding of CD as being commonly reported as a vague clinical picture compared to peripheral vestibular disorders. The gradual onset of dizziness and description of lightheadedness is contrary to vestibular disorders, which often have an acute onset with rotatory vertigo [133]. One possible explanation may be that CD, if this may be presumed to explain the symptoms in at least some of these patients, most commonly develops due to a slowly progressive, degenerative neck disorder where symptoms may wax and wane, but rarely have a distinct onset. Reports of visual disturbances as an accompanying symptom could possibly be explained with disturbances of cervical proprioception causing a mismatch between the VOR and COR, that usually work in conjunction to stabilize gaze [134]. Another explanation could be coexisting migraine with visual auras. Future research needs to examine these associations further.

Patients with dizziness have previously been shown to have physical impairments [93, 96] and in this study, we found that healthy controls performed better on some physical tests when compared to patients with dizziness only. The patients in the two neck pain groups had physical impairments, such as decreased cervical range of motion, decreased neck and shoulder flexibility and increased number of ACR tender points. Interestingly, as anxiety is associated with dizziness disorders, an increase of perceived symptom disability and somatization symptoms in patients with dizziness [135, 136], both neck pain groups scored higher on the autonomic/anxiety subscore on the VSSsf, compared to the group with only dizziness. Anxiety symptoms and physical impairment could both result in fear of movement, leading to rigid movement patterns, resulting in an increase of physical impairment. These results are important to consider, as they could lead the patients into a vicious circle where the different components interact and amplifying each other. Thus, these findings may indicate that neck pain should be considered when examining patients with dizziness.

Even though the two neck pain groups shared some of the same characteristics there were certain interesting distinctions between them, emphasizing the role of the primary complaint. Compared to the other two groups, the group with neck pain as their primary complaint was less likely to report a rotatory vertigo and reported a higher degree of headache accompanying their dizziness. The neck pain group with dizziness as a primary complaint was more likely to report a rocking sensation of vertigo, had the highest symptom severity on the VSSsf total score and the highest pain sensitivity (PPT) in the neck.

It is important that the results from this study are interpreted with caution as this was an exploratory study where many associations were examined. However, trends can be found in the data. The lack of consistency in clinical characteristics and diagnostic criteria in patients with suspected dizziness of cervicogenic origin (Paper I) emphasized the need for more research on this topic. The results from this paper may give indications for future research on certain characteristics in patients with these concurrent complaints. The results corroborate the findings from Paper II that neck pain adds to the burden of dizziness, perhaps especially when dizziness is the primary complaint. Thus, it is reasonable to consider cervical pain or impairment as a contributing factor to the patient's dizziness impairment and that burden of neck pain seems to be associated with postural control, dizziness characteristics, physical impairments, anxiety and the quality of life.

5.2 Methodological considerations

The strengths and limitations of the methods used in this project and the different papers are discussed in the following section.

5.2.1 Design & measurements

Detailed protocols were generated prior to the start of the study to limit extraneous variables and enhance control over test procedures and data collection. Three of the studies (Papers II, III & IV) had a cross-sectional design. This design is appropriate for describing relationships among phenomena when there is a cogent theoretical rationale behind the analysis [137]. We investigated the relationship between neck pain and aspects of dizziness and balance, which is founded on theoretical theories and previous evidence between interactions of the cervical afferent system, the visual and the vestibular system. The advantage of such a design is that it provides better precision and control of the data collection, enhancing the precision of the association in question. A drawback of this broad methodological approach is the inability to gain a deeper understanding of the results with the largest disadvantage being the lack of ability to conclude in a causal way. This makes it difficult to consider the internal validity of the project as it cannot establish causal effects [138].

Using subjective measures such as questionnaires as outcome measures could introduce bias as the patient may not be in the necessary physical or psychological state to give accurate opinions of their experienced health status or be influenced by recall bias. They may also be concerned by the consequences of their answers in terms of care given by the healthcare provider[139, 140]. However, patient-reported outcome measures is a valuable tool as it provides insight into the patient's perception of their own health, which is important information to providing patientcentered care [140]. In addition, the questionnaires used in this thesis are widely used and have previously been validated. As this was a multicenter study, there were more than one assessor examining the patients and conducting the physical tests. Several assessors on the different centers may have led to measurement bias. Thus, prior to the study, the examiners had two sessions and then an additional session after five months for calibration of the different tests to ensure consistency in the measures. The physical tests used in Paper IV have previously shown adequate validity and reliability and were assessed by experienced physiotherapists. In addition to the use of validated questionnaires, this improves the quality of the data and that it measures the intended construct, which is important when considering the internal validity of the project [139].

In Paper II, the diagnostic process was thorough and carried out by an otolaryngologist; however, a large portion of patients were diagnosed with a nonvestibular diagnosis. Even though the diagnostic process was based on several objective measures, the study could have been strengthened by the inclusion of an objective measure of vestibular function, such as the caloric test. Paper III used posturography as a measure of postural sway. Even though it is a widely used tool and indicated to be reliable, the findings by Ruhe et al [89] indicated that at least three trials should be used with 90 seconds of data acquisition. This deviated from our protocol and we acknowledge that the results should be interpreted with caution. Further, we used PPT as a way of measuring pain sensitivity in the neck, which has been proposed to affect cervical afferent input [48, 141]. The PPT has shown good reliability and concurrent validity when compared to other subjective measures of pain [80]. For these reasons, PPT seems beneficial and feasible for research purposes. However, PPT does not directly measure altered proprioception of the neck. Perhaps other tests that are directly aimed to measure proprioception should have been added, such as the joint position error [142].

5.2.2 Setting and sample

There are limitations to consider when interpreting the results and considering the external validity and thus, the generalizability of this thesis. The population may be prone to sampling errors as the inclusion criteria were fairly wide and based on referral for either dizziness or neck pain to a specialized care unit. Thus, the populations were heterogeneous as we included patients based on symptom complexes and not a specific diagnoses. Caution should thus be exercised when considering the generalizability of the studies. Stricter inclusion criteria for neck pain could have improved the generalizability of the results, making the sample less heterogeneous. For instant, using subgroups of patients with neck pain as proposed by Guzman et al. [143]. However, subgrouping would lead to a reduction in group sizes and thus statistical power.

The inclusion of patients with these symptom complexes in this setting is also a strength. The associations were examined in two unselected patient groups with dizziness and neck pain, i.e. the patients were not selected due to any a priori assumption of a causal link between their neck symptoms and dizziness or balance. The results from this thesis may be generalizable to these types of patients, referred for either dizziness or neck pain, as they appear in a clinical setting in a specialized care unit. Women were overrepresented at both centers; however, women are usually overrepresented in both neck pain and dizziness populations [2, 144].

In Paper III and IV, the populations recruited from the outpatient spine center did not undergo an otoneurologic examination of their dizziness. Even though the diagnosis was not the objective of these studies, an overview of the patients having vestibular dysfunction in this group would perhaps enhance the clinical value and the interpretation of the studies.

One strength of this thesis was the relatively large sample size. However, the sample size was a convenient sample and a power estimation was only conducted for Paper III. There was a relatively large difference in group sizes in Papers III and IV, which should be considered when interoperating the results from these studies. The results from Paper IV call for caution as several associations were investigated, increasing the risk of type I errors.

5.2.3 Systematic review

The results and comparison of the different studies in the systematic review (Paper I) should be considered with caution as the test procedures, equipment and variables differed across the studies. A considerable limitation was the low number of studies, varying outcomes and the relatively low methodological quality of the included studies, making pooling of data and meta-analysis not possible. However, the lack of clinical studies on patients with CD emphasizes the importance of increasing the knowledge in this field. In addition to the small numbers of studies, a limitation of the systematic review was that half of the studies were more than 9 years, old with publications dating from 1993 to 2017. Thus, the results from this review should be interpreted with caution. In addition, this review only reflects the diagnostic criteria for the studies meeting its inclusion criteria and is thus not representative of all studies on CD. However, the fact that the included studies had to have a comparison group for clinical outcome would probably not exclude other valuable clinical studies on patients with CD. Another limitation could be the inclusion of studies comparing patients with CD with healthy controls which makes the review somewhat heterogenic. However, as we do not know how these patients differ from other diagnoses or even healthy controls, and with the general low number of clinical studies examining these patients, we found that comparisons with healthy controls would contribute to the limited knowledge within the area. The strength of this review is the thorough and systematic search process, adherence to guidelines and the use of two independent reviewers.

5.3 Implication and future research

In this thesis we have examined different associations between dizziness and neck pain. Even though there exist clinical studies on patients with CD, these relationships have not previously been investigated in such large symptom groups. By doing this, we were able to examine how neck pain is associated with different characteristics in a dizzy population regardless of the cause or origin of the dizziness. The associations found indicate relationships between neck pain, postural control, physical impairment, symptoms characteristics, symptom severity and quality of life in patients with dizziness. These findings contribute to a controversial field on whether neck pain influences dizziness and if so how. The high prevalence of neck pain among dizzy patients, indicates that it is a common clinical issue. The association between neck pain and certain dizziness characteristics should be considered when examining these patients as the patient's description of dizziness is often used for diagnostic purposes. However, many patients report multiple types of dizziness, making this information difficult to interpret [145]. If neck pain influences these descriptions and associated symptoms, this may be useful information for the health practitioner when assessing the patient. In addition, it seems that the patients with dizziness as their primary complaint and additional neck pain were most prone to adverse outcomes such as dizziness severity, poor quality of life and physical impairment. Health practitioners should be aware of these relationships when examining or treating patients with concurrent complaints as these patients may need additional attention or follow-ups.

In this thesis, only the association between the symptoms has been explored. The simultaneous presence of both dizziness and neck pain may lead to the assumption of an etiological relationship rather than a coincidental one. This thesis cannot answer whether any causal relationship exists. However, considering the lack of consistent diagnostic criteria found in Paper I, the results from this thesis may be a first step in establishing more precise characteristics of neck induced dizziness and need to be further examined in future research. There is also a lack of knowledge about the long-term effect of concurrent complaints. Even though previous research has indicated that neck pain should be considered as a predictor for long-term dizziness [7], there is little evidence of a causal relationship or the consequences of having concurrent complaints over time. Thus, there is a need for both longitudinal studies examining how neck pain affects dizziness symptoms over time, and intervention studies examining the possible effect of neck intervention on dizziness symptoms. This would contribute to further understanding of the underlying mechanisms and causality between this common clinical issue of concurrent neck pain and dizziness.

5.4 Ethical considerations

This project was approved by the Norwegian Regional Committee for Medical and Health Research Ethics (REK 2017/783). The project reference number is provided in the method section of each paper. Ethical considerations were discussed, and the study protocol was considered to provide minimal harm to the participant other than the time it took to complete the examination. Breaks were given if the participant needed them. The study was based on voluntary participation and the participants were told they could withdraw from the study at any time without having to give a reason. The examination related to this project was done in addition to, and independent of, their treatment at the respective clinics. The participants were given detailed written and oral information about the study prior to the examination and were asked to give their written consent. All information was treated anonymously and secured on a local hospital dedicated server.

6. Conclusion

The main objective for this thesis was to explore whether and how neck pain is associated with dizziness symptoms, physical characteristics, dizziness severity, postural control and quality of life. The systematic review (I) found limited research on the clinical characteristics of patients with CD, with reduced postural control being the most consistent finding. Despite the lack of studies and consistent findings in the systematic review, results from our research projects suggest that neck pain influences dizziness characteristics. Patients with concurrent neck pain and dizziness reported higher disability due to dizziness and lower quality of life. In addition, neck pain was evenly distributed among vestibular and nonvestibular diagnoses (Paper II). With closed eyes, the tolerance for pain in the cervical region is associated with performance on posturography in patients with dizziness (Paper III). In patients with dizziness, neck pain was associated with certain dizziness symptoms, symptom severity and impaired physical characteristics compared to patients with only dizziness (Paper IV). Thus, the overall findings of this thesis indicate that neck pain may influence postural control, dizziness severity, dizziness symptoms, physical impairments and quality of life. As the relationship between dizziness and neck pain is a controversial topic, these findings may be helpful and should be considered when physiotherapists or physicians examine patients with concurrent complaints. The relationship between neck pain, dizziness disability and quality of life should make medical practitioners aware of patients with concurrent complaints regardless of diagnosis.

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RESEARCH ARTICLE

WILEY

Clinical characteristics in patients with cervicogenic dizziness: A systematic review

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Abstract

Background and aims: Cervicogenic dizziness (CD) is a clinical syndrome of dizziness associated with neck dysfunction. CD represents a considerable diagnostic challenge since dizziness and neck pain are common symptoms with complex and multifactorial etiologies. Both research and clinical work on CD is limited by the lack of accepted diagnostic criteria. The aim of this study was to review clinical studies on CD and to assess current evidence regarding the clinical characteristics of this syndrome.

Methods: A comprehensive PubMed and MEDLINE search was conducted from the date of inception of the database, with the last search conducted in September 2018. Included studies had to contain operable diagnostic criteria as well as a comparison between patients considered to have CD and a clinical comparison group. Data extracted were clinical outcomes, diagnostic criteria, age, sex, and sample size. Studies were assessed for methodological quality using the Crowe Critical Appraisal Tool.

Results: Out of 2161 screened studies, eight studies comprising 225 patients met the inclusion criteria. Studies were of low to acceptable methodological quality. The most frequent and consistent clinical characteristic in patients classified as having CD, compared with other populations, was reduced posturographic stability. The most consistent diagnostic criteria were based on the concurrence of neck pain with dizziness after exclusion of other possible reasons for dizziness.

Conclusion: There are few studies examining clinical characteristics in patients with cervicogenic dizziness. Altered posturography appeared to be the only consistent characteristic used when distinguishing CD from other populations. Diagnostic criteria currently used in research are likely to have low specificity, since they rest on the exclusion of other causes rather than on positive distinctive features. More studies are needed to better understand the clinical interrelations between dizziness and neck pain.

KEYWORDS
dizziness, neck pain, proprioception, vertigo

JEL CLASSIFICATION
Neurology; Otolaryngology

[Correction added on 02 August 2019, after first online publication: The statement “reduced posturographic instability” in the abstract was corrected to “reduced posturographic stability“.]

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1 | INTRODUCTION

The clinical diagnosis of cervicogenic dizziness (CD) is commonly reserved for patients presenting with dizziness associated with neck dysfunction after all other potential causes for the dizziness have been excluded.[1] However, the usefulness of this diagnostic approach in a clinical setting is limited for several reasons.

Dizziness is a common symptom that may arise from a great number of disorders.[2,3] In approaching the dizzy patient, it is essential to narrow down this number by assessing symptoms, their time course, and possible triggers. The word "dizziness," in itself, is insufficient to qualify as a diagnostic criterion. Typical clinical symptoms of CD are suggested to consist of disorientation, lightheadedness, or disequilibrium accompanied by cervical pain, limited range of motion, and reduced balance.[4,5] In addition, a close temporal relationship between the dizziness and neck symptoms is considered important by some authors (Wrisley et al 2000). An *ex juvantibus* confirmation of the diagnosis—based on the resolution of dizziness after treatment of the neck disorder—has been proposed.[1] However, clinical studies documenting the vestibular or extra-vestibular symptoms, whether they be vertiginous or not, whether acute, episodic, or chronic, or triggered by specific activities or events, are needed. CD has several proposed causes, such as vascular or neurovascular.[6] However, the most common theory is considering CD to be a disorder of neck proprioception.[1,7] Furman and Cass[7] defined it as a "nonspecific sensation of altered orientation in space and disequilibrium originating from abnormal afferent activity from the neck." Because of high demands of both stability and mobility, the cervical spine has a well-developed proprioceptive system.[8-10] Thus, the functional status of the neck should be examined, and the use of neck pain as a diagnostic marker of CD may, therefore, be inadequate. Thus, there is a need for clinical studies documenting neck function in patients with CD.

To date, there is no consensus on diagnostic criteria for CD. Several reviews have been published on the topic, but these have mainly focused on the theoretical basis for the diagnosis, eg, the abundance of muscle spindles in the deep cervical muscles,[10] the close integration between cervical and vestibular afferents in the brain stem and cerebellum,[11] and experimental studies on the effect of selective neck lesions or injection on balance and dizziness.[12-15] To the authors' knowledge, no systematic review exists of clinical studies on CD and how these patients differ from other relevant patient populations such as those with other diagnosis of dizziness, patients with neck pain, or even healthy controls. Identifying studies examining how CD patients differ from other populations would contribute to better understand the condition and guide future research.

The aim of this paper is to review clinical studies on CD and to assess current evidence regarding the clinical characteristics of this syndrome. A secondary aim was to examine and compare the diagnostic criteria that were used in the included studies.

2 | METHODS

2.1 | Study design

This systematic review adhered to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement.[17]

2.2 | Search strategy

A comprehensive literature search was performed through PubMed and MEDLINE from the inception of the database to September 2018 (last search date: 9th of September 2018). The search terms were used as mesh terms or text words and were adjusted for the different databases. The search terms and the full search strategy are available in Appendix S1. Each step in the screening process was performed by two reviewers independently (MKK and FKG). References from included papers were screened by the reviewers for potentially relevant studies not captured by the electronic search.

2.3 | Eligibility criteria

This review was restricted to published, peer-reviewed original studies. Unpublished studies, case reports, editorials, reviews, and conference abstracts were not included. The search was restricted to articles written in English. We included original studies on patients with CD because of allegedly altered neck proprioception, comparing their clinical characteristics to those of other populations. Thus, for inclusion, the study had to contain a reference group, either with another diagnosis or healthy controls, for comparison. To assure higher comparability between studies, included studies had to state whether or not other causes of dizziness had been ruled out. This included other causes of alleged CD such as neurovascular or vascular disorders. In addition, the diagnostic process or criteria had to be accounted for. Studies were excluded if the study population (CD) was composed of patients suffering from other confirmed diseases that could explain their symptoms. For readability and consistency, this review uses the term CD, although some of the included papers have used slightly different names for the same condition (Table 1).

2.4 | Study selection

All titles and abstracts were screened by the two reviewers after duplicates were discarded and irrelevant citations were removed. Full text versions of eligible articles were evaluated by the two reviewers to determine inclusion. Any disagreements were resolved through discussion among reviewers. The process was facilitated by the use of the Rayyan systematic review web application,[16] which allows for blinding in each step of the process. The PRISMA 2009 Flow Diagram (Figure 1)[17] illustrates the selection process of the studies.

TABLE 1 Included studies in the review (n = 8)

Article	Type of Study	Diagnostic Criteria	Patients with Cervicogenic Dizziness	Reference Group	Outcome Measures	Main Findings	CCAT Score
Reid, S. A., Callister, R., Katekar, M. G., & Treleaven, J. M. (2017)	Case-control	Stiff and/or painful neck, dizziness described as “unsteadiness” triggered by neck movement, Palpable upper cervical joint dysfunction on assessment by an experienced musculoskeletal physiotherapist. Other causes excluded by assessment by neuro-otologist	Patients with cervicogenic dizziness (n = 86; age: 66; sex: 43 females, 43 males).	Patients with dizziness of other, non-cervicogenic causes (n = 86; mean age: 64; sex: 55 females, 31 males).	DHI	Questions 1 (Does looking up increase your problem?), 9 (Because of your problem, are you afraid to leave your home without having someone accompany you?), and 11 (Do quick movements of your head increase your problem) on DHI were most discriminatory to cervicogenic dizziness compared with general dizziness. The optimal threshold on these scores were <9 for cervicogenic dizziness.	26
Karlberg, M., Johansson, R., Magnusson, M., & Fransson, P. A. (1996)	Cross-sectional	Neck pain and concomitant complaints of dizziness or vertigo. Other causes excluded.	Patients with vertigo of suspected cervical origin (n = 16; age: 38; sex: 14 females, 2 males.)	Patients with vestibular neuritis (n = 18; mean age: 49; sex: 10 females, 8 females). Controls (n = 17. Mean age: 40. Sex: 9 females, 8 males.).	Posturographic measurement of postural responses to vibratory stimulation of the calf muscles	Patients with cervicogenic dizziness were distinguished both from controls and VN with regard to disturbed postural control. Both in the “eyes open” and “eyes closed” conditions; patients with suspected cervical vertigo were characterized by significantly lower values for stiffness and significantly higher values of damping compared with healthy controls and significant lower values for stiffness than the VN patients for any of the individual parameters under any test conditions.	28
L'Heureux-Lebeau, B. Godbout, A. Berbiche, D.& Saliba, I. (2014)	Case-control	Neck pain associated with dizziness Cervical pain, trauma/or disease If from traumatic origin, temporal proximity between the onset of dizziness and the neck injury. Other causes excluded.	Patients with cervicogenic dizziness (n = 25; sex: 22 female, 3 male; age: 49.12 [10.21]).	Patients with benign paroxysmal positional vertigo (n = 25; sex: 20 female, 5 male; mean age: 57.28 [16.17]).	Smooth pursuit Neck torsion test Cervical torsion test Cervical relocation test DHI State trait anxiety Inventory Dizziness characteristics Neck pain	There was a significant difference in mean cervical joint position error, and videonystagmography showed differences in the cervical torsion test between the two groups. No difference in DHI or anxiety was observed. There was a difference in sensorimotor disturbances	25

(Continues)

TABLE 1 (Continued)

Article	Type of Study	Diagnostic Criteria	Patients with Cervicogenic Dizziness	Reference Group	Outcome Measures	Main Findings	CCAT Score
						between the two groups, particularly in the control of head and eye movement and cervical proprioception. Patients with cervicogenic dizziness were more likely to have sensation of drunkenness/lightheadedness, pain induced during examination of upper cervical vertebra, joint position error of 4.5° during cervical relocation test, and exhibit more than 2° per second nystagmus during cervical rotation test.	
Karlberg, M. Magnusson, M. Malmstrom, E. M., Meler, A., & Moritz, U. (1996)	Prospective randomized, controlled trial	Recent onset of neck pain and simultaneous complaints of dizziness or vertigo Extracervical causes of dizziness excluded.	Patients with dizziness of suspected cervical origin (n = 17; sex: 15 female, 2 male; age: 39)	Healthy controls (n = 17; sex: 15 female, 2 male; mean age: 35)	Posturography	Patients with cervicogenic dizziness had impaired postural performance compared with healthy controls in all posturographic conditions.	23
Grande-Alonso, M. Moral Saiz, B. Minguez Zuazo, A. Lerma Lara, S. & La Touche, R. (2016)	Cross-sectional	Neck pain on visual analogue scale Neck pain according to the Neck Disability Index Dizziness associated with pain, movement, rigidity, or certain neck positions Duration of neck pain and dizziness >3 mo Age 18-65 years	Cervicogenic dizziness (n = 20; sex: 18 female, 2 male; age: 36.5 [11.03]).	Asymptomatic healthy controls (n = 22; sex: 15 female; 7 male; mean age: 35.2 [10.03])	VOR activity Postural control TSK-11 HADS anxiety HADS depression	There was no difference in VOR activity between patients with cervicogenic dizziness and asymptomatic subjects. There were differences with a medium-to-large effect size in variables related to proprioception and visual information integration. There was a difference in TSK-11 and HADS anxiety and HADS depression.	24
Yahia, A. Ghroubi, S. Jribi, S. Malla, J. Baklouti, S. Ghorbel, A.	Cross-sectional	Chronic neck pain (>3 mo (in presence or absence of vertigo) linked to cervical arthritis or minor intervertebral disorders Excluded patients with a history of cervical spine	Chronic neck pain patients with vertigo (G1) (n = 32; age: 48.15; sex: 68.7% female).	Neck pain (G2) (n = 30; mean age: 47.1; sex: 76.66 % female). Healthy (G3) (n = 30; age: 47.13; sex: 83.33 % female).	VAS CROM Neck-related headache Static and dynamic posturography	The mean neck pain intensity on a VAS was 6.65 out of 10 in G1 and 4.03 in G2. Cervical spine mobility was significantly lower in G1 than in G2 and G3. Neck-related headache was more frequent in G1 than in	14

(Continues)

TABLE 1 (Continued)

Article	Type of Study	Diagnostic Criteria	Patients with Cervicogenic Dizziness	Reference Group	Outcome Measures	Main Findings	CCAT Score
& Elleuch, M. H. (2009)		trauma or surgery or those with abnormal results in ear, nose, and throat examinations (vestibular damage), ophthalmological test (vision disorders), and/or neurological assessment (sensorimotor or coordination impairments).				G2 (65.5% vs 40%, respectively). Balance abnormalities were found more frequently in G1 than in G2 or G3. Static and dynamic posturographic assessments (under "eyes open" and "eyes shut" conditions) revealed significant abnormalities in statokinetic parameters in G1.	
Alund, M., Ledin, T., Odkvist, L., & Larsson, S. E. (1993)	Cross-sectional	Localized neck pain and stiffness for more than one year Long-lasting general neck pain as well as vertigo and/or unsteadiness Central and peripheral vestibular abnormalities excluded	Patients with suspected cervical vertigo (n = 15; age: 48; sex: 12 females, 3 males).	Neck pain (n = 10; mean age: 47; sex: 6 female, 4 male.). Healthy (n = 15; age and sex matched).	VAS CROM Dynamic posturography	There was no difference in VAS between cervicogenic vertigo and the neck pain group and no difference between groups in neck range of motion. Patients with cervicogenic vertigo had significant lower mean equilibrium scores with head in neutral position, left rotation, and right lateral rotation compared with controls. Patients with cervicogenic dizziness had lower equilibrium score when examined in the position most prone to elicit vertigo/ unsteadiness compared with neck patients.	16
Heikkila, H. Johansson, M. & Wenngren, B. I. (2000)	Single subject	Patients with complaints of dizziness or vertigo of suspected cervical origin. Excluded if there was a possibility of extracervical causes, older than 55, vertigo persisting in less than 3 mo or with a history of central nervous system diseases or trauma, ear disease, arteriosclerotic, or rheumatoid arthritis.	Patients with complaints of dizziness or vertigo of suspected cervical origin (n = 14; sex: 8 female, 6 men; age: 36).	Healthy volunteers (n = 39; sex: 24 female, mean age: 35).	Kinesthetic sensibility test	Significant differences in relocation success was found in all directions in flexion, extension, and rotation between groups.	17

Abbreviations: Age: reported as mean; CROM, cervical range of motion; DHI, Dizziness Handicap Inventory; HADS, hospital anxiety and depression scale; TSK, Tampa Scale for Kinesophobia; VAS, visual analog scale; VN, vestibularis neuritis; VOR, vestibular ocular reflex.

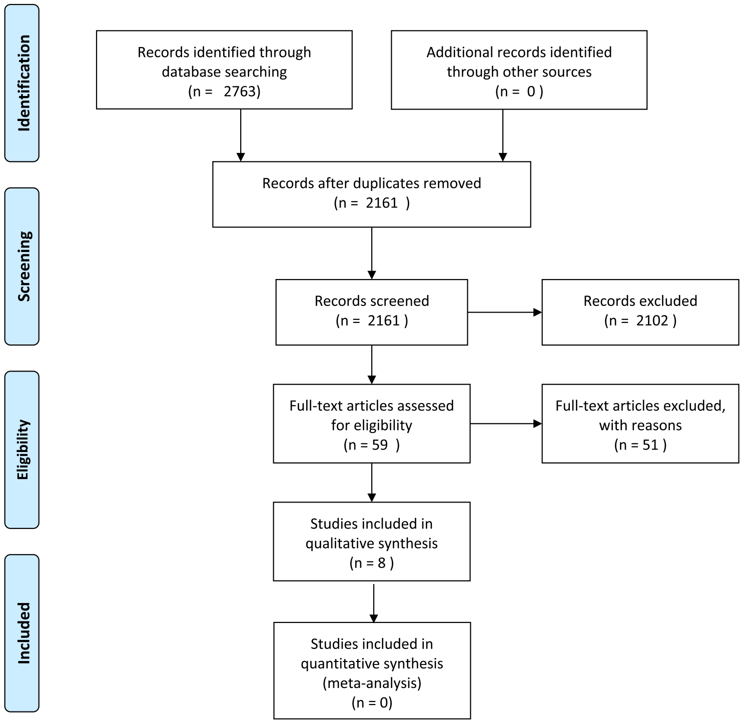

FIGURE 1 Illustration of the study selection process with the PRISMA 2009 Flow Diagram

2.5 | Data extraction process

The following data were extracted, compared, and compiled in a spreadsheet by both reviewers: population (age, sex, and sample size), study design, diagnostic criteria, and clinical findings compared with other diagnosis/healthy controls. The two reviewers compared the entered data and corrected missing entries.

2.6 | Assessment of methodological quality

Because of the heterogeneous nature of the studies with regard to design and outcome measures, quality of data, and study design, a meta-analysis was not appropriate for this review. Thus, a quality analysis of the included studies was performed. The methodological quality of the studies was assessed using the Crowe Critical Appraisal Tool version 1.4 (CCAT), which allows for a variety of research designs to be evaluated using the same tool.[18] This tool consists of nine categories. The first eight categories have a score range from 0 to 5. The ninth category states the total sum from the previous eight categories, which can range from 0 to 40, where a higher score indicates higher quality.

2.7 | Ethical Approval

Ethical approval was not required for this systematic review.

3 | RESULTS

3.1 | Search

The search resulted in 2161 articles, after removing duplicates. After screening titles and abstracts for irrelevant citations, we identified 59 articles, which were assessed in full text. No additional articles were found when screening reference lists. Fifty-one studies did not meet the inclusion criteria and were excluded from this review. See Appendix S2 for a list of excluded studies with reasons for exclusion. A total of eight studies met the inclusion criteria. The selection process is shown in Figure 1. The eight included studies comprised four cross-sectional studies,[19-22] one prospective study,[23] two case-control studies,[24,25] and one single-subject design study.[26] The included studies comprised a total of 225 patients classified as CD, with group sizes ranging from n = 14 to 86. Patients were compared with healthy controls (n = 140) in five studies,[19,21-23,26] to patients with BBPV (n = 25) in one study,[24] to patients with general dizziness (n = 86) in one study,[25] to patients with vestibular neuritis (n = 18) in one study,[21] and to patients with only neck pain (n = 40) in two studies.[19,22] Most studies included more women (n = 136) than men (n = 89), with the percentage of women ranging from 42 % to 87 %. The age of the CD patients ranged from 36 to 66 years. The included studies, with methodological quality assessment, are shown in Table 1.

3.2 | Clinical findings

3.2.1 | Posturography

A total of five studies included posturography. One of the studies found that the posturographic response to vibratory stimulation of the calf muscles could distinguish patients with vertigo of suspected cervical origin from patients with vestibular neuronitis and healthy controls.[21] Two of the studies found that patients with CD had reduced postural control compared with both patients with only neck pain and healthy controls.[19] The last two studies found reduced postural control in CD patients compared with healthy controls.[20,23]

3.2.2 | Cervical proprioception measured by relocation tests

Two studies examined cervical proprioception using relocation tests. These tests use a laser placed on the patient's forehead to measure the overshoot/undershoot when patients attempt to move the head back to a neutral position (straight ahead) after different head turns.[24,26] L'Heureux-Lebeau et al.[24] reported that patients classified with CD had a higher positioning error compared with patients with BPPV. Heikkila et al.[26] reported higher relocation errors after cervical flexion, extension, and rotation in patients classified with CD compared with healthy controls.[26]

3.2.3 | Cervical range of motion

Cervical range of motion (CROM) was examined in two studies, with different measurements methods.[19] Yahia et al.[22] found that patients with chronic neck pain and vertigo had significantly lower CROM (measured in centimeters from chin to sternum, chin to acromion, and earlobe to acromion) compared with both patients with only chronic neck pain and healthy controls. Alund et al.[19] found no difference in CROM (measured with a three-dimensional electrogonimetric equipment) between patients with suspected CD, neck pain, and healthy controls.

3.2.4 | Symptom duration

Two of the studies reported duration of dizziness. In one of the studies, the patients with CD had longer duration of dizziness (81 months) compared with patients with general dizziness (23 months).[25] In the other, the patients with CD exhibited shorter dizziness duration (30 months) compared with patients with BPPV (38 months).[24]

3.2.5 | Neck pain

Neck pain was examined in three studies. L'Heureux-Lebeau et al.[24] found more frequent neck pain in patients classified as having CD compared with patients with BPPV. Alund et al.[19] found no difference in neck pain between patients with CD and patients with only neck pain. The other study, that of Yahia et al,[22] found that chronic neck pain patients with vertigo scored significantly higher on neck pain compared with chronic neck pain patients without vertigo.

3.2.6 | Psychometric measures

L'Heureux-Lebeau et al.[24] found no difference in anxiety or dizziness handicap between patient with CD and those with BPPV, using the Dizziness Handicap Inventory and State-Trait Anxiety Inventory. Grande-Alonso et al.[20] found that patients with CD had higher fear of movement and higher anxiety and depression levels than asymptomatic individuals, as measured by the Tampa Scale for Kinesophobia and Hospital Anxiety and Depression Scale.

3.2.7 | Dizziness characteristics and triggers

Only one study examined differences in dizziness characteristics between patients with CD and other dizziness diagnoses. The study found that patients with CD were more likely to have a sensation of drunkenness/lightheadedness[24] compared with patients with BPPV. Patients with BPPV were more likely to experience rotatory vertigo. The CD group was more likely to report cervical movement as a precipitating factor. There were no differences in self-reported imbalance, dizziness, lightheadedness, floating sensation, sway sensation, nausea, falls, or dizziness frequency between the two groups. Reid et al.[25] found that Questions 1 (Does looking up increase your problem?), 9 (Because of your problem, are you afraid to leave your home without having someone accompany you?), and 11 (Does quick movement of your head increase your problem) of the Dizziness Handicap Inventory allowed to better classify patients as having CD compared with general dizziness.

3.2.8 | Headache

One of the included studies[22] found that patients with chronic neck pain and vertigo had more neck-related headaches compared with patients with only chronic neck pain.

3.2.9 | Smooth pursuit, nystagmus during neck torsion, video head impulse test (vHIT)

L'Heureux-Lebeau et al.[24] reported that patients with CD were more likely than patients with BPPV to have a positive smooth pursuit neck torsion test as well as nystagmus elicited by neck torsion (2° per second or more). However, the criteria for the former test were not specified. Grande-Alonso et al. (2016) reported no difference in vHIT responses between patients with CD and asymptomatic individuals.

3.3 | Diagnostic criteria

3.3.1 | Coexistence of dizziness and neck pain

All but one[26] of the included studies had the coexistence of neck pain and dizziness as an explicit diagnostic criterion. In Heikkila et al.,[26] neck pain was implicated in the criterion "dizziness or vertigo of suspected cervical origin."

3.3.2 | Vestibular symptoms, triggers, and aggravating factors

Most of the included studies did not specify particular dizziness symptoms as criteria for classifying patients as CD. However, one study[25] included dizziness "described as unsteadiness triggered by neck movement" as a criterion. Another study included dizziness "associated with pain, movement rigidity, or certain neck positions" as a criterion.[20]

3.3.3 | Timing and duration of neck symptoms and dizziness

Four of the included studies specified duration of symptoms in the diagnostic criteria. One study reported that the patients had to have "recent onset" of and simultaneous complaint of dizziness or vertigo.[21] Another reported that the duration of both neck pain and dizziness had to be longer than 3 months.[20] Yahia et al.[22] used chronic neck pain of more than 3-month duration as a criterion. Alund et al.[19] chose neck pain and stiffness for more than one year as a criterion. The criteria for dizziness were only reported as "long-lasting." Finally, one study added that if the neck pain had a traumatic origin, there needed to be a temporal proximity between the onset of dizziness and the neck injury.[24]

3.3.4 | Neck examination

Two studies included decreased neck mobility in the diagnostic criteria.[19] Reid et al.[25] reported stiff and/or painful neck as one of their criteria, whereas Alund et al.[19] mentioned "localized neck pain and stiffness." Reid et al.[25] additionally required "palpable upper cervical spine dysfunction" assessed by an experienced physical therapist.

3.3.5 | Other causes excluded

All studies reported exclusion of causes of dizziness/vertigo, such as vestibular and central. The studies described in detail the method and examination used for ruling out patients with other causes of dizziness or vertigo, except for one.[20] However, this study noted that presence of an otorhinolaryngological diagnosis of central or peripheral vertigo would exclude the patient from their study.

3.4 | Methodical quality of the studies

The studies were given CCAT scores ranging from 14 to 28, indicating low to acceptable methodical quality. Common limitations in the included studies were insufficient information on sampling methods, insufficient sample size justification, insufficient information on ethical matters, and limitations related to statistical analysis.

4 | DISCUSSION

This review identified eight original studies comparing patients with CD with groups of patients either suffering from other established and well-defined conditions or healthy controls. Based on CCAT scores, the studies were of low to acceptable methodological quality. Pooling of the results was not possible since outcomes varied. Nevertheless, the studies shed some light on current opinions on CD.

4.1 | Clinical findings

Although the International Classification of Vestibular Disorders distinguishes between vertigo and dizziness,[27] and some consider it unlikely that disorders of neck proprioception should be associated with illusory perceptions of self-motion such as spinning vertigo,[28] only one study in this review[25] required the a priori exclusion of patients with vertigo, stressing that dizziness should be described as "unsteadiness." This follows the definition by Furman & Cass,[7] where patients with CD are more likely to have a "nonspecific sensation" of dizziness, in contrast to patients with BPPV or those with other types of vestibular disorders, where the dizziness is usually reported as rotatory.[7] However, one of the included studies[21] found that seven out of 16 patients with dizziness of suspected cervical origin reported vertigo defined as a sensation of movement. L'Heureux-Lebeau et al.[24] found that 32% of patients with CD reported a rotatory sensation compared with 76% in a group with BPPV. In this study, most patients reported a sensation of "drunkenness" (92%) or imbalance (76%). Admittedly, one should not rely solely on the description of vestibular symptoms in making a diagnosis, since patients have difficulties reporting vestibular symptoms in a consistent way.[29] However, a strong sensation of spinning vertigo should clearly lead to the suspicion of extracervical causes and probably also to the exclusion of CD as long as objective tests are unavailable to confirm this diagnosis.

The onset and time course of CD were not addressed specifically in any of the studies. While vestibular disorders like vestibular neuritis, BPPV, and Menière's disease are usually distinguished by an acute onset, dizziness caused by degenerative neck disorders would be expected to develop gradually. One of the included studies found that the average patient reported daily symptoms (mean score 4 on a frequency scale from 0 to 4).[21] L'Heureux-Lebeau et al.[24] found that a large group (40%) reported attacks of a few seconds duration, while 32% reported constant dizziness, indicating a variable time course, although most patients had dizziness every day (76%). Compared with patients with BPPV, patients with CD more often reported aggravation of dizziness because of cervical pain, fatigue, anxiety, stress, and to "any neck movements." Several of these factors also aggravate symptoms in patients with persistent postural-perceptual dizziness,[30] but some distinction should be possible because of the sensitivity of the latter group to visual and motion stimuli. The study by Reid et al.[25] found that patients with CD were more likely to report aggravation of symptoms when looking up or during quick head movements than patients with dizziness of other causes. This seems reasonable based on the suspected pathophysiology of CD decreasing or altering proprioceptive feedback from the neck.[1,7] However, looking up and moving the head quickly also aggravates symptoms in patients with vestibular disorders, such as BPPV or vestibular neuritis. In addition, a way to distinguish peripheral vestibular lesions from nonvestibular causes of dizziness is by examining the vestibulo-ocular reflex in response to high-velocity head movements (eg, the head impulse test). These triggers can, therefore, hardly be considered diagnostic.

Based on the present studies, CD would be expected to cause vestibular symptoms of gradual onset and present on a daily basis, aggravated by neck pain and be related to any neck movements rather than to specific head positions.

Most of the studies focused on identifying objective signs in the patients with CD, such as abnormal postural sway during platform posturography or increased positioning errors during cervical relocation tests, with posturography as the most consistent finding. Even though CD is thought to be associated with limited CROM,[5] the results found in this review were contradictory. L'Heureux-Lebeau et al.[24] reported finding nystagmus induced by neck torsion as well as pathology on the smooth pursuit neck torsion test; however, criteria for the latter finding were not specified. Compared with patients with BPPV, patients with CD were consistently sensitive to induced cervical pain during physical examination, particularly at the level of C3–C4. It seems reasonable to include a physical examination of neck tenderness and mobility in the diagnosis of CD, and because of the importance of neck proprioception to postural balance, quantitative measurements of posture and gait, particularly during dynamic conditions, might reveal diagnostically relevant information. However, because of the scarcity of data and the differences in outcome measures, more studies are needed before any conclusions can be made as to the usefulness of posturographic or cervical relocation tests in the diagnosis of CD.

4.2 | Diagnostic criteria for cervicogenic dizziness

The diagnostic criteria used in the reviewed studies were predefined by the authors, and because of the lack of a diagnostic "gold standard," their validity cannot be determined. The criteria of CD was, in most studies, based on the patient simultaneously reporting neck pain and dizziness as well as the exclusion of other neurological or neuro-otological disorders. The distinction between vertigo and dizziness was not considered essential for the diagnosis in most of the reviewed studies. One study specified that the dizziness should be described as "unsteadiness",[25] while another required vertigo defined as an "erroneous impression of the movement of objects relative to the subject or the movement of the subject relative to his/her environment."

Neck stiffness or rigidity was not usually required for the diagnosis but mentioned in the inclusion criteria of three studies.[19,25] The same was the case with localized tenderness in the neck, which was mentioned in two studies.[19,25] Positive objective signs were usually not considered necessary, except for one study[25] that required "palpable upper cervical spine dysfunction" assessed by an experienced physiotherapist. Yahia et al.[22] included patients with cervical arthritis or minor intervertebral disorders on standard cervical X-ray imaging.

Symptom duration varied widely in the reviewed studies. Karlberg et al.[21] required a recent onset of neck pain and simultaneous complaints of dizziness or vertigo. This may be reasonable simply because the patients' memory of the temporal relationship between the two symptoms would be more reliable. Conversely, long symptom duration may increase the likelihood of other comorbidities entering the equation, eg, functional disorders or dysfunction related to psychosocial consequences of long-lasting disease. However, several authors had long-lasting symptoms as a criteria. Heikkila et al.[26] excluded patients with vertigo persisting for less than 3 months. Grande-Alonso et al.[20] required a duration of neck pain and dizziness for more than 3 months. Yahia et al.[22] specified chronic neck pain for more than 3 months, while Alund et al.[19] included patients with localized neck pain and stiffness for more than 1 year.

A specific time course and triggers of vestibular symptoms were not required for the diagnosis by most authors. Reid et al.[25] included patients with dizziness described as unsteadiness triggered by neck movement. Grande-Alonso et al.[20] required dizziness associated with pain, movement, rigidity, or certain neck positions.

It has been argued that the diagnosis of CD may be mainly of exclusive academic interest, since the treatment is often the same as for patients with cervical pain syndrome.[28] However, a correct diagnosis will always be clinically meaningful in guiding the treatment and in reassuring the patient that an explanation for their distressing symptoms has been found. Lastly, a conclusive diagnosis could save both the patients and the health care system from the consequences of unnecessary diagnostic and therapeutic procedures.

5 | LIMITATIONS

The review was limited to studies reported in English. Because of the low number, varying outcomes, and the low to moderate methodological quality of the included studies, pooling of the data was not possible, and firm conclusions as to the nature and clinical characteristics of CD cannot be made. The review reflects diagnostic criteria in studies that met the inclusion criteria and is not representative of all studies on CD. However, the inclusion criteria were not likely to exclude valuable clinical studies on CD, stating merely that included studies should contain operable diagnostic criteria as well as a comparison group. The inclusion of studies comparing patients with CD with healthy controls makes the review somewhat heterogenic. However, with the general lack of clinical studies on CD, we found that comparisons with healthy controls would also contribute to the limited knowledge within the area. The review provides an overview of the current understanding of CD as reflected by existing clinical studies. However, it may be considered a limitation that the studies in this review were published from 1993 to 2017, with half of them being more than 9 years old. This highlights the need for further studies within this field.

6 | CONCLUSIONS AND IMPLICATIONS

Studies comparing the clinical characteristics of patients with CD with other populations are few and of low to acceptable methodological quality. There is some evidence that patients with CD may have altered postural balance on platform posturography compared with patients with other diagnoses or healthy controls. Larger and more robust studies are needed to corroborate these findings and to establish the clinical syndrome of CD and whether it is indeed an independent and separate condition from other well-established ones. Diagnostic criteria differed between studies and were mostly based on the coexistence of neck pain with dizziness and the exclusion of other neurological and neuro-otological causes. Thus, the sensitivity and specificity of the criteria are likely to be low. As this review revealed significant differences in methodical and experimental approaches, this should be considered when designing future studies, making comparison between studies more feasible.

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CONFLICTS OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

Conceptualization: Mari Kalland Knapstad, Frederik Kragerud Goplen
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Writing—review and editing: Mari Kalland Knapstad, Frederik Kragerud Goplen, Stein Helge Glad Nordahl

All authors have read and approved the final version of the manuscript. Mari Kalland Knapstad had full access to all of the data in this study and takes complete responsibility for the integrity of the data and the accuracy of the data analysis.

TRANSPARENCY STATEMENT

The lead author (MKK) affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned have been explained.

DATA AVAILABILITY

The authors confirm that the data supporting the findings of this study are available within the article and/or its supplementary materials.

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The study was supported by the University of Bergen. The funder had no role in study design; collection, analysis, and interpretation of data; writing of the report; or the decision to submit the report for publication.

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SUPPORTING INFORMATION

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RESEARCH ARTICLE Open Access

Associations between pressure pain threshold in the neck and postural control in patients with dizziness or neck pain – a cross-sectional study

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Abstract

Background: It is theorized that neck pain may cause reduced postural control due to the known physiological connection between the receptors in the cervical spine and the vestibular system. The purpose of this study was to examine whether the pressure pain threshold in the neck is associated with postural sway in patients with dizziness or neck pain.

Methods: Consecutive patients with dizziness ($n = 243$) and neck pain ($n = 129$) were recruited from an otorhinolaryngological department and an outpatient spine clinic, respectively. All subjects underwent static posturography. Pressure pain thresholds were measured at four standardized points in the neck, and generalized pain was assessed using the American College of Rheumatology tender points. The relationship between postural sway and pressure pain threshold was analyzed by linear regression, and the covariates included age, sex, and generalized pain.

Results: In the dizzy group, there was a small, inverse relationship between pressure pain thresholds and sway area with eyes closed, after adjusting for age, sex, and generalized pain (bare platform; lower neck, $p = 0.002$, $R^2 = 0.068$; upper neck, $p = 0.038$, $R^2 = 0.047$; foam rubber mat; lower neck, $p = 0.014$, $R^2 = 0.085$). The same inverse relationship was found between pressure pain thresholds in the neck and the Romberg ratio on a bare platform after adjusting for age, sex and generalized pain (upper neck, $p = 0.15$, $R^2 = 0.053$; lower neck, $p = 0.002$, $R^2 = 0.069$). Neither of these relationships were present in the neck pain group.

Conclusion: Our findings indicate that the pressure pain threshold in the neck is associated with postural sway in patients suffering from dizziness after adjusting for age, sex, and generalized pain, but only with closed eyes. The association was small and should be interpreted with caution.

Trial registration: Trial registration: Clinicaltrial.gov NCT03531619. Retrospectively registered 22 May 2018.

Keywords: Posturography, Neck pain, Dizziness

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Background

Postural control is a complex system [1] and to maintain control, the body requires input from the vestibular, visual, and somatosensory systems. As part of the somatosensory system, the proprioceptive system in the cervical spine is vital for fine tuning orientation and balance [2]. This proprioceptive system consists of the deep cervical muscles, particularly the segmental muscles of the upper spine – with an abundance of muscle spindles – in addition to mechanoreceptors from joints and tendons. This system is important for both the stability and the mobility of the different regions in the neck. The cervical receptors provide afferent information to the central nervous system on the orientation of the head with respect to the rest of the body via modulation of vestibular and visual afferent information [3]. Integration of symmetrical afferent input from the cervical, vestibular, and visual systems in the vestibular nuclei complex is vital for normal head perception and postural control, and for providing responses resulting in precise motor commands to the eyes and body [3, 4]. Thus, it is theorized that an asymmetry or disturbance of inputs from cervical receptors might lead to a feeling of imbalance or dizziness [3, 4]. The mechanism by which reduced cervical proprioception might lead to sensory disturbances and reduced postural control is still uncertain and disputed, even though the confluence of vestibular and cervical afferents in the brain is well known [5]. It has, however, been proposed that pain, either as a primary or secondary event, may lead to altered sensitivity of the muscle spindles and mechanoreceptors due to ischemic or inflammatory events [6]. Further, pain may cause maladaptive strategies and change the neck muscle coordination and reduce the specificity of neck muscle activation, for instance, through reduced activation of the deep segmental muscles and increased activation of the superficial muscles [7]. Pain may also alter the cortical representation and modulation of the cervical afferent input [8]. The relationship between altered neck proprioception and pain has been found in healthy subjects receiving injections to induce neck pain [9], and animal studies have shown that local injections, nerve blockades, and dissection of neck muscle in the upper cervical region, lead to decreased balance, coordination, ataxia, and even nystagmus [10–12]. Lastly, both patients with chronic neck pain and whiplash-related disorders have been found to have reduced postural control [13], and the same has been found in patients with dizziness of suspected cervical origin [14–18]. The relationship has previously been mostly studied in patients with neck pain; however, it is not established whether the degree of neck pain is associated with the degree of postural control. It is also not known if neck pain influences postural control in dizzy patients as many patients with dizziness suffer from neck pain [19, 20]. Exploring this relationship in both patients with dizziness and patients with neck pain may provide information on how the degree of neck pain influences postural control in two patient groups known to have altered balance.

Self-reported pain intensity has been the most common approach to pain measurement. While self-reported pain is indeed important, it is mediated by biopsychosocial aspects [21] that can make it difficult to interpret. The pressure pain threshold (PPT) is a tool of both self-report but additionally a more objective technique [22] that is used to quantify mechanical pain sensitivity [23, 24]. It is defined as the minimal amount of pressure that first becomes on of pain [25].

The main aim of this study is to examine whether there is an association between PPT and postural sway in patients with dizziness and in patients with neck pain. As patients with pain syndromes, such as Fibromyalgia, have been shown to have reduced balance [26, 27] and patients rarely have isolated neck pain as it is usually a part of a wider pain pattern [28], we wanted to adjust for generalized pain. Finally, we wanted to examine the upper and lower regions of the cervical spine separately due to their differences in mechanical properties and distribution of mechanoreceptors.

Methods

Design and setting

We conducted a prospective cross-sectional study of consecutive outpatients examined at two clinical centers at a university hospital in Norway. The first center was an ear-nose-throat (ENT) clinic that receives referrals from general practitioners and specialists, both nationally and locally, concerning dizziness of suspected vestibular origin. The second center was an outpatient spine clinic that admits patients from primary care physicians concerning long-lasting musculoskeletal pain either causing or threatening to cause work disability.

Participants

During a one-year period (2017–2018), we included consecutive patients examined in both clinics. The recruitment is illustrated in Fig. 1. Patients with dizziness as their primary complaint ($n = 243$) were recruited from the ENT clinic. The ENT clinic also receives tertiary referrals nationally and is a quaternary referral center for vestibular schwannomas and for divers suffering from vestibular problems. As we wanted the study population to be representative of secondary referrals, persons having the latter conditions were not invited to participate (based on medical records) and only locally referred patients from western Norway were included. They were diagnosed by an otorhinolaryngologist, and the examination

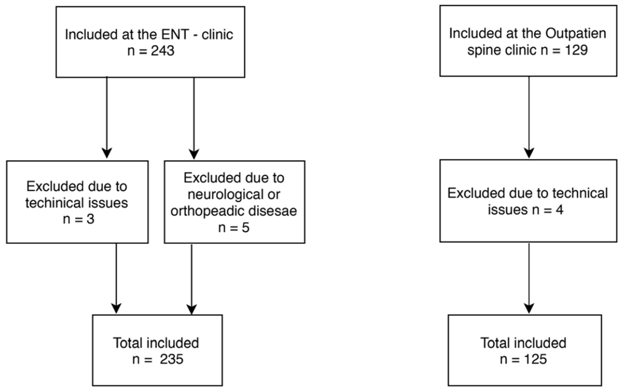

Fig. 1 Recruitment process

included pure-tone audiometry, dynamic posturography, videonystagmography with measurements of ocular smooth pursuit, saccades and bithermal caloric tests, a standard ENT examination including otomicroscopy, examination of cranial nerves and cerebellar function as well as clinical tests of postural sway, gait, and nystagmus. In addition, hospitalized patients with acute vertigo were also excluded.

Patients with long-lasting (> 3 months) neck pain (n = 129) as their primary complaint were recruited from the outpatient spine clinic where they were examined by a multidisciplinary team and diagnosed by a physician. In both groups, the participants had to be between 18 and 67 years old. Exclusion criteria included language barriers associated with filling in patient questionnaires and neurological or orthopedic disorders known to interfere with postural control (these were excluded prior to invitation to participate based on medical records). The project was approved by the Regional Committee for Health and Medical Research Ethics of South-Eastern Norway (REK 2017/783). The participants signed a written consent prior to testing.

Pressure pain threshold

Neck PPT were used to quantify the mechanical pain sensitivity of the cervical region using a pressure algometer. This threshold has previously been found to predict shoulder/neck pain [29] and to correlate with other measures of neck pain [30]. The PPT was measured in all subjects in the prone position by trained physiotherapists. A Wagner FDX-25 digital force gage (Wagner Instruments, Greenwich, CT) with a linear response of 0–1300 kilopascals (kPa) and a 1 cm^2 round rubber tip was used to apply pressure to the upper four standardized and defined American College of Rheumatology (ACR) tender points [31]: bilaterally suboccipital and 2 cm lateral to the spinous process of the axis (upper neck) and bilaterally at the anterior aspects of the intertransverse space at C5–C7 (lower neck). The algometer has been shown to be a reliable tool on these sites in dizzy patients with intraclass correlation values of 0.82–0.90 on intrarater reliability and 0.85–0.91 on test–retest reliability. The minimal detectable change showed values from 44.5 kPa – 86.1 kPa on intrarater reliability and 77.7 kPa – 88.2 kPa on test–retest reliability [30]. Prior to the study, the examiners practiced applying pressure at a rate of approximately 50 kPa/s. The digital force gage maintained its peak value, and the examiner was blinded to the display while applying pressure. The patient was told to immediately state when the pressure sensation changed into a pain sensation, at which time the pressure was stopped and the score was noted. A lower score indicated a greater degree of pain sensitivity. Three measurements were recorded at each site, starting on the left at the suboccipital site and ending on the right on the intertransverse space at C5–C6. As the last two measurements have been found to have the highest reliability [30], we used the mean of those measures for further analysis.

Generalized pain

Pressure testing at the 18 ACR tender points was used to measure the level of generalized pain. The test assesses nine defined points on each side of the body as illustrated in Wolfe et al. (1990) [31]. The tester gradually administered increasing pressure to each point, stopping at approximately 4 kg pressure. The patient was told to say "yes" if they experienced pain or "no" if they experienced only discomfort at each point after pressure was applied. The number of tender points (0–18) was used in further analysis.

Postural control

Postural control was evaluated by static posturography using a commercially available force platform (Synapsys, Marseille, France). The center of pressure under the feet was sampled at a rate of 100 Hz. The evaluated parameter was the sway area in mm^2 described by the center of pressure during each test lasting 2 × 20 s. The patients were instructed to stand quietly on the force platform with their arms hanging freely along their body and their feet aligned with markings corresponding to their foot size. To evaluate the different contributions of proprioceptive and visual inputs, the patients were tested under four different conditions: eyes open or eyes closed while standing on the bare platform and eyes open or closed while standing on a foam rubber mat placed on top of the platform. Additionally, as an indicator of the proprioceptive contribution to postural stability the Romberg ratio [32] was calculated as the sway area with eyes closed divided by the sway area with eyes open with and without the foam rubber on the platform. A higher ratio, and thus greater difference between eyes closed and eyes open, indicates greater proprioceptive deficit as they rely more on vision to maintain postural control.

Procedure sequence

A study nurse at each clinic recruited the patients the same day as their appointment at their respective clinic. Four experienced physiotherapists conducted subsequent testing on the day of their appointment. To ensure consistent examination techniques, the examiners had two practice sessions before the study and one more after 5 months. Before testing, the participants filled in medical chart data such as age, sex, and symptom characteristics. The examination was carried out in the following sequence: PPT, ACR tender points, and posturography. At the ENT clinic, the patients were examined before or after their physician appointment, and at the outpatient spine clinic the patients were tested as a part of the physiotherapy examination and after they were examined by a physician.

Statistical analysis

Linear regression was used to estimate the relationship between postural sway (sway area and Romberg ratio) and PPT after adjusting for age, sex, and generalized pain (number of ACR tender points). Sway area was used as the dependent variable and PPT as the predictor variable. Three regression models were generated, including the unadjusted model (Model 1), the age and sex-adjusted model (Model 2), and the age, sex, and generalized pain-adjusted model (Model 3). The alpha level was set to 0.05. Descriptive statistics included means and standard deviations for normally distributed data or median and interquartile range for skewed data. Categorical data were presented as percentages. The sample size was estimated based on recommendations by Green [33], which state that for a power of 0.8 the minimum sample size should be $104 + m$ where m is the number of predictors; thus, resulting in a sample size of at least 105 patients for each regression analysis. Sway area and Romberg ratio were positively skewed and were logarithmically transformed prior to regression analysis. PPT in the upper and lower neck was highly correlated and thus assessed in separate analyses to avoid multicollinearity. To facilitate interpretation of the coefficients, they were back transformed after analysis. Statistical analysis was performed using Stata® version 15 (StataCorp, Texas, USA).

Results

This study included 243 patients from the ENT clinic with dizziness and 129 patients from the spine clinic with neck pain. Due to technical issues, three patients from the ENT clinic and four patients from the spine clinic had to be excluded because of missing posturography data. In addition, five patients from the ENT clinic were excluded due to neurological or orthopedic disorders that were not uncovered prior to participation in the study. Diagnoses of the different populations are shown in Additional file 1: Table S1. In the neck pain group, only 17% (21 patients) reported a neck injury as the trigger for their neck pain. Descriptive statistics are given in Table 1.

PPT was not significantly associated with postural sway with eyes open with or without the foam mat in any of the groups. After adjusting for age, sex, and generalized pain, there was an inverse relationship between PPT and sway area in both the eyes closed conditions (with and without foam) in the lower neck in the dizziness group. An increase of 10 kPa was associated with a 3.1% reduction of sway in the eyes closed condition (95% confidence interval [CI], − 5.0 to − 1.1%, $p = 0.002$) and a 1.8% reduction of sway in the eyes closed on foam condition (95% confidence interval [CI], − 3.3 to − 0.4%, $p = 0.014$). In the upper neck, there was an inverse relationship between PPT and sway area in the third model, when standing with eyes closed on bare platform and an increase of 10 kPa was associated with a 1.6% reduction of sway in the eyes closed condition (95% confidence interval [CI], − 3.1 to − 0.1%, $p = 0.038$). In the patients with neck pain, PPT was not associated with postural sway in any of the models (Table 2).

Regression analysis adjusted for age, sex, and generalized pain found an inverse relationship between PPT and Romberg ratio in both the upper and lower neck on the bare platform in the dizziness group. A 10 kPa increase in PPT in the upper neck was associated with a 1.1% decrease in Romberg ratio (95% confidence interval [CI], − 2.0 to − 0.2%, $p = 0.015$) and a 1.8% decrease in PPT in the lower neck (95% confidence interval [CI], − 3.0 to − 0.7%, $p = 0.002$). On foam rubber, the PPT was only associated with the Romberg ratio in the age and

Table 1 Descriptive data on postural control, neck PPT, and generalized pain

Variable	Dizziness group (*n* = 235)	Neck pain group (*n* = 125)
Age	45.7 ± 12	41 ± 11
Sex (female) (%)	73.5%	79.2%
Duration dizziness, months[a]	12 (6–38)	
Duration neck pain, months[a]		14 (5–89)
Concurrent complaints (%)	53%	45%
Posturography[a], sway area, mm^2		
-Eyes open; bare platform	226 (148–419)	144 (93–212)
-Eyes closed; bare platform	403 (243–904)	213 (124–328)
-Eyes open; foam mat	544 (346–887)	277 (194–368)
-Eyes closed; foam mat	1662 (1019–2956)	639 (432–1028)
Romberg ratio[a,c]		
-Bare platform	1.85 (1.13–2.74)	1.49 (1.07–1.98)
-Foam mat	3.12 (2.19–4.39)	2.26 (1.71–3.14)
PPT, kPa[b]		
-Upper neck	216.7 ± 112.8	219.3 ± 115.8
-Lower neck	184.0 ± 86.4	192.8 ± 96.6
Generalized pain (ACR count)	9.2 ± 5.9	7.7 ± 4.9

[a]Reported as median and interquartile range, [b]Reported as mean and standard deviation, [c]Romberg ratio = sway area with eyes closed divided by sway area with eyes open. *PPT* Pressure pain threshold, *ACR* American College of Rheumatology tender points, *n* sample size. *Concurrent complaints* presence of both dizziness and neck pain the last 14 days

sex-adjusted model. No relationship was found in the neck pain group in either of the conditions (Table 3).

Discussion

This study found an inverse relationship between PPT in the neck, postural sway, and Romberg ratio. The effect of PPT on sway was small and the association was only present in the eyes closed conditions and only in patients examined at the ENT clinic for dizziness. The inverse relationship indicated that a higher PPT (lower pain sensitivity) was associated with better performance (lower sway area and lower Romberg ratio) on the platform, and thus, a lower PPT (higher pain sensitivity) was associated with worse performance (higher sway area and higher Romberg ratio). The associations tended to remain significant after adjustment for age, sex, and generalized pain.

Previous studies have demonstrated impairments of postural control in patients with assumed cervicogenic dizziness [14–18] and in neck pain patients [13]. However, these studies did not analyse the quantitative relationship between the degree of neck pain and postural control, nor did they adjust for generalized pain. Ruhe et al. (2013) found a linear relationship between the numeric pain rating scale and postural sway in patients with non-specific neck pain [34]. However, in theory, PPT might be a more objective surrogate measure of pain than a subjective rating because subjective measures may be more influenced by both physiological and psychosocial factors [35]. PPT cannot directly measure altered proprioception of the neck, but the theory is that pain in the neck region influences the afferent input, and previous studies have supported this [8, 36].

An association between postural sway and PPT was found in patients examined for dizziness at the ENT clinic. This is an interesting finding. Postural control relies on several sensory systems, and a deficit in one of these may be compensated for by the others. In the ENT clinic, approximately 50% were diagnosed with a vestibular problem. A possible explanation for our findings in this group may be that there was a synergistic interaction between neck pathology and vestibular deficit. Neck pain alone may not be sufficient to cause an association between neck pain and postural imbalance. However, 45% in the neck pain group reported dizziness. It may be speculated that dizziness in most of these patients was non-vestibular, possibly related to their neck pain.

After adjusting for age, sex, and generalized pain, the association with PPT in the neck was only present with eyes closed, i.e. when the patients were deprived of visual feedback. In the eyes closed condition, the central nervous system has to rely on accurate vestibular and somatosensory feedback, including important information about head-on-body position from proprioceptive afferents in the neck [37]. This is corroborated by the association between PPT and Romberg ratio. The Romberg ratio is considered to be an indication of visual dependency due to proprioceptive deficit [32], and we

Table 2 Linear regression analysis between the logarithm of sway area and neck PPT in persons with dizziness ($n = 234$) and in persons with neck pain ($n = 125$)

	PPT Upper Neck			PPT Lower Neck		
Groups	*B*(CI)	*p*	R^2	*B* (CI)	*p*	R^2
Eyes open						
Model 1: Unadjusted						
Neck Pain	−.0001 (−.0013 to .0010)	.815	.0004	−.0003 (−.0018 to .0011)	.637	.0020
Dizziness	−.0002 (−.0013 to .0007)	.569	.0014	−.0007 (−.0021 to .0005)	.258	.0055
Model 2: Adjusted for age and						
Neck Pain	−.0005 (−.0018 to .0008)	.5436	.0468	−.0007 (−.0023 to .0008)	.363	.0485
Dizziness	−.0007 (−.0018to .0003)	.181	.0318	−.0014 (−.0028 to <−.0001)	.047	.0409
Model 3: Adjusted for age, sex, and GP						
Neck Pain	−.0003 (−.0017 to .0010)	.625	.0495	−.0005 (−.0022 to .0012)	.548	.0504
Dizziness	−.0004(−.0016 to .0007)	.432	.0357	−.0011(−.0027 to .0093)	.124	.0431
Eyes open on foam						
Model 1: Unadjusted						
Neck Pain	<.0001(−.0009 to .0009)	.977	<.0001	<−.0001 (−.0012 to .0011)	.930	.0001
Dizziness	−.0002 (−.0013 to .0007)	.555	.0015	−.0001 (−.0013 to .0009)	.769	.0004
Model 2: Adjusted for age and sex						
Neck Pain	−.0001 (−.0012 to .0009)	.780	.0492	−.0002 (−.0014 to .0011)	.799	.0491
Dizziness	−.0006 (−.0016 to .0004)	.263	.0295	−.0012 (−.0026 to .0001)	.086	.0367
Model 3: Adjusted for age, sex, and GP						
Neck Pain	.0001 (−.0010 to .0012)	.838	.0602	.0002 (−.0011 to .0016)	.764	.0606
Dizziness	−.0003 (−.0015 to .0009)	.626	.0345	−.0009 (−.0024 to .0006)	.234	.0394
Eyes closed						
Model 1: Unadjusted						
Neck Pain	−.0003 (−.0017 to .0009)	.592	.0023	−.0004 (−.0021 to .0011)	.601	.0022
Dizziness	−.0015 (−.0027 to −.0002)	**.020**	.0230	−.0026 (−.0042 to −.0009)	**.002**	.0408
Model 2: Adjusted for age and sex						
Neck Pain	−.0005 (−.0019 to .0009)	.471	.0786	−.0004 (−.0021 to .0012)	.613	.0766
Dizziness	−.0018 (−.0032 to −.0004)	**.010**	.0460	−.0031 (−.0049 to −.0013)	**.001**	.0682
Model 3: Adjusted for age, sex, and GP						
Neck Pain	−.0004 (−.0019 to .0011)	.592	.0794	−.0002 (−.0021 to .0016)	.781	.0778
Dizziness	−.0016 (−.0031 to <−.0001)	**.038**	.0468	−.0031 (−.0050 to −.0011)	**.002**	.0681
Eyes closed on foam						
Model 1: Unadjusted						
Neck Pain	−.0001 (−.0012 to .0010)	.837	.0003	−.0002 (−.0015 to .0012)	.792	.0006
Dizziness	−.0008 (−.0017 to .0002)	.131	.0098	−.0014 (−.0027 to −.0002)	**.028**	.0206
Model 2: Adjusted for age and sex						
Neck Pain	−.0008 (−.0019 to .0004)	.190	.1254	−.0008 (−.0022 to .0006)	.243	.1228
Dizziness	−.0011 (−.0022 to −.0002)	**.024**	.0659	−.0021 (−.0034 to −.0008)	**.002**	.0837
Model 3: Adjusted for age, sex, and GP						
Neck Pain	−.0003 (−.0015 to .0009)	.638	.1517	−.0003 (−.0017 to .0014)	.841	.1504
Dizziness	−.0009 (−.0020 to .0003)	.134	.0700	−.0018 (−.0033 to −.0004)	**.014**	.0852

PPT Pressure pain threshold, R^2 explained R-squared, *p* *p*-value, *CI* confidence interval, *B* regression coefficient, *n* sample size, *GP* generalized pain (number of ACR tender points)
Figures in bold indicate significant *p*-value

Table 3 Linear regression analysis between the logarithm of the Romberg ratio and neck PPT in persons with dizziness ($n = 234$) and in patients with neck pain ($n = 125$)

	PPT Upper Neck			PPT Lower Neck		
Groups	*B* (CI)	*p*	R^2	*B* (CI)	*p*	R^2
Romberg ratio						
Model 1: Unadjusted						
Neck Pain	−.0002 (−.0011 to .0007)	.620	.0020	<−.0001 (−.0011 to .0009)	.881	.0002
Dizziness	−.0012 (−.0019 to −.0004)	**.002**	.0413	−.0018 (−.0029 to −.0009)	**<.001**	.0571
Model 2: Adjusted for age and sex						
Neck Pain	<−.0001 (−.0009 to .0009)	.989	.0423	.0002 (−.0009 to .0014)	.625	.0442
Dizziness	−.0010 (−.0018 to −.0002)	**.011**	.0519	−.0017 (−.0028 to −.0006)	**.002**	.0667
Model 3: adjusted for age, sex, and GP						
Neck Pain	<−.0001 (−.0011 to .0009)	.894	.0430	.0002 (−.0009 to .0014)	.625	.0442
Dizziness	−.0011 (−.0020 to −.0002)	**.015**	.0533	−.0018 (−.0030 to −.0007)	**.002**	.0687
Romberg ratio on foam						
Model 1: Unadjusted						
Neck Pain	−.0001 (−.0009 to .0007)	.749	.0008	−.0001 (−.0012 to .0008)	.795	.0006
Dizziness	−.0005(−.0011 to .0002)	.143	.0092	−.0007 (−.0015 to .0009)	.082	.0130
Model 2: Adjusted for age and sex						
Neck Pain	−.0006 (−.0015 to .0002)	.154	.0746	−.0006 (−.0016to .0004)	.207	.0712
Dizziness	−.0005 (−.0012 to <.0001)	.082	.0212	−.0009 (−.0017 to <−.0001)	**.039**	.0264
Model 3: Adjusted for age, sex, and GP						
Neck Pain	−.0004 (−.0013 to .0005)	.383	.0845	−.0003 (−.0014 to .0008)	.530	.0817
Dizziness	−.0005 (−.0013 to .0002)	.120	.0206	−.0009 (−.0018 to <.0001)	.057	.0258

PPT Pressure pain threshold, R^2 explained R-squared, *p* p-value, *CI* confidence interval, *B* regression coefficient, *n* sample size, *GP* generalized pain (number of ACR tender points)
Figures in bold indicate significant *p*-value

found that a reduction in the Romberg ratio (less sway difference between eyes closed and eyes open) was associated with an increase in PPT in both the upper and lower neck. Seemingly, patients with a higher PPT had a smaller ratio between the eyes closed and eyes open conditions. A possible interpretation of our findings is that a lower PPT in the neck is associated with less reliable cervical proprioceptive information and thus higher visual dependency, therefore causing increased sway in the eyes closed condition compared to the eyes open condition. Other sensory deficits could affect the ratio such as degree of vestibular dysfunction. However, such measures do not seem to associate well with postural control [38]. PPT was not associated with postural sway in the eyes open conditions either with or without the foam mat; however, standing steadiness with eyes open is quite robust in patients with vestibular disorders and in those with proprioceptive disorders [39]. Posturography with eyes closed when standing on foam rubber is considered mostly to rely on vestibular function because vision is eliminated and proprioceptive feedback from the feet is unreliable [39]. In this condition, the brain might choose not to rely on proprioceptive information from the neck as well as from the feet. The finding of a relationship between sway area and PPT in this condition, might indicate that neck proprioception still contributes to postural stability when standing on foam rubber. However, it is important to emphasize that PPT had a small explanatory power for both sway area and Romberg ratio, thus interpretation must be done with caution. The coefficients of the association were small with small changes in percentage of sway. Previous studies examining PPT in the neck area found a minimal detectable change ranging from 69 to 113 kPa [30, 40]. Larger differences in PPT would cause a larger percentage of sway. In addition, it is mostly assumed that dizziness with a suspected cervical origin rarely involves true vertigo and is often characterized with more vaguely described dizziness, such as a feeling of unsteadiness, disequilibrium, or light-headedness [4, 41]. In light of this, it is interesting to speculate whether the association found in this study, however small, might influence a patient's symptoms and a feeling of unsteadiness.

The relationship between sway area and PPT was most consistent in the lower neck. This was somewhat contradictory to the fact that the mechanoreceptors are more concentrated in the upper region of the cervical spine [3]. The PPT was lower in the lower neck region in both the dizziness group and neck pain group compared to the upper region. One explanation might be that the upper region is the most mobile part of the vertebral column, lack of motor control due to pain might cause the lower region of the cervical spine to compensate, and thus increase stiffness or pain sensitivity in the lower cervical spine. Additionally, it is important to note that the PPT was measured at standardized sites, and therefore perhaps not at the sites that patients perceived to be most painful.

This study has several limitations. First, the coefficients of the association were small with small changes in percentage of sway. In addition, the small explanatory power (R^2) shows that the PPT has small effects on sway. Although a small significant association was found, there is no consensus on normative values for the sway area; thus, making an interpretation of the importance of the percentage change difficult. However, the aim of this paper was merely to determine whether an association exists between PPT and sway area. The relationship between neck pain and reduced postural control is founded on basic research and experimental evidence showing that the activity of primary vestibular neurons is modulated by proprioceptive afferents in the neck [9–12, 42] making it a plausible explanation for our findings. The populations in this study were heterogeneous as we examined the associations in symptom complexes and not specific diagnoses. Persons with traumatic neck pain were underrepresented in the neck pain group. Even though reduced postural control has been linked to neck pain of non-traumatic origin, it might be more common in patients with traumatic origin of neck pain [13]. Patients referred to the clinics with vestibular schwannomas, diving related inner ear trauma, severe neurologic or orthopedic injuries or referred from other parts of the country were excluded based on the medical referral prior to their visit. However, we did not register how many patients were excluded prior to their visit based on referral information. Still, if any patient reported any severe neurological or orthopedic injury after inclusion, they were registered and excluded. Finally, to examine the same association in a control group would have enhanced this study. A strength of the study was the large sample size and the correction for generalized pain, emphasizing the cervical contribution to postural control. Moreover, the measurements of PPT and postural sway were objective and were performed on two unselected patient groups with dizziness and neck pain, i.e. the patients were not selected due to any a priori assumption of a causal link between their neck symptoms and dizziness.

Conclusion

This study found an inverse relationship between PPT and postural sway. The association was present with eyes closed in patients suffering from dizziness after adjustment for age, sex, and generalized pain (ACR tender points). In addition, the Romberg ratio was associated with PPT. However, altered postural control has a myriad of possible causes and the effect of PPT on sway was small and needs to be corroborated in future studies.

Supplementary information

Supplementary information accompanies this paper at https://doi.org/10.1186/s12891-019-2922-4.

Additional file 1: Table S1. Frequency of diagnosis of 231 patients referred to the ENT clinic and the 125 patients referred to the outpatient spine clinic.

Abbreviations

ACR: American College of Rheumatology; COP: center of pressure; PPT: pressure pain threshold

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Authors' contributions

MK conducted the statistical analysis, analyzed the results, and drafted the first version of the manuscript. MK, FG, TA, JS, and SN critically interpreted the data and edited the manuscript. All authors read and approved the final version of the manuscript.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The Regional Committee for Health and Medical Research Ethics Norway approved the study (REK 2017/783). The participants signed a written consent prior to testing. Study participation was voluntary with the option to withdraw/drop-out at any time.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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IV

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RESEARCH ARTICLE

WILEY

Neck pain associated with clinical symptoms in dizzy patients—A cross-sectional study

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Abstract

Objective: Many patients suffer from concurrent neck pain and dizziness. The aim of this study was to describe the clinical symptoms and physical findings in patients with concurrent neck pain and dizziness and to examine whether they differ from patients with dizziness alone.

Methods: Consecutive patients with dizziness and neck pain were recruited from an ear–nose–throat department and a spine clinic. They were divided into three groups: patients with dizziness only (n = 100), patients with dizziness as their primary complaint and additional neck pain (n = 138) and finally, patients with neck pain as their primary complaint accompanied by additional dizziness (n = 55). The patients filled in questionnaires regarding their symptom quality, time-course, triggers of dizziness and the Vertigo Symptom Scale Short Form. The physical examination included Cervical Range of Motion, American College of Rheumatology (ACR) Tender Points, Cervical Pressure Pain Thresholds and Global Physiotherapy Examination 52-Flexibility.

Results: Both neck pain groups were more likely to have a gradual onset of dizziness symptoms, more light-headedness, visual disturbances, autonomic/anxiety symptoms, decreased cervical range of motion, decreased neck and shoulder flexibility and increased number of ACR tender points compared with patients with dizziness alone. The group having dizziness as their primary complaint and also reporting neck pain had the highest symptom severity and tended to report rocking vertigo and increased neck tenderness. The group with neck pain as their primary complaint was more likely to report headache.

Conclusion: Neck pain is associated with certain dizziness characteristics, increased severity of dizziness and increased physical impairment when compared with dizzy patients without neck pain.

KEYWORDS
dizziness, musculoskeletal system, neck pain, population characteristics

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1 | INTRODUCTION

Dizziness and neck pain are both common complaints with negative impact on work productivity and use of health-care resources (Benecke, Agus, Kuessner, Goodall, & Strupp, 2013; Hurwitz, Randhawa, Yu, Cote, & Haldeman, 2018; Neuhauser et al., 2008). Previous studies have shown that concurrent dizziness and neck pain are common in both patients with dizziness (Iglebekk, Tjell, & Borenstein, 2013; Wilhelmsen, Ljunggren, Goplen, Eide, & Nordahl, 2009) and patients with neck pain (Humphreys, Bolton, Peterson, & Wood, 2002) as their presenting complaint. Dizziness is a complex symptom, and in the absence of other diagnosis or explanations, concurrent neck pain is sometimes suspected to play a role. Anatomically and physiologically, the vestibular and cervical proprioceptive systems are closely linked (Kristjansson & Treleaven, 2009). However, the clinical interrelations between dizziness and neck pain have yet to be established.

Patients with long-lasting dizziness have been shown to have physical impairments (Kvale, Wilhelmsen, & Fiske, 2008), and neck pain has been found to be an independent predictor of long-term dizziness (Wilhelmsen, Ljunggren, Goplen, Eide, & Nordahl, 2009). In theory, pain may lead to a disruption or alteration in the cervical afferent information, causing a sensory mismatch, resulting in a sensation of dizziness (Brandt & Bronstein, 2001; Kristjansson & Treleaven, 2009). Still, the concept of so called cervicogenic dizziness or vertigo is controversial (Magnusson & Malmstrom, 2016) as there is no international consensus on diagnostic criteria, and symptoms of patients with both dizziness and neck pain often resemble or overlap with other entities (Yacovino & Hain, 2013). Cervical dizziness is commonly reported as a more vague clinical picture than peripheral vestibular disorders, which at least in the acute phase can be recognized by a combination of spinning vertigo with nausea, vomiting, nystagmus and lateropulsion (Brandt, Dieterich, & Strupp, 2013; Devaraja, 2018; Yacovino & Hain, 2013). Considering the close physiological connections between the vestibular and cervical proprioceptive systems, it is likely that neck pain could modify the clinical picture in patients with dizziness. To the authors' knowledge, no previous studies have examined how neck pain associates with clinical symptoms and physical findings in dizzy patients. The aim of this explorative study was to describe the clinical symptoms and physical findings in patients with concurrent neck pain and dizziness and to examine whether they differ from patients having dizziness alone.

2 | METHODS

2.1 | Design and setting

We conducted a prospective cross-sectional study comparing of outpatients examined at two clinics at a university hospital. Patients with persistent dizziness were included consecutively from an ear–nose–throat (ENT) department that receives patients with dizziness of suspected vestibular origin referred by general practitioners and specialists. Patients with persistent neck pain were included from an outpatient spine clinic that admits patients with long-lasting musculoskeletal pain either causing or threatening to cause work disability. The neck-pain patients were also referred by general practitioners and specialists.

The study was given advance approval by the Regional Committee for Medical and Health Research Ethics of South-Eastern Norway (2017/783). Participation was based on written informed consent.

2.2 | Subjects

Consecutive patients with persistent dizziness or neck pain at the two clinics were included over a 1-year period. At the ENT-clinic, acute hospitalized patients were thus excluded. The secondary complaint, whether dizziness or neck pain, had to have been present over the last 14 days. The participants had to be between 18 and 67 years old. Patients with language barriers to filling in the questionnaires were excluded. As this study was part of a larger project, examining balance, patients with orthopaedic or neurologic diseases known to affect balance, such as stroke, peripheral neuropathy, hip or knee replacement or severe rheumatic disorders, were excluded. As the ENT clinic is a quaternary referral centre for patients with diving-related inner ear disorders and vestibular schwannomas, these conditions were excluded for the purpose of precluding bias. The patients were divided into three groups. The dizzy subjects at the ENT-clinic were divided into dizzy patients with complaints of neck pain (DN) over the last 14 days and patients with dizziness only (DO) and no neck complaints. The third group consisted of consecutive patients from the outpatient spine clinic whose primary complaint was neck pain, but who also reported complaints of dizziness (ND) over the last 14 days.

A total of 47 healthy controls were included and recruited among the hospital staff for the physical tests. They had to be between 18 and 67 years old, without neck pain and not suffer from any known vestibular pathology, orthopaedic or neurological diseases affecting balance during the previous three months.

2.3 | Data collection

2.3.1 | Questionnaires

The questionnaires collected data regarding the onset of dizziness, triggering events, time-course, type of dizziness, accompanying symptoms, age and gender. We assessed the severity of dizziness symptoms using a validated Norwegian version of the Vertigo Symptom Scale-Short form (VSSsf). The VSSsf has two subscales, with eight items relating to vertigo balance (VSSsf-V) and seven items relating to autonomic-anxiety symptoms (VSSsf-A). The main score ranges from 0 to 60, and a higher score indicates a more severe problem (Wilhelmsen, Strand, Nordahl, Eide, & Ljunggren, 2008).

2.3.2 | Physical tests

Cervical active range of motion was measured using a cervical range-of-motion device (CROM 3, Performance Attainment Associates, USA). The patients sat at an angle of 90° in both hip and knees and with their feet resting on the floor without leaning against the back of the chair. The CROM 3 was placed on the top of the head, and the patients were asked to move their head as far as possible within the limits of pain in the six cervical motions: flexion, extension, right and left lateral flexion and right and left rotation. Two trials of all motions were performed. For each trial all six motions were measured once, and the mean values of the trials were used in the analysis.

Neck pressure pain thresholds (PPTs) were measured in all subjects in the prone position. A Wagner FDX-25 digital force gage (Wagner Instruments, Greenwich, CT) with a linear response between 0 and 1,300 kPa and a 1 cm^2 round rubber tip was used to apply pressure to the upper four standardized and defined ACR tender points (Wolfe et al., 1990): bilaterally suboccipital, 2 cm lateral to the spinous process of the axis (upper neck) and bilaterally at the anterior aspects of the intertransverse space at C5–C7 (lower neck). The patient was instructed to immediately signal when the pressure sensation changed from no pain to a pain sensation, and the score was noted. A lower score indicates a lower tolerance of pain. Three measurements were recorded at each site, starting left at the suboccipital site and ending right on the intertransverse space at C5–C6. Because the last two measurements have been found to have the highest reliability (Knapstad et al., 2018), we used the mean of those measures in further analysis.

Last, we conducted two tests of global physical function. The American College of Rheumatology's (ACR) nine bilateral tender points (Wolfe et al., 1990) were used to assess the level of generalized pain. The tester provided a gradually increasing pressure stopping at approximately 4 kg. The patient was told to say "yes" if they experienced pain or "no" if they experienced only discomfort at each point after pressure was applied. The pressured was applied one time for each of the different points.

Flexibility is one of the subscales of the Global physiotherapy Examination-52 (GPE-52) that reflects the flexibility of the spine as well as the ability to relax. This subscale has proven to be able to differentiate healthy participants from patients with generalized and localized pain (Kvale, Ljunggren, & Johnsen, 2003).

2.4 | Procedure sequence

A study nurse at both centres recruited the patients on the same day as they appeared for their appointment at the clinic. Patients filled in the questionnaires prior to the physical tests. The tests were performed by experienced physiotherapists who were familiar with the tests. Prior to the study, the examiners had two sessions and then an additional session after 5 months for calibration of the different tests to ensure consistency.

2.5 | Statistical analysis

Categorical variables were reported as frequency and percentages and the continuous variables as mean and standard deviation. Chi-square tests (X^2) were used for the initial examination of variables (binary) independently associated with the different groups. Fisher exact was used when expected cell count was <5. The analysis was supplemented with Cramer's *V* test as a measure of strength of association. Additionally, follow-up comparison between groups of the independent variables was conducted with a univariate logistic regression with groups as the dependent variable. Differences between physical tests, the VSSsf and the different groups were examined with simple and multiple multinomial logistic regression where the DO group was used as reference category. Age and sex were used as adjustment variables as they are known to influence physical function. The alpha level was set to 0.05. A total of 14 patients did not fill out the survey due to lack of time on the day of inclusion. In the surveys, missing variables were <10%. Missing data were found to be Missing Completely at Random (Little's test, $p > 0.05$) and thus deleted listwise prior to analysis. Analyses were conducted in Stata14, StataCorp. 2015. *Stata Statistical Software: Release 14*. College Station, TX: StataCorp LP.

3 | RESULTS

The study included 100 patients in the DO group and 138 patients in the DN group, from both the ENT department, and 55 patients in the ND group from the outpatient spine clinic and 47 healthy controls. Descriptive statistics are reported in Table 1.

3.1 | Dizziness characteristics

Table 2 shows the comparison of dizziness characteristics between the three patient groups (DO, DN and ND). Characteristics of onset, duration and type of dizziness, as well as accompanying symptoms, discriminated between the three groups (Table 3).

Table 3 shows that both neck pain groups were more likely to have a gradual onset of dizziness, dizziness resembling presyncope/light-headedness and visual disturbances compared with the DO group. The ND group was more likely to report headache and less likely to report spinning dizziness, vomiting and having a constant dizziness, compared with the two other groups. The DN group differed from the DO group in being more likely to report a rocking sensation.

Figure 1 displays the differences between VSSsf total score and the two subscores (vertigo balance and autonomic anxiety) between groups.

Using multinomial logistic regression with DO as the reference group, we found a significant association between a higher VSSsf total score (OR: 1.03, 95% CI: 1.00–1.06, $p = 0.034$) and the DN group but not to the ND group (OR: 0.98, 95% CI: 0.95–1.02 $p = 0.559$). In the vertigo-balance subscore, a lower score was associated with the ND group (OR: 0.90, 95% CI: 0.84–0.96, $p = 0.003$) but no association

TABLE 1 Descriptive statistics of the three groups with dizziness, examined at two outpatient clinics and in a group of healthy controls

Groups Variables	DO (*n* = 100)	DN (*n* = 138)	ND (*n* = 55)	Controls (*n* = 47)
Age	45.5 (11.9)	45.7 (12.4)	42.5 (11.8)	40.5 (13.7)
Gender (female)	64.0%	80.3%	83.6%	65.9%
Diabetes[a,b]	3.0%	2.9%	2.9%	2.3%
Heart disease[a,b]	2.9%	0.7%	1.8%	2.1%
Hypertension[a,b]	8.9%	14.7%	10.7%	8.5%
Migraine[a,b]	11.9%	22.8%	14.3%	2.1%
Previous neck injury[a]		10.2%	18.2%	
GPE 52-flex	4.4 (SD 1.8)	4.8 (SD 1.7)	5.4 (SD 1.6)	3.5 (SD 1.8)
ACR	5.9 (SD 5.4)	11.6 (SD 5.2)	8.6 (SD 5.0)	5.2 (SD 5.7)
PPT UN	25.6 (12.9)	19.0 (SD 9.1)	21.4 (SD 12.2)	27.7 (SD 8.6)
PPT LN	21.2 (10.0)	16.6 (SD 7.1)	18.3 (SD 9.8)	25.7 (SD 7.6)
VSSsf total	13.4 (SD 9.9)	16.3 (SD 10.3)	12.5 (SD 7.2)	
VSSsf-A	4.9 (SD 4.3)	7.4 (SD 5.4)	7.1 (SD 4.2)	
VSSsf-V	8.5 (SD 6.7)	8.9 (SD 6.2)	5.4 (SD 4.5)	

Abbreviations: DO: dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN: dizzy patients with neck pain, examined at an ENT Outpatient clinic; ND: neck pain with dizziness from an outpatient spine clinic; GPE 52-flex: global physiotherapy examination 52-flexibility sum score; CROM: Total Cervical Range of Motion; ACR: American College of Rheumatology tender points; PPT, pressure pain threshold; UN: upper neck; LN, lower neck; VSSsf total: Vertigo Symptom Scale short form total score; VSSsf-A: Vertigo Symptom Scale short form Autonomic-Anxiety sub score; VSSsf-V: Vertigo Symptom Scale short form Vertigo-Balance sub score.

[a]Self-reported.

[b]Previously diagnosed by a medical doctor.

was found with the DN group (OR: 1.01, 05% CI: 0.96–1.05, $p = 0.623$). Last, a higher autonomic-anxiety subscore was significantly associated with both neck pain groups, DN (OR: 1.12, 95% CI: 1.05–1.19, p = <0.001) and ND (OR: 1.11, 95% CI: 1.03–1.19, $p = 0.006$).

3.2 | Physical findings

Scores of physical characteristics between groups are illustrated in Figure 2.

In the adjusted multinomial logistic regression (Table 4), we found that a lower total CROM, a higher ACR-tender point count and higher GPE-flexibility score associated significantly with both neck pain groups. A decrease in PPT in both upper and lower regions of the neck discriminated the DN from the DO group. The control group discriminated from DO with significantly with higher CROM, higher PPT in the lower neck and a lower score on the GPE 52-flexibility.

4 | DISCUSSION

This exploratory study found several associations between the presence of neck pain and clinical characteristics in patients with dizziness.

In the diagnosis of dizzy patients, the description of dizziness, although sometimes unclear and overlapping (Newman-Toker et al., 2007), is thought to be of importance. The semicircular canals are constructed for precise and rapid detection of head rotations (Halterman, 2005; Schubert & Shephard, 2014) and thus, a deficit or damage to this system often manifests as a strong sense of spinning, which is often of acute onset (Magnusson & Karlberg, 2002). Contrary to this, dizziness of cervical origin is usually thought to manifest itself as an unpleasant or vague feeling of dizziness without a strong sense of rotation (Thompson-Harvey & Hain, 2019). However, there is a lack of clinical studies reporting descriptions of dizziness of suspected cervical origin. Patients with cervicogenic dizziness seem to report a feeling of drunkenness/light-headedness more often than patients with benign paroxysmal positional vertigo (L'Heureux-Lebeau, Godbout, Berbiche, & Saliba, 2014), and less likely to report spinning vertigo than patients with benign paroxysmal positional vertigo and other vestibular disorders (L'Heureux-Lebeau, Godbout, Berbiche, & Saliba, 2014; Thompson-Harvey & Hain, 2019). Interestingly, this study found that both neck pain groups were more likely to report light-headedness, which has been suggested to be related to neck-related dizziness (Devaraja, 2018; Wrisley, Sparto, Whitney, & Furman, 2000). Patients in the DN group were more likely to report a rocking sensation. A rocking or floating sensation, although describing illusory movement, has previously been associated with chronic types of dizziness (Fife & Kalra, 2015; Iglebekk, Tjell, & Borenstein, 2013) rather than ongoing vestibular dysfunction. Patients in the ND group were less likely to report a spinning type of dizziness, compared with those in the DO group. Furthermore, both groups with neck pain were more likely to report a gradual onset of dizziness. As neck pain is often of long duration (>3 months; Hurwitz, Randhawa, Yu, Côté, & Haldeman, 2018), a gradual onset of dizziness could be due to an accumulation of cervical sensory disturbances over time. Both neck pain groups described visual disturbances as an accompanying symptom. Possibly, neck disorders leading to pain might be associated with disturbances of cervical proprioception causing a mismatch between the vestibular-ocular and cervical-ocular reflexes, that usually work in conjunction to stabilize gaze (de Vries et al., 2016). In the ND group, more than 70% of the patients reported headache. A previous study found a higher prevalence of headache in chronic neck pain patients with dizziness than in those with neck pain only (Yahia et al., 2009). Additionally, headache has previously been suggested to be related to dizziness of

TABLE 2 Comparison of dizziness-related characteristics between three groups of dizzy patients with and without neck pain examined at two outpatient clinics

Groups	DO		DN		ND		X^2	*Cramer's V*	*p*
Variables	n	%	n	%	n	%			
Onset									
Acute	66	70.2	66	55.0	16	30.2	21.91	0.29	<0.001*
Gradual	26	27.6	58	48.3	34	64.2	19.80	0.27	<0.001*
Triggering event									
Head movement	12	12.9	22	17.9	8	15.1	1.01	0.06	0.603
Stress	18	19.4	27	22.1	18	34.0	4.24	0.13	0.120
Head injury[a]	0	0	4	3.4	3	5.7		0.13	0.100
Infectious disease[a]	3	3.23	5	4.1	0	0		0.09	0.466
No apparent cause	54	58.1	63	52.9	23	43.4	2.92	0.10	0.233
Time course									
Short attacks (seconds)	27	29.0	28	22.8	20	27.8	4.22	0.13	0.121
Long attacks (>20 min)	14	15.0	30	24.4	7	13.21	4.42	0.13	0.109
Constant	25	26.9	29	23.8	2	3.8	12.03	0.21	0.002*
Type of dizziness									
Spinning	57	61.3	68	55.3	16	30.2	13.83	0.23	0.001*
Rocking	33	35.5	67	55.5	21	39.6	8.48	0.18	0.014*
Unsteadiness	45	48.4	72	58.5	24	45.3	3.54	0.11	0.171
Presyncope/light-headedness	5	13.8	25	20.3	10	18.9	10.18	0.19	0.006*
Other	18	19.4	20	16.3	12	22.64	1.05	0.06	0.591
Accompanying symptoms									
Nausea	56	60.2	74	60.2	27	50.9	1.49	0.07	0.473
Headache	27	29.0	48	39.0	41	77.4	33.69	0.35	<0.001*
Light sensitivity	20	21.4	36	29.3	17	32	2.29	0.09	0.319
Tinnitus	26	28.3	49	39.8	17	32.1	3.25	0.11	0.194
Vomiting	16	17.4	19	15.5	1	7.1	7.74	0.17	0.021*
Visual disturbance	5	5.5	20	16.8	36	13.7	8.39	0.18	0.015*
Sound sensitivity	17	18.5	27	21.9	16	30.2	2.67	0.10	0.262

Abbreviations: DO: dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN: dizzy patients with neck pain, examined at an ENT Outpatient clinic; ND: neck pain with dizziness from an Outpatient spine clinic; X^2: Chi-square statistics (3 × 2); *p*: *p*-value; *n*: number of positive (yes) responses.
[a]Fisher exact test.
[*]Statistically significant with *p*-value <0.05.

cervical origin (Reiley, Vickory, Funderburg, Cesario, & Clendaniel, 2017; Wrisley, Sparto, Whitney, & Furman, 2000). With more than 70% of the ND patients reporting headache, it is possible that some of these met the criteria for vestibular migraine. Further, 14.3% in the ND group and 23% in the DN group reported having migraine. Migraine is an important cause of both dizziness and headache. Whether it could also be responsible for some of the cases of neck pain would make an interesting topic for further study.

Both groups with neck pain scored higher on the autonomic/anxiety subscale of the VSSsf compared the DO group, suggesting an increased prevalence of these symptoms when neck pain is present. This is of particular interest because anxiety has been found to be a predictor for disability (Mahoney, Edelman, & Cremer, 2013). The DN group reported the highest total score on VSSsf, indicating the highest symptom severity among the three groups. Pain could perhaps work as an exacerbator for dizziness as it may alter cervical proprioception (Thompson-Harvey & Hain, 2019) even when the neck disorder is secondary to the dizziness.

Studies have found patients with dizziness to have physical impairments (Iglebekk, Tjell, & Borenstein, 2013; Kvale, Wilhelmsen, & Fiske, 2008). Our study showed that patients in the DO group had increased physical impairment, including decreased CROM, neck and shoulder flexibility and a lower PPT in the neck, compared with healthy controls, indicating that patients with only dizziness (and not

TABLE 3 Univariate logistic regression of dizziness characteristics between groups

Groups Variables	DN vs DO			ND vs DO			ND vs DN		
	OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Onset									
Acute onset	0.51	0.29–0.92	0.024*	0.18	0.08–0.38	<0.001*	0.35	0.17–0.70	0.003*
Gradual onset	2.44	1.37–4-35	0.002*	4.68	2.27–9.62	<0.001*	1.91	0.98–3.72	0.056
Time course									
Constant	0.84	0.45–1.57	0.602	0.10	0.02–0.47	0.003*	0.12	0.02–0.54	0.006*
Type of dizziness									
Spinning	0.78	0.45–1.35	0.376	0.27	0.13–0.56	<0.001*	0.35	0.17–0.69	0.003*
Rocking	2.17	1.25–3.78	0.006*	1.19	0.59–2.39	0.619	0.54	0.28–1.05	0.072
Presyncope/Light-headedness	4.48	1.64–12.23	0.003*	4.09	1.31–12.71	0.015*	0.91	0.40–2.06	0.824
Accompanying Symptoms									
Headache	1.56	0.88–2.78	0.128	8.35	3.81–18.28	<0.001*	5.33	2.55–11.17	<0.001*
Vomiting	0.86	0.42–1.80	0.703	0.09	0.01–0.71	0.022*	0.10	0.01–0.80	0.030*
Visual disturbance	3.47	1.25–9.65	0.017*	4.50	1.47–13.80	0.008*	1.29	0.57–2.94	0.535

Abbreviations: DO, dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN, dizzy patients with neck pain, examined at an ENT outpatient clinic; ND, neck pain with dizziness from an outpatient spine clinic; OR, Odds Ratio; CI, Confidence Intervals.
*Statistically significant with p-value <0.05.

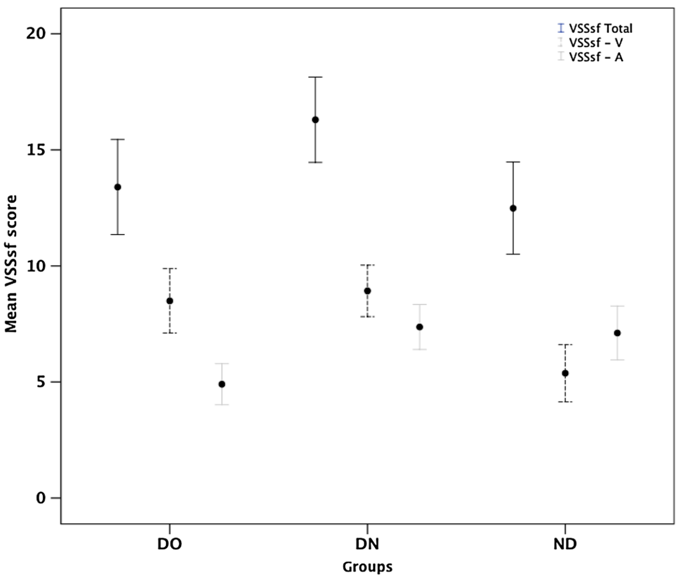

FIGURE 1 Differences between groups with error bars (95% Confidence Intervals) of the Vertigo Symptom Scale short-form (VSSsf Total), with sub-score Vertigo-Balance (VSSsf-V) and Autonomic-Anxiety (VSSsf-A). DO: dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN: dizzy patients with neck pain, examined at an ENT Outpatient clinic; ND: neck pain with dizziness from an outpatient spine clinic

neck pain) have reduced physical function, which is usually explained by avoidance behaviour due to fear or anxiety of movement (Godemann, Schabowska, Naetebusch, Heinz, & Strohle, 2006; Lahmann et al., 2015). Both neck pain groups had increased physical impairment not only locally in the neck with reduced CROM but additionally with more generalized pain and reduced flexibility, thus suggesting that neck pain is associated with additional impairment for patients with dizziness. This may be due to increased avoidance behaviour and fear of head movements in patients with concurrent complaints. There was a trend for patients in the DN group to score highest on pain/sensitivity measures (PPT and ACR) and for the ND patients to score highest on the neck stiffness/flexibility measures (CROM and GPE-52 flexibility).

As there is a lack of clinical studies on dizziness of cervical origin, the present study was of an exploratory rather than confirmative nature. The association between different types of

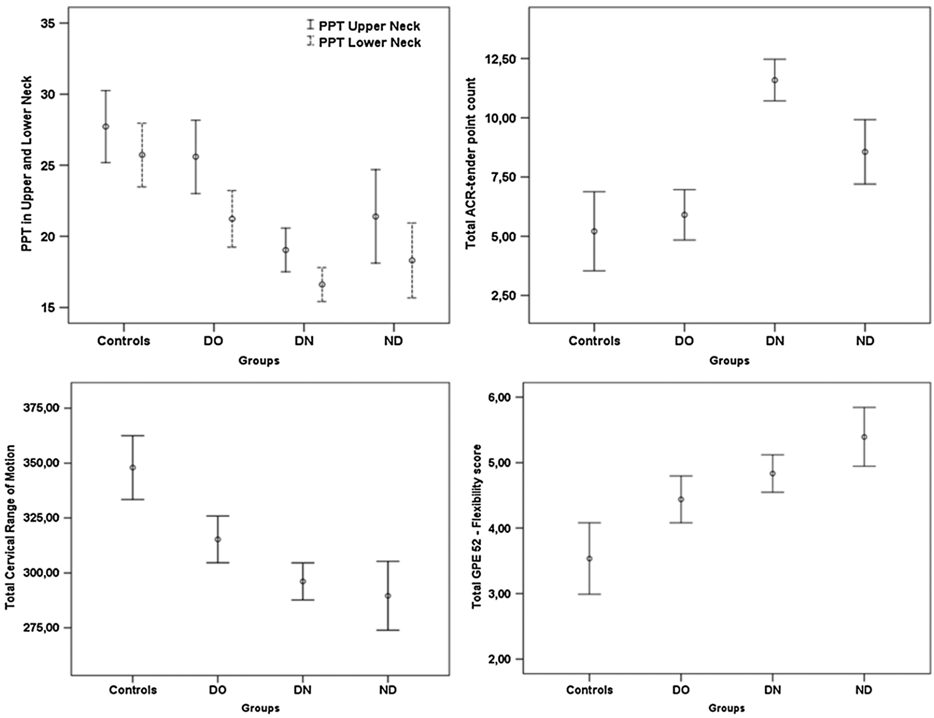

FIGURE 2 Error bars (95% confidence intervals) displaying differences between groups in physical tests. ACR: American college of rheumatology; GPE: Global physiotherapy examination; PPT: pressure pain threshold; DO: dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN: dizzy patients with neck pain, examined at an ENT outpatient clinic; ND: neck pain with dizziness from an outpatient spine clinic

dizziness and neck pain is interesting, because a previous study (Knapstad, Goplen, Skouen, Ask, & Nordahl, 2019) found neck pain to be evenly distributed across diagnoses of peripheral and non-vestibular origin. As previous debates have focused on the premises of whether or not cervicogenic dizziness is an actual condition, it is important to consider how neck pain could influence dizziness, regardless of the origin. The two neck pain groups had similarities when compared with the group without neck pain. This is an interesting finding because it implies that patients with neck pain and dizziness have similarities irrespective of which of the two symptoms is the primary complaint. To our knowledge, this is the first clinical study on the associations between neck pain and dizziness symptoms in a larger group of patients. Instead of trying to isolate patients with dizziness of cervical origin—which is difficult due to the lack of consensus on diagnostic criteria—the approach of this study was to explore the three study populations with a priori assumption, namely, that patients with cervicogenic dizziness would be overrepresented in the two groups of dizzy patients with neck pain and underrepresented in the DO group. This explorative approach has some limitations. The populations in this study were heterogeneous. However, we examined the associations between symptoms complexes and not specific diagnoses. In addition, cross-sectional trials cannot prove causality. The findings nevertheless indicate some important symptom complexes in patients with neck disorders and dizziness that should be explored further and particularly the long-term consequences of the two conditions in longitudinal clinical studies.

5 | IMPLICATION FOR PHYSIOTHERAPY PRACTICE

Neck pain and dizziness are associated with certain dizziness symptoms and physical characteristics. Furthermore, these findings imply that neck pain may influence both dizziness symptoms and physical function. As cervical dizziness is a controversial topic, the result of this study may be helpful and could be considered when physiotherapists examine patients with concurrent complaints. The results may contribute to future longitudinal intervention studies on neck pain and dizziness.

TABLE 4 Differences in physical characteristics between groups examined with multinomial logistic regression

Variables	Crude OR	Crude 95%CI	Crude *p*	Adjusted OR	Adjusted 95% CI	Adjusted *p*
Controls vs DO						
CROM	1.013	1.005–1.021	<0.001*	1.015	1.004–1.025	0.005*
ACR	0.973	0.907–0.043	0.449	0.974	0.904–1.049	0.490
GPE 52-flex	0.757	0.619–0.925	0.007*	0.783	0.624–0.983	0.035*
PPT UN	1.01	.098–1.04	0.334	1.02	0.99–1.06	0.083
PPT LN	1.04	1.01–1.08	0.013*	1.07	1.03–1.12	0.001*
DN vs DO						
CROM	0.992	0.987–0.997	0.005*	0.985	0.978–0.992	<0.001*
ACR	1.207	1.144–1.273	<0.001*	1.208	1.142–1.279	<0.001*
GPE 52-flex	1.148	0.990–1.330	0.067	1.273	1.078–1.505	0.005*
PPT UN	0.941	0.91–0.96	<0.001*	0.94	0.92–0.97	<0.001*
PPT LN	0.93	0.90–0.96	<0.001*	0.94	0.01–0.97	<0.001*
ND vs DO						
CROM	0.990	0.984–0.997	0.004*	0.979	0.971–0.988	<0.001*
ACR	1.099	1.034–1.167	0.002*	1.083	1.015–1.156	0.015*
GPE 52-flex	1.389	1.139–1.694	0.001*	1.688	1.346–2.116	<0.001*
PPT UN	0.96	0.93–0.99	0.032*	0.97	0.94–1.01	0.227
PPT LN	0.96	0.92–1.00	0.04*	0.97	0.94–1.02	0.331

Abbreviations: CROM: cervical range of motion; ACR: American College of Rheumatology - tender points; GPE 52: global physiotherapy examination-flexibility; PPT: pressure pain threshold; UN: upper neck; LN: lower neck; DO: dizzy only: Patients without neck pain examined at an ENT Outpatient clinic; DN: dizzy patients with neck pain, examined at an ENT outpatient clinic; ND: neck pain with dizziness from an outpatient spine clinic; OR: odds ratio; CI: confidence intervals.

*Statistically significant with *p*-value <0.05.

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