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The correlation between cervical proprioception and cranio-cervical flexion tests in patients with whiplash-associated disorders

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CHAPTER 1:

INTRODUCTION

The term whiplash was introduced in 1928 by the American orthopedist H.E Crowe (Rosenfeld, et al 2000) and is defined as an acceleration-deceleration mechanism of energy transfer to the neck, normally due to a motor vehicle accident (Jull et al 2004). A whiplash-type injury consists of a hyper-flexion phase, where the head is forced forwards followed by a hyper-extension phase forcing the head backwards (Twomey and Taylor 1993).

Whiplash injuries are a common occurrence especially on South Africa's roads where, according to the "arrive alive" campaign (www.arivealive.co.za) about one hundred people are injured every day. Common symptoms of whiplash-associated disorders include: neck pain, neck stiffness, headaches, shoulder pain, back pain and difficulties with concentration and memory. Dizziness, ringing in the ears, insomnia, depression and anxiety are also reported (Borchgrevink et al 1998). It is the researcher's opinion that early and effective physiotherapy intervention is recommended. Physiotherapeutic intervention strategies include pain relieving and rehabilitative techniques but additional treatment methods are important. An aspect of rehabilitation that has been neglected but is now gaining more attention is proprioception of the cervical spine (Loudon et al 1997).

Proprioception is an awareness of the movements and position of the limbs and other body parts (Meyer et al 1994). This awareness of movement and position is possible by means of receptors that are part of the sensory system. The sensory system is made up of neural pathways that transport the necessary sensorimotor information which modulates muscle function. Proprioceptors are found in muscles, ligaments,tendons and joints and when these structures are injured, muscle and joint mechanoreceptors are disrupted causing a reduced proprioceptive ability. Reduced proprioception could lead to the development of chronic symptoms because of the resulting impaired balance and decreased co-ordination, diminished joint position sense and altered reflexes when performing specific or general movements (Brukner and Khan 1993). The cervical spine proprioception will not necessarily improve just with the reduction of pain (Sterling et al 2003). New ideas regarding how to retrain cervical proprioception of the spine are

emerging, but they are not commonly implemented (Revel et al 1991; Loudon et al 1997).

Whiplash- associated disorders:

The cervical spine can sustain structural damage during a whiplash-type injury. Structures vulnerable to injury include the neural, soft tissue and articular systems (Twomey and Taylor 1993). The deep cervical flexors (longus colli, longus capitis and rectus capitis) are particularly vulnerable during the hyper-extension phase of a whiplash injury. Based on their morphological design, they provide support of the cervical lordosis and cervical joints aiding in stability (Falla et al 2003). They also help maintain a good neutral zone. A neutral zone is described as the small range of displacement around a vertebral segment's neutral position, where little resistance is offered by passive spinal restraints (Richardson and Jull 1995). When rehabilitating the cervical spine following a whiplash-type injury, the physiotherapist will include improving the recruitment ability of the deep cervical flexors in order to restore a functional neutral zone (Jull et al 2004).

The physiotherapy management strategy for whiplash-type injuries is extensive and includes a subjective and objective evaluation. During the objective evaluation, careful attention is paid to the injured structures. The soft tissues that are vulnerable to injury in the hyper-extension phase of whiplash are, among others, the deep cervical flexors. Rehabilitation of this muscle group is based on improving recruitment ability rather than increasing strength, as their role is one of stability rather than torque production of the cervical spine. The deep cervical flexors are more likely to be inhibited than to become weak, possibly due to pain (Falla et al 2003).

Recruitment training of the deep cervical flexors improves cervical posture and control (Jull et al 2002). The deep cervical flexor muscles are rich in muscle spindles and proprioceptors. It is therefore possible that there is a correlation between recruitment training of the deep cervical flexors and cervical proprioception. It has been shown that training involving components that may enhance proprioceptive ability, for example body awareness training and eye-head-coupling, can improve the ability to recruit the deep cervical flexors (Djupsjobacka 2003). These techniques, however, are not commonly known or applied (Loudon et al 1997). It is possible that by implementing the now standard, evidence-based practice of recruitment training of the deep cervical flexors,

one could influence cervical proprioception in some way through the very same training method (Sterling et al 2003).

PROBLEM STATEMENT:

Extensive research being conducted on patients suffering from whiplash-associated disorders highlights the importance of recruitment training of the deep cervical flexors for stability and improved posture (Jull et al 2002, Diener 2003, Falla et al 2003, Sterling et al 2003). Also emerging, is the importance of cervical proprioception and its effect on the development and/or prevention of chronic pain. Treatment methods to address this are also emerging. The question is whether a correlation exists between recruitment ability of the deep cervical flexors and cervical proprioception.

RESEARCH QUESTION:

Is there a correlation between cranio-cervical-flexion and cervical proprioception in patients suffering from whiplash-associated-disorders?

AIM:

It is the aim of this study to establish whether a correlation exists between cranio-cervical-flexion test and a cervical repositioning test in patients with whiplash-associated disorders.

SIGNIFICANCE:

This study highlights the importance of addressing cervical spine proprioception rehabilitation in the management plan of patients suffering from whiplash-associated disorders. It also suggests the possibility that the process of training the muscle recruitment of the deep cervical flexors would improve the cervical proprioception due to the nature of the rehabilitative technique.

OBJECTIVES:

1. To test the ability of subjects with whiplash-associated-disorders to perform the cranio-cervical-flexion test which tests the ability of the subject to recruit the cranio-cervical stabilising muscles/ deep neck flexors.

HYPOTHESIS:

There is a correlation between cranio-cervical flexion and cervical proprioceptive ability.

NUL-HYPOTHESIS:

There is no correlation between cranio-cervical flexion and cervical proprioceptive ability.

CHAPTER 2:

LITERATURE REVIEW:

2.1 Introduction:

Literature reveals that whiplash-associated-disorders are common and often difficult to treat (Loudon et al 1997). This challenge is due to the nature of the injury itself, which is complicated and multi-faceted and often combined with external factors such as litigation or psychological stress associated with being involved in a serious motor vehicle accident (Borchgrevink, 1998**)**. As a result of extensive research in the field of rehabilitation of whiplash-associated disorders, recruitment training of the deep cervical flexors has become standard physiotherapy practice (Jull et al 2002, Falla et al 2003). Research has shown that global strengthening of the cervical musculature does not address the imbalance that is often present between the two functional muscle groups (viz. the stabilisers and the movers) of the cervical spine (Falla et al 2003, Jull et al 2004). Training that emphasises the correct use of the deep stabilisers of the cervical spine before introducing strengthening of the global cervical spine musculature has shown to be more effective in the rehabilitation of the cervical spine (Falla et al 2003, Jull et al 2004).

Current research findings recognise cervical proprioception as playing a significant role in the treatment or prevention of chronic cervical pain following whiplash injuries (Sterling 2004). Following a whiplash-type injury, sensory receptors in the cervical spine are injured. These include muscle spindles in the intervertebral, anterior and posterior cervical spine musculature (Meiring et al 1993). Afferent input from the muscle spindles provides information about muscle length, tension and rate of change of muscle length (Loudon et al 1997).

Therapists are aware of the importance of proprioceptive training in peripheral joints and this type of rehabilitation is accepted physiotherapy practice (Brukner and Khan 1993). Proprioceptive training of the spine is a relatively new concept and more complex due to

the spine having numerous, complex joints (Loudon et al 1997). It is not clear from the literature what the link is, if any, between the recruitment training of the deep cervical flexors and cervical proprioception.

Reduced cervical proprioception may predispose the cervical spine to further injury and this could contribute to the development of degenerative joint disease of the spine through wear and tear of a joint with poor sensation. Decreased proprioception causes an altered ability of the cervical spine musculature to provide co-contractions for stabilisation which could lead to re-injury. The therapist must appreciate that the central nervous system can influence motor activities through joint proprioception. The joint proprioception aids the central nervous system to incorporate muscle control (Comerford and Mottram 2001, Heikkila and Astom 1996, Lephart and Missouri 1993, Loudon et al 1997,Sterling et al 2003).

2.2 The cranio-cervical-flexion test:

EMG measurement of the deep cervical flexors is difficult. The cranio-cervical-flexion test using the bio-feedback unit was designed as an indirect measurement of this muscle group. Extensive studies have been undertaken to show the reliability and validity of this test with the use of complicated EMG applications (Jull 1997, Jull et al 2002, Falla et al 2003, Falla et al 2004; Jull et al 2004, Sterling 2004). Falla et al (2003) conducted a study to investigate the effectiveness of the cranio-cervical-flexion test to demonstrate the recruitment ability of the deep cervical flexor muscles. The reliability of the electromyography measurements obtained from the deep cervical flexors was also assessed. They found that the technique of fine-wire EMG was difficult and invasive. This technique was also complicated by the fact that the electrodes were placed near delicate structures such as the trachea, carotid artery, vagus nerve and the lymphatics. Falla et al (2003) proposed a study that evaluated an EMG technique for the examination of the deep cervical flexors using specially designed suction catheters. These were placed on the posterior oropharyngeal wall using a nasopharyngeal application. The proximity of the deep cervical flexors to the posterior oropharyngeal wall provided a location to make recordings of the deep cervical flexor muscle activity via the mucosal wall. This ensured that the intramuscular recording techniques were not required. Test subjects included ten volunteers who consented to participate in the study. They were aged between twenty-one and fifty-three years of age. The subjects

had to be free of neck pain at the time of testing. They were to have no past history of orthopaedic or neurological disorders affecting the neck. Patients were also screened according to exclusion criteria that were based on the contraindications and precautions for the use of Xylocaine spray (local anesthetic) and for the use of the nasopharyngeal suctioning technique (Falla et al 2003). The test included application of the suction catheter through the nose to the posterior oropharyngeal wall. The patient was instructed to perform the cranio-cervical-flexion test that consisted of five incremental movements of increasing the cranio-cervical-flexion range of movement (that is nodding the head). Falla (2003) stated that although the activity of adjacent muscles may contribute to the signal, this was minimised by fixing the electrodes to the mucosa with suction pressure at the level of C2 -3 (uvula) which is the level at which the longus colli muscle has its greatest cross-sectional area. EMG recordings were also taken bilaterally from the sternal head of the sternocleidomastoid and anterior scalene muscles using disposable bipolar surface electrodes. Patients were asked to perform the five stages of the cranio-cervical-flexion test and at each stage of the test data collection commenced at the point when the subjects reached the pressure target. From this study, and others (Jull 1997, Jull et al 2002, Jull et al 2003, Falla et al 2004; Sterling 2004) it was concluded that the cranio-cervical-flexion test is a good, indirect measurement of the recruitment ability of the deep cervical flexors.

2.2.1 Rehabilitation of the deep cervical flexors:

Emphasis has been placed on the way in which physiotherapists need to rehabilitate the deep cervical flexors. Their role is one of stability. Rehabilitation needs therefore to focus on precision and correct use of the right muscles rather than strengthening of muscles. The term “recruitment of muscles” was coined following the current research trends (Jull et al 2004). Earlier models of exercise therapy included strength training of the global cervical musculature. This involved six to twelve repetitions of physiological neck movements (Berg and Berggren 1994) or “gentle, active, small range and amplitude rotational movements of the neck, first in one direction, then the other. Movements were repeated ten times in each direction every waking hour” (Rosenfeld et al 2000). Emphasis now is on accuracy and correct use of the stabilisers of the cervical spine rather than a general physiological movement which involves the use of the global musculature of the cervical spine. Falla et al (2004) used a cross-sectional study design to investigate muscle impairment in patients suffering from chronic neck pain. The study

aimed at comparing activity of the deep and superficial cervical flexor muscles and the cranio-cervical flexion range of motion during a cranio-cervical-flexion test. The study involved ten patients with chronic neck pain and ten patients as controls. The patients in the neck pain group had a history of chronic neck pain for longer than one year. Patients were excluded if they had either undergone cervical spine surgery, reported any neurological signs, had participated in a neck exercise program in the past twelve months or were undergoing treatment at the time of testing. Exclusion criteria for the control group included a history of back pain or orthopaedic disorders affecting the neck or a history of neurological disorders.

EMG recordings of the deep cervical flexor muscles were made unilaterally using bipolar electrodes. A suction catheter was inserted via the nose to the posterior oropharyngeal wall. The patients were asked to perform the cranio-cervical-flexion test. Patients in the control group showed a linear increase in deep cervical flexor EMG amplitude in relation to the flexion movement as did the pain patients but to a lesser degree than the control group. The study concluded that decreased performance of the cranio-cervical flexion test was related to impaired performance of the deep cervical flexor muscles. This study also highlighted the importance of the correct rehabilitation. Cervical flexors become dysfunctional due to neck pain. This is significant as deficits in muscle co-ordination results in poor support and overload on cervical structures which could lead to the development of chronic pain.

Jull (1997) conducted a study examining the interaction of several neck muscles. It was noted that if only the larger, more superficial muscles were stimulated, then regions of local instability resulted. This study determined that the deep cervical flexors had direct attachments that span the vertebrae causing them to have more influence on joint control rather than torque production. This implied a more postural role. The study supported the now accepted form of rehabilitation of the recruitment ability of the deep cervical flexors. This rehabilitation regime aimed at precision and control of the deeper stabilising muscles rather than a general strengthening program**.** Jull et al (2002) performed a randomised controlled trial of exercise and manipulative therapy for patients suffering from cervicogenic headaches (a symptom common in patients suffering from whiplash associated disorders). This study was conducted with unblinded treatment and blinded assessment of the outcomes (Jull et al 2002). The aim of their study was to

determine the effectiveness of manipulative therapy and a low-load exercise program when used alone and in combination as compared to a control group of normal subjects. Two hundred subjects aged between eighteen and sixty years participated in this trial. They were to have unilateral or unilateral dominant side-consistent headaches associated with neck pain and aggravated by neck postures or movement, joint tenderness in at least one of the upper three cervical joints and frequent headaches of at least one per week over a period of two months to ten years. Subjects were excluded if they had typical signs of tension or migraine type headaches or if they were unable to follow the prescribed treatment regime of the study. They were also excluded if they were involved in any litigation or workers compensation claims or if they had received any physiotherapy or chiropractic treatment within twelve months of the study. The subjects were randomised into four groups: manipulative therapy group, exercise therapy group, combined group and a control group. Their primary outcome was the frequency of headaches. The treatment period was six weeks with follow-up assessments after treatment, then at three, six and twelve months. It was found that at twelve month follow-up both manipulative therapy and specific exercise groups had significantly reduced headache frequency and intensity. This study described the importance of correct recruitment training of the deep cervical flexors and their role in maintaining cervical stability which aids in reduction of cervical symptoms. In their study, Jull et al (2002) emphasize the importance of recruitment training and use is made of the cranio-cervical-flexion test both as a measurement of the recruitment ability of the deep cervical flexors as well as a training aid.

2.3 The mechanism of a whiplash-type injury:

Twomey and Taylor (1993) describes a whiplash type injury as one of high speed and rapid velocity changes**.** This high velocity acceleration injury of hyper-flexion is followed by a hyper-extension movement resulting in predominantly soft tissue damage. In order to plan the rehabilitation required following whiplash injuries, one must have an understanding of the underlying pathology resulting from such trauma. Twomey and Taylor (1993) removed whole cervical spines as post-mortem from thirty-two subjects. Sixteen of the spines came from subjects who died as a result of the motor vehicle accidents while for the remainder trauma was not the cause of death. Two sectioning methods were used to examine clefts in the annulus fibrosus for vertebral end plate lesions, traumatic disc ruptures, facet injuries and for the presence of blood or bruising in

the discs or facet joints. This study revealed the following interesting pathological changes in the cervical spine following a whiplash injury. The initial movement of hyper-extension of the cranio-vertebral and cervico-thoracic joints results in injury to the cervical vertebral disc. This injury is in the form of disc tears, especially of the anterior fibres of the annulus fibrosis, and damage to the cartilaginous end plates of the disc. Ligaments vulnerable to injury are the alar, transverse and anterior longitudinal ligaments. Articular surfaces, neural tissue (including the cervical sympathetic trunk and ganglia as well as neuromeningeal tissue in the intervertebral foramen) and possibly the vertebrae itself are all at risk of injury (Twomey and Taylor 1993). During the hyper-extension phase, the pharynx and oesophagus are also easily injured. Vertebral arteries are vulnerable and in a side ways collision the brachial plexus is at risk of a traction type injury. The hyaline cartilage of the facet joints are at risk due to the compressive forces applied to them during this phase of injury. The second phase of injury involves cervical hyper-flexion. During this phase posterior structures including the deep cervical extensors are more at risk. The muscles tear resulting in spasm. This causes inhibition of the deep cervical flexors. Ligaments vulnerable to injury during this phase include the supraspinous, interspinous, ligamentum nuchae and the posterior longitudinal ligaments. Facet joint capsules and nervous tissue (meninges and nerve roots) are all at risk of damage (Twomey and Taylor 1993).

2.4 Muscle imbalances:

In his single case study investigating the dysfunction of the Longus Colli muscle and its relationship to cervical pain and dysfunction, Beazell (1998) found that the neck extensors and scalenes were tight with corresponding weak and poorly recruited deep neck flexors. Jull et al (2004) described progressive anterior-to-posterior muscle imbalance with the cervical flexors becoming relatively weaker as compared to the extensors. Sterling et al (2003) noted deficits in cervical proprioception acuity in patients suffering from whiplash associated disorders.The clinical image of patients suffering from whiplash- associated disorders is therefore one of reduced cervical stability due to muscle weakness and imbalance as well as reduced cervical proprioception.

Of particular risk are the sternocleidomastoid muscles which would attempt to prevent the hyper-extension phase (Jull et al 2004). These are phasic muscles so they react to pain by contracting, resulting in spasm. The scalenes are most vulnerable in a side ways

collision. It is clear that many structures are at risk of being injured during the whiplash-type injury. Structures at risk need to be examined and necessary intervention planned accordingly.

2.5 The stages of healing:

It is important for the physiotherapist to remember that the necessary healing could be extensive. One has to consider the stage of healing of those structures when planning treatments as this could have a vital impact on the nature of treatment. The stage of healing of the soft tissue injured in a whiplash-type injury would determine when the physiotherapist could test cervical proprioception and when to commence rehabilitation to the cervical spine. This would influence when proprioceptive training would commence.

Stages of healing include the inflammatory, fibroblastic and the remodelling stages. The remodelling phase lasts for twenty- one days to six to twelve months. During this phase connective tissue maturation with final aggregation and arrangement occurs (Mc Gongile and Matley 1994). Physiotherapeutic aims in this phase include strengthening of scar tissues without causing new inflammatory reactions, restoring normal strength, endurance and co-ordination in the neck muscles that are affected (David 1996). Stronger mobilisation techniques are implemented and more attention is placed on stability and strengthening exercises of the cervical spine.

The physiotherapist would have started rehabilitating the recruitment ability of the deep cervical flexors during this phase.

2.6 The physiotherapeutic rehabilitation process involving the recruitment ability of the deep cervical flexors:

Rehabilitation is aimed at reaching optimal, mechanical function (Jull 2003).To achieve this the physiotherapist would follow certain principles of rehabilitation. The first stage includes rehabilitation of the deeper muscle groups designed to stabilise the spine, this is referred to as core stabilisation (Jull 2004). The goal of core stabilisation is to maintain a correct, upright posture of the spine so that the muscles of the extremities are able to function effectively and efficiently (Kisner and Colby 2002). Training is initiated with developing patient awareness of safe spinal positions and spinal movement in the basic positions of supine, prone, side-lying and sitting. The patient is taught to activate his/her

core stabilisers in these positions. The therapist would begin in gravity assisted positions (eg: lying) and progress to positions in which the patient
would have to stabilise and control movement and posture against the effects of gravity. The second stage of progression of rehabilitation would include the combination of effective stabilisation with dynamic neck and trunk strengthening exercises. The third stage would include aerobic conditioning exercises as soon as the patient can tolerate repetitive activity without exacerbating symptoms. Finally the physiotherapist would work toward training skills for good body mechanics, safe work habits and effective recreational or sport activities (Kisner and Colby 2002).When rehabilitating the recruitment ability of the deep cervical flexors, it is important for the physiotherapist to explain the aim of the exercise to the patient. The aim of rehabilitation is to focus on precision and control rather than increasing the strength of the muscles (Jull 2003).

Literature shows that cervical proprioception is a vital part of patient recovery and techniques used to improve this should be more regularly implemented (Revel et al 1991; Loudon et al 1997). It is important for the physiotherapist to be aware of the effect, if any, that the routine recruitment training of the deep cervical flexors has on cervical proprioception as the very same training method may influence proprioception as well.

2.7 Cervical proprioception testing:

Revel et al (1991) noted in his study that to date only strength and mobility were evaluated in cervical spine rehabilitation programs. He commented on the importance of proprioceptive information in dynamic functions of the cervical spine and noted that limitations were present in the ability of therapists to evaluate proprioception in the cervical spine. In his study he aimed to define a simple, reproducible and quickly executed test that was capable of objectively studying changes in cervical proprioception. The sensitivity of the test was established in a second study (Revel et al 1994). This contributes to the construct validity of the test. Within and between subject reliability was established by Revel et al (1991) Active positioning of the head-on-trunk was evaluated in the horizontal and sagittal planes. This was done achieved by positioning a patient on a chair facing a target mounted on a wall. A laser pointer was attached to a band on the patients head. The patient was asked to relocate to what he/she felt was a neutral position, without visual aid, after rotating his/her head to the left. This was repeated for ten rotations to the left and right and ten extensions.

2.7.1 Proprioception

Proprioception from the muscles is a primary sensory mechanism for motor control. It relates to i) sensation of position and movement of the joints ii) sensation of the force, effort and heaviness of work load iii) sensation of perceived timing of muscle contraction (Lephart and Missouri 1993; Loudon et al 1997). Proprioception is possible due to receptors such as the Golgi tendon organs, pacinian corpuscles and the muscle spindle receptors (which include the annulospiral and flower spray endings) that are present in muscles, joints and tendons as well as in the labyrinth of the ear (Meyer et al 1994).

2.7.2 How information reaches the brain for interpretation:

Low threshold, fast conducting (Aα) fibres mediating, among others, proprioception ascend in the posterior columns of the spinal cord to the medulla in the brain. They synapse with cells and cross the midline to the brainstem and thalamus where they project to the primary somatic sensory area of the cortex.

Other proprioceptive fibres synapse on neurons in the posterior horn of the spinal cord. The axons of these neurons cross the midline and ascend in the anteroletaral part of the spinal cord on the contralateral side (Meyer et al 1994). Abnormal articular afferent information gained due to injury of proprioceptors during a whiplash-type injury may decrease α and γ motor neuron excitability causing propioceptive deficiencies which could lead to joint damage. Muscle fatigue following injury could also contribute to decreased proprioceptive repositioning accuracy (Meyer et al 1994).

Comerford and Mottram (2001) show, in their commentary, that there is a clear link between reduced proprioceptive input, altered slow motor unit recruitment and the development of chronic pain. Muscle action must be co-ordinated to occur at the correct time, for the correct duration and in the correct combination of forces for efficient movement, control and alignment. This co-ordination requires sensory, biomechanical and motor control. Improved proprioception from muscles may serve as a pain gate that blocks or inhibits nociceptor transmission into the spinal cord and higher centres of the nervous system.

There is evidence that in the presence of pain, fatigue or inflammation, receptors convey inaccurate information resulting in altered proprioceptive sense (Loudon et al 1997). This affects optimal motor control. Poor proprioceptive input could result in increased activation of phasic muscles leading to pain and stiffness and non-optimal postures. Loudon et al (1997) concluded this following a cross-sectional study (level III) involving eleven patients who sustained whiplash injuries and eleven control subjects. No mention was made of a power calculation in this study. Inclusion and exclusion criteria for the participants of the study were listed. These included the following: The whiplash group consisted of individuals who had sustained one or more whiplash injuries within two years of the testing date. Patients were to be at least three months post-injury. The control group consisted of age and sex matched healthy individuals who had no history of whiplash or cervical injury or pain. Two physical therapists performed proprioceptive testing on the individuals. Proprioceptive testing was done using a cervical range-of-motion device (CROM; Performance Attainment Associates, Roseville, Minnesota) which assessed joint angles. The CROM was a plastic device that was attached to the head of the patient and aligned according to the three cardinal planes of movement. Goniometers were used to measure the movement. Studies were sited to show the reliability of this test procedure. Patients who were participating in this study were seated in a chair with sufficient back support. They were wearing the CROM device on their heads. They were asked to perform full active range of motion within a pain free range and these measurements were recorded. The therapist would then place the patient's head at a 30º angle of right rotation and then asked to return to 0º with his/her eyes closed. This was repeated three times within a sixty – second period. The angles were recorded. The patients performed three trials at five more test positions. Results of this study showed good intraclass coefficient values for intratester reliability of 0.975 for therapist 1 and 0.985 for therapist 2. Intertester reliability was 0.972. The whiplash group averaged an absolute difference of 5.01º from their recorded angle measure compared with the true angle measure compared to the control group which averaged a 1.75º absolute difference. ANOVA testing was used to reveal a significant difference ($p<0.05$) between the whiplash and control groups.

Heikkila and Astom (1996), by means of a cross-sectional study (level III), investigated cervical proprioception in patients who were suffering from whiplash associated disorders. Fourteen patients who sustained whiplash injuries and thirty four healthy

subjects participated. No mention was made of a power calculation in this study. Cervical proprioception was tested in all the patients in the following way: The participating patients were given goggles to wear which limited their vision. They wore a helmet to which a laser pointer was attached. The patients were seated on a chair facing a target mounted on the wall. The target was placed in such a way that the laser beam was in the centre of the target when the patient was sitting in a neutral position. The patient was asked to rotate his/her head and to return to what he/she thought was the neutral position. This position was marked on the target by the physiotherapist. The procedure was repeated for ten rotations to the left and right and ten extensions. The data of this study was analysed using the Friedmann Test. The absolute value of the global error for each trial and the values for horizontal and vertical replacement were compared in the two groups. The mean and standard deviations were calculated for the 10 trials. Pearson correlation matrix was used to correlate between age, sex and relocation error. This study concluded that active head repositioning was significantly less precise in the whiplash subjects compared to the control group. This had improved after a five week rehabilitation program consisting of generalized cervical strengthening. The researchers surmised that it was probable that cervical proprioception was linked to sensory information from the cervical musculature and articular proprioceptive system.

Studies show that cervical proprioception is crucial for motor control and contributes to balance and general postural control (Loudon et al, 1997; Djupsjobacka 2003).
Sterling et al (2003) conducted a prospective study on sixty-five patients with whiplash injuries. The researchers measured cervical range of movement, joint position error and activity of the superficial neck flexors as well as the patients' fear of re-injury. These measurements were done within one month of injury and then at three and five months post-injury. Motor function which included the ability to perform the cranio-cervical-flexion test was also measured in twenty control subjects. The results of the patients who recovered were compared with those that developed persistent symptoms. Of particular interest was the cervical joint position error. The patient's ability to relocate the head to a neutral position without any visual aid was measured following active cervical left and right rotation and extension. Evidence of altered kinaesthetic awareness was apparent in the group of whiplash patients reporting persistent moderate or severe pain at three months. Also important to note is the fact that proprioceptive ability did not necessarily improve with the reduction of symptoms. Sterling et al (2003) concluded that

acute musculoskeletal pain was capable of inducing changes in cervical range of movement, proprioception, deep cervical flexor activity and fear-avoidance incidence.

This study (Sterling et al 2003) suggests that recruitment ability may affect proprioception of the cervical spine but this has not been examined specifically. The present study aims to examine any correlation between the recruitment ability of the deep cervical flexors and cervical proprioception.

2.8 Conclusion:

The literature indicates that recruitment training of the deep cervical flexors is common practice amongst physiotherapists treating patients suffering from whiplash-associated disorders (Jull et al 2004). An aspect of rehabilitation that has not received much attention has been cervical proprioception (Loudon et al 1997). The importance of proprioceptive training of the spine is becoming more evident but it is a difficult structure to rehabilitate due to the complex nature of the numerous joints in the spine (Revel et al 1991). Studies suggest that the now common, evidence-based practice of recruitment training of the deep cervical flexors may have an effect on cervical proprioception due to the nature of the rehabilitative technique as well as the fact that the deep cervical flexors are rich in proprioceptors (Comeford and Mottram 2001). It is the aim of this study to evaluate any correlation between subjects' ability to perform the cranio-cervical flexion and cervical proprioceptive tests in patients with whiplash-associated disorders.

CHAPTER 3:

Methodology:

3.1. Introduction:

The purpose of this study was to establish the relationship, if any, between the recruitment ability of the deep cervical flexors and cervical proprioception in subjects suffering from whiplash-associated disorders. This chapter describes the method and instrumentation used to collect the data.

3.2 Study design:

A correlation study design was used implying no manipulation of independent variables. The relationship between the recruitment ability of the deep cervical flexors and cervical proprioception was investigated. The purpose of this was to establish the extent to which these two variables relate to each other.

3.3 Ethical Considerations:

Each potential participant of the study was given an information sheet to read (Appendix 2) before signing a consent form on which was also stated that the subjects were under no obligation to participate in the study and could choose to discontinue participation at any time with no recourse (Appendix 1). The information sheet clearly stated what would be required of the participants and also stipulated that the participant could withdraw at any time. The researcher applied to the University of the Witwatersrand's ethics committee for ethical clearance to conduct this study, which was granted (Appendix 3).

3.4 Sampling:

A sample of convenience was used. Twenty-nine subjects who complied with the inclusion and exclusion criteria were recruited. These subjects were referred for physiotherapy following a motor vehicle accident. Subjects who participated were to have sustained a whiplash-type injury within one year of being evaluated for this study. The following was the criteria used to select the subjects:

Inclusion Criteria:

- Subjects who have sustained whiplash-associated disorders within a maximum of one year prior to the assessment.
- Subjects who have sufficient (half or more of normal) pain free range of movement to complete the necessary tests.
- Subjects who were asymptomatic prior to the initial accident causing the whiplash -associated disorder.
- Subjects aged between 21 – 60 years of age.

Exclusion Criteria:

- Subjects who have had previous cervical spine surgery.
- Subjects suffering from Rheumatoid Arthritis.
- Subjects in the last stage of Osteoarthritis, with associated instability.
- Subjects with associated disc pathology.

Randomisation:

The subjects were recruited as they were referred to the practice. In order to randomise the sequence of testing, the researcher labelled the cranio-cervical-flexion test as test A and the cervical proprioception test as test B. The subject was asked which test he/she would like to do first without knowing what test A or test B represented.

3.5 Instrumentation:

The cranio-cervical-flexion test makes use of the biofeedback unit (an instrument similar to a blood pressure cuff: Pressure Biofeedback Unit, Chattanooga group, Hixon, TN) that is placed under the occiput of the supine subject (Jull 1997, Jull et al 2002, Falla et al 2003, Falla et al 2004, Jull et al 2004, Sterling 2004).

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The cervical proprioceptive test requires the subject to be seated in front of a target mounted on a wall with a laser pointer attached to a band placed around his/her head. Using the beam from this laser pointer the physiotherapist would mark the subject's relocation points on the target.

3.6 Procedure:

The subject was asked to choose whether he/she would like to do test A (cranio-cervical-flexion test) or test B (cervical proprioception test) first, not knowing what each test represents. This is to ensure randomisation of the testing. The tester was not blinded and therefore knew the outcome of both tests.

3.6.1 The cranio-cervical-flexion test:

This test was used to test the subject's ability to control incremental stages of "head nodding" by recruiting the deep cervical flexors. Falla et al (2003) conducted a study to develop this test. In this study the researchers showed the validity and reliability of this test. The test began with the biofeedback unit placed under the subject's occiput.

Caution:

- Care was taken to position the folded biofeedback unit under the neck against the occiput.
- The inflatable cushion was not to shift down to the lower cervical area during the test.
- If pressure sometimes decreased the researcher had to re-inflate the inflatable cushion to the baseline pressure before the test commenced.

The subject was positioned supine on a plinth while the physiotherapist was to ensure that the upper cervical region was free. The cuff was filled with air to a pressure of 20mmHg.The pressure dial was turned so that the patient was able to see it. The subject was asked to nod the head untill a reading of 22mmHg was reached. Substitution of the platysma muscle or hyoids was discouraged by asking the subject to put the tongue on the roof of the mouth. The physiotherapist was to be vigilant for any compensatory actions of the subject. These included the following: Retracting the neck, lifting the head, using superficial muscle activity especially the sternocleidomastoid muscles, activation of the jaw and hyoid musculature (this would be noted by palpating the jaw musculature and mobility of the trachea), quick movements that over shoot the target, unsteady maintenance of the pressure gauge, erratic pressure changes. If no compensatory changes were noted while maintaining the position for ten seconds then a ten second rest was given before the subject was

asked to perform to same action to a pressure of 24mmHg. This was repeated at 2 mmHg increments untill a maximum of 30 mmHg. When this was achieved, then the subject was said to have a good recruitment ability of the deep cervical flexors (Jull et al 2004). The physiotherapist measured the maximum pressure the subject achieved without the use of compensatory mechanisms (Jull 1997, Jull et al 2002, Falla et al 2003, Falla et al 2004, Jull et al 2004, Sterling 2004).



Figure 1: A diagram illustrating the positioning of the biofeedback unit. In this diagram the subject has a blood pressure cuff situated under her occiput. This is exactly where the biofeedback mechanism would be placed. The pads on the subject's neck are EMG electrodes not used in the current study. This subject has consented to her picture being published.

3.6.2 The cervical proprioceptive test:

The subject was seated on a comfortable chair sixty centimetres away from a target mounted on the wall. A headband was placed around to subject's head to which a laser pointer was attached. The subject was asked to sit in a comfortable, neutral position. The mark that the laser pointer made on the wall in this position was called the centre point. The target was shifted so that the centre point was in the centre of the target and then fixed to the wall.



Figure 2: Positioning of Revel's test (Revel et al 1991) for cervical proprioception

The subject was then instructed to close his/her eyes and to rotate his/her head to the left. The subject was instructed to return to what he/she felt was neutral position (with the eyes closed). The laser pointer mark was marked on the target by the physiotherapist. This procedure was repeated for a total of ten rotations to the left and ten to the right as well as ten neck extensions (Revel et al 1991).

Reliability:

The researcher's supervisor and work colleagues observed how each test was conducted. Five normal subjects were tested and re-tested to establish a test-re-test reliability. One researcher did all the testing.

Test-re-test analysis:

Test – re – testing was done on five normal subjects to determine the reliability of the test procedures. This was measured using an intra-class correlation co-efficient (ICC) of which the maximum score is 1. This was done at a ninety-five percent confidence interval. The test-retest for the cranio-cervical flexion test was 0.58 which indicated a moderate – strong degree of association (Sim and Wright 2000). This was less compared to the test-retest for the cervical proprioception which was 0.98 (indicating excellent reliability).

3.7 Data Analysis:

Linear regression was employed using the One-way analysis of variance (ANOVA) to establish the relationship between the ability to recruit the deep cervical flexors and cervical proprioception. A pairwise comparison using the Bonferroni adjustment was obtained to locate specific areas of correlation. Confidence bands were determined and testing was done at a 0.05 level of significance.

CHAPTER 4:

RESULTS:

This chapter will present the results obtained from the two tests that were employed. It will aslso present the linear regression analysis that tested the correlation between the cranio-cervical-flexion and cervical proprioceptive ability of patients suffering from whiplash-associated-disorders.

4.1 Demographic Data

Table 4.1: Demographic Profile

Mean age	36.14 (n = 29)
Females	15 (52%)
Males	14 (48%)

All the patients were aged between twenty- one and sixty with a mean age of 36.14. All were involved in a motor vehicle accident within one year of evaluation. Fourteen females and fifteen males participated making this an equally represented sample group.

4.2 Calculation of the results

4.2.1: Cervical proprioceptive test:

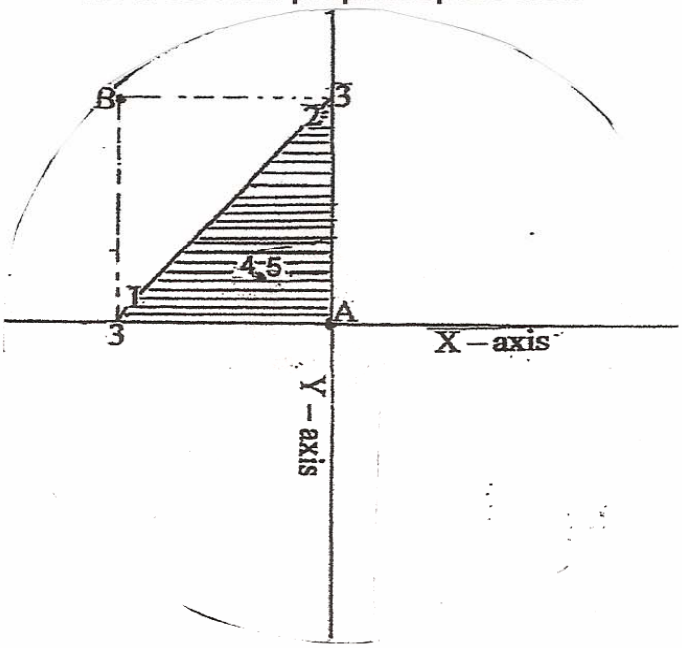


Figure 3: Schematic representation of the target used in the cervical proprioceptive test. Point A is the central point and Point B the relocation point after the subject either rotated or extended his/her head. The shaded area is a representation of the proprioceptive ability of the patient.

To assess any correlation between the two tests listed in the objectives of this study, the researcher needed to compact the raw data obtained. The compacted form of the raw data had to be presented as a single, numerical value for each test, for each patient, which could then be correlated. This was done in the following way: The cranio-cervical-flexion test resulted in the subjects achieving a certain pressure before using any compensatory methods. This pressure was used as a numerical representation for the subject's ability to perform the test. When assessing the data obtained from the cervical proprioceptive test it was noted that the centre point and the relocation point on the target (see figure 3) formed a triangle. The researcher calculated the size of the area of the triangle and used that result as the single, numerical representation of cervical proprioception.

For example: in Figure 3 the vertical displacement of the relocation point is three cm and the horizontal displacement is three cm. To calculate the shaded area the researcher would do the following:

Step 1: 3cm x 3cm = 9.cm²

Step 2: 9cm/2 = 4.5 cm².

This is done for each of the thirty relocation attempts per patient (the relocation attempts would be: 10 rotations to the left, 10 rotations to the right and 10 extensions).

Step 3: Each value is finally added and divided by thirty to obtain an average value for the cervical proprioception. These are presented in Table 3.2.

According to Revel (1991) a circle with a radius of 4.5º represents the normal value for healthy subjects undergoing the proprioceptive test.

4.2.2 Interpretation of results:

The greater the area of a patient's cervical proprioceptive test result, the poorer the patient's proprioception. These are presented in Table 4.3.

4.2.3 Cranio-cervical flexion:

The single, representative, numerical value used for measuring the cranio-cervical-flexion was the pressure at which each participant was able to maintain for ten seconds without using any compensatory mechanisms. These are presented in Table 4.2.

Table 4.2: Frequency distribution of the Cranio-cervical Flexion Test (n=29)

Pressure (mmHg)	Frequency (n)	Percentage (%)
20	5	17
22	7	24
24	8	27
26	9	31
28	0	0
30	0	0

This table shows that most of the patients (31%) were able to reach the 26mmHg and none reached the highest of 30mmHg. Only 5 participants (17%) were able to only manage maintain the minimum pressure of 20mmHg for less than ten seconds.

Table 4.3: **A comparison between the patients' cervical proprioception and cranio-cervical-flexion ability at each pressure level of the cranio-cervical-flexion test.**

Pressure mmHg	Area cm²	Mean cm²	±SD(mean area)
20 (n = 5)	**30.52**	34.17	5.97
	30.57		
	32.59		
	43		
	10.04		
22 (n = 7)	**43.73**	17.17	3.10
	20.97		
	12.33		
	16.16		
	19.89		
	16		
	17.69		
24 (n = 8)	**29.47**	18.68	5.49
	23.13		
	19.2		
	17.31		
	14.16		
	13.11		
	18.98		
	14.07		
26 (n = 9)	5.37	9.55	6.12
	9.9		
	21.87		
	0.41		
	7.9		
	11.56		
	13.32		
	4.7		
	5.37		

Four (80%) of the patients that could manage 20mmHg had poor proprioceptive ability as indicated by the red areas represented in the table. One patient of the high control group (those patients able to reach 26 mmHg) indicated poor proprioceptive ability with a representative area of 21.87 cm², also in red.

4.3 Pairwise comparison between the cranio-cervical-flexion test and cervical proprioceptive test.

A Bonferroni adjustment was used to correlate the differences between the pressure groups in the cranio-cervical-flexion test.

Table 4.4: A Bonferroni adjustment locating specific areas of correlation between the pressures reached during the CCFT and the mean areas between each pressure.

Pressure at which the CCFT was tested: ⇩ ⇨	**20 mmHg**	22mmHg	**24mmHg**
22mmHg	16.9967 cm² **P = 0.000**		
24mmHg	15.4913 cm² **P = 0.001**	1.50542 cm² 1.000	
26mmHg	24.6167 cm² **P =0.000**	7.62 cm² 0.079	9.12542 cm² **P = 0.012**

Table 4.4 is an analysis comparing the correlation between proprioception and deep cervical flexor ability between the different pressures reached during the CCFT. For example: When comparing the patients that were able to reach 20 mmHg during the CCFT with those that managed to reach 24mmHg, the mean area (representing proprioception) between these two groups was calculated at 15.4913 cm². This means that there is a significant difference ($P<0.05$) in proprioceptive ability between the patients who performed poorly (reaching 20mmHg) and those patients who reached 24mmHg. Similar, significant correlations are shown between pressures of 20mmHg and 22mmHg, 20mmHg and 26mmHg and 24mmHg and 26mmHg.

Table 4.5: Final analysis of the comparison between the ability to perform the CCFT and cervical proprioceptive ability.

CCFT mmHg	Mean (area) cm²	SD
20 (poor)	**34.17 (poor)**	**5.97**
22	17.17	3.10
24	18.68	5.49
26 (good)	9.55 (good)	6.12

Table 4.5 indicates that those participants that showed signs of poor deep cervical flexor control (i.e. those only able to reach 20mmHg before using compensatory mechanisms) indicated the highest mean area (34.17 cm²) showing poor proprioceptive ability. A similar correlation is seen on the opposite end of the scale where participants that showed a better recruitment ability of their deep cervical flexors (i.e. those able to reach 26mmHg before using compensatory mechanisms) indicated improved proprioceptive ability with a smaller mean area (9.55 cm²).

CHAPTER 5:

DISCUSSION:

5.1 Introduction:

In this chapter, the results will be discussed with reference to the aim and objectives of the study. The aim of this study was to determine whether a correlation exists between the recruitment ability of the deep cervical flexors and cervical proprioception in patients suffering from whiplash-associated disorders.

Patients suffering from whiplash-associated disorders often present with injury to the deep cervical flexors. Other soft tissue changes occur in the cervical discs, facet joint capsules and ligaments and surrounding musculature (Twomey and Taylor 1993). These soft tissues are rich in proprioceptors and therefore resulting injury could lead to changes in cervical proprioception (Comerford and Mottram 2001, Jull et al 2004).

When examining current, evidence-based rehabilitation of the cervical spine, the deep cervical flexors have been shown to play a massive role. It is now standard practice to evaluate and rehabilitate poor muscle control of the deep cervical flexors in patients presenting with chronic pain in this area. It is accepted that conscious awareness of joint position or movement is one of the foundations of motor learning during the early phase of training for neuromuscular control of functional movements (Kisner and Colby 2002).

Cervical proprioception is a facet of rehabilitation which is gaining attention due to current research trends. Djupsjobacka (2004) investigated techniques such as body awareness training or eye-head-coupling in an attempt to improve cervical proprioception but these techniques are not yet part of standard physiotherapy practice as is the case with peripheral joint injuries where poor proprioception is effectively addressed.

5.2 Cranio-cervical flexion control:

Testing cranio-cervical-fexion ability was one objective of the study. The researcher was not blinded to the results of the study. The results of this test show that 31% of participants in this study were able to obtain a relatively high measure of cervical flexion control during the cranio-cervical-flexion test compared to 17% who fared low (Table 4.2). One would assume that more individuals would have poorer control but it is also interesting to note that not one participant was able to reach the maximum of 30 mmHg and maintain this for the ten seconds required. This could imply that the participants were fatiguing during the test procedure. An important contributing factor to the outcome of this study as well as the rate and extent of improvement during rehabilitation of these individuals is the condition of the cervical spine prior to injury. An individual with good cervical control prior to injury would be assumed to respond more rapidly and effectively to the tests. It was not possible to assess this contributing factor but it must be considered as affecting the outcome measures of this study.

It would be interesting to assess whether the individuals who showed signs of poor cervical control (i.e. the 17% of the sample who only obtained a pressure of 20 mmHg during the cranio-cervical-flexion test) showed any similarities in age or demographics. It would be recommended that further studies consider this.

It is assumed that conducting the proprioceptive test prior to the cranio-cervical-flexion test could fatigue the small deep cervical flexors. Recordings of which test was completed first were not made in this study in order to draw any such conclusion. Further investigation in this field should consider which test was conducted first and observe any significant changes. This could possibly impact the outcome of the study.

5.3 The correlation between cranio-cervical-flexion control and cervical proprioceptive ability:

5.3.1 Deep cervical flexors:

Revel (1991) stated that health subjects would relocate to a zone of a radius of 4.5º. All the relocation points that did not fall within this demarcated area were considered to be abnormal. All the abnormal values were indicated in red on Table 4.3. The participants who obtained the lowest results in the cranio-cervical-flexion test showed the poorest

proprioceptive ability with areas as high as 43 cm². Individuals with the greatest amount of control of the deep cervical flexors showed better proprioception with proprioceptive areas from as little as 0.41 (table 4.3). These results were obtained from participants completing the cervical proprioceptive test, a second objective of the current study. This supports the implication of Sterling et al (2003) that a correlation exists between deep cervical flexor control and cervical proprioception. When treating the cervical spine of patients following a whiplash injury the physiotherapist will improve the recruitment ability of the deep cervical flexors (Falla et al 2003, Falla et al 2004, Jull et al 2004, Jull et al 2002, Sterling et al 2003). Recruitment training of the deep cervical flexors is important as eighty percent of cervical spine stability originates from the cervical spine musculature (Falla et al 2004).To train the recruitment ability of the deep cervical flexors, patients are positioned in supine and will be progressed to a sitting position and other functional postures, as tolerated. It is important for patients to understand what spinal positions aggravate or ease their symptoms and what the effect of control of these spinal positions has on pain levels. The therapist progresses to rehabilitate the local stabilisers of the cervical spine in these positions once the patient is aware of the correct positioning of the spine. To do this the physiotherapist makes use of verbal, visual and tactile reinforcement by interacting with the patient, using mirrors to encourage correct alignment or placing the patient in the correct position (Kisner and Colby 2002). By encouraging this correct positioning using tactile, visual and verbal aids the therapist is encouraging proprioception as well as improving motor control. It could therefore be deduced that by improving the cervical spine's ability to use the deep cervical flexors, one must be influencing cervical proprioception through this same method of training. This deduction is supported by the results obtained in this study (table 4.5) which shows that patients with poor control of the deep cervical flexors have poor cervical propriocpetion and patients with good control of the deep cervical flexors have better cervical proprioception. It highlights the correlation between the ability to control the deep cervical spine musculature and cervical proprioception.

5.3.2 Proprioception:

This study aims to highlight the importance of addressing cervical proprioception when rehabilitating the spine following a motor vehicle accident as this could relieve or prevent chronic symptoms. Chronic pain is described as being physiologically abnormal. The development of chronic pain could possibly be due to sensitization of the pain system or a dysfunctional pain system. Patients suffering from chronic pain would experience stimuli as exaggerated pain. This is a complex pain syndrome and is very difficult to treat (Jull et al 2004). Comerford and Mottram (2001) suggested that improving proprioceptive abilities in the cervical spine could possibly relieve or prevent the onset of chronic pain by serving as a pain gate inhibiting nociceptive input. Studies show that cervical proprioception is affected following a whiplash-type injury to the cervical spine (Revel et al 1991; Heikkila and Astom 1996; Loudon et al 1997; Djupsjobacka 2003; Sterling et al 2003). This is due to the soft tissues which are rich in proprioceptors being injured. The deep cervical flexors are rich in proprioceptors and when injured could directly influence afferent input reducing the cervical spine's proprioception (Djupsjobacka 2003). Abnormal articular afferent information gained due to injury of the proprioceptors during a whiplash-type injury may decrease γ and α motor neuron excitability causing proprioceptive deficiencies which could lead to joint damage. Muscle fatigue may also contribute to reduced proprioceptive repositioning accuracy (Comerford and Mottram 2001). This is supported by Loudon et al (1997) who noted reduced cervical proprioceptive ability in whiplash-associated disorders. The severity of the whiplash injury could also impact on the rate of recovery, rate of improved recruitment ability of the deep cervical flexors and cervical proprioception (Sterling 2003).

Studies suggest that a possible link exists between the ability to control and recruit the deep cervical flexors and cervical proprioception but this has not yet been specifically investigated (Sterling et al 2003). It was therefore the aim of the current study to examine whether a correlation exists between cranio-cervical-flexion and cervical proprioceptive ability in patients suffering from whiplash-associated disorders.

When interpreting the results the study supports the hypothesis that there is a correlation between the ability to recruit the deep cervical flexors and cervical proprioception in patients suffering from whiplash-associated disorders

5.4 Demographic Data:

On evaluation of the demographic data of the sample group, the distribution between males and females was quiet even. Although not addressed in the current study, it would be interesting to assess whether the results between the two sexes differ. The cranio-cervical-flexion test is one of muscle recruitment ability rather than muscle strength so one would expect the results to be fairly similar. It would also be interesting to evaluate if participation in sport, hobbies or working environment prior to injury has any effect on the outcome measures of rehabilitation of the spine. It could be assumed that individuals who spent most of their working days at a computer work station would be likely to have poor postural habits and therefore reduced cervical control and proprioception compared to an active dancer, as an example. Jull (2003) supports this and mentions the importance of posture re-education when rehabilitating patients who have suffered from whiplash-associated-disorders. It is recommended that researchers embarking on further studies in this field evaluate this possibility.

5.5 Conclusion:

This study has highlighted the importance of cervical proprioception and its effect on the recovery and or development of chronic pain. Literature has also shown that cervical propriocpetion does not improve when symptoms of whiplash-associated disorders decrease, over time (Sterling 2004). It is essential for the physiotherapist to evaluate and address cervical proprioception when treating patients suffering from whiplash-associated disorders. This would serve to prevent or slow the degenerative process and result in an improved cervical control. What this study suggests is that a correlation exists between the recruitment ability of the deep cervical flexors and cervical proprioception. It highlights the fact that when rehabilitating the cervical spine by encouraging recruitment of the deep cervical flexors, the physiotherapist could be improving cervical proprioception through the same method of recruitment training. Physiotherapists must be aware of the fact that a decreased cervical proprioception could result in cervical joint overload, over-activity of the phasic muscles of the cervical spine leading to spasm and ultimately pain. Conversely, as Comerford and Mottram (2001) suggest improved proprioceptive imput could act as a pain gate, inhibiting slow conducting pain fibres thus directly decreasing the sensation of pain.

Revel et al (1991) also found that patients who have suffered from whiplash-type injuries showed reduced proprioception. Their study concluded that a rehabilitation program involving eye-head co-ordination improved proprioception. The current study supports the suggestion that rehabilitation, especially techniques that incorporate recruitment training of the deep cervical flexors that are rich in proprioceptors and are vulnerable to the hyper-extension phase of whiplash injury, improve proprioception. It is important for physiotherapists to investigate other ways of improving cervical spine proprioception as this could possibly prevent and even alleviate chronic cervical pain.

CHAPTER 6

CONCLUSION:

Recruitment training of the deep cervical flexors as part of an active stabilisation program for patients suffering from whiplash-associated disorders is now widely used in clinical practice. To date the correlation between this and cervical proprioception ability has not been established. This study indicates that a correlation does exist and this implies that recruitment training of the deep cervical flexors could influence cervical proprioception. This is significant as it highlights the role of rehabilitation of the recruitment ability of the deep cervical flexors and its possible contribution to cervical proprioception. It also highlights the importance of assessment and rehabilitation of cervical proprioception which, if neglected, can lead to the development of chronic pain. Chronic pain may develop due to over-active phasic muscles of the cervical spine, joint over-load and muscle fatigue. Cervical proprioceptive ability could also directly affect intensity of pain. Proprioceptive input could block the slow conducting pain fibres reducing the perception of pain. To conclude it must be mentioned that although it seems that routine rehabilitative techniques such as recruitment training of the deep cervical flexors in patients with cervical pathology can influence cervical proprioception, the physiotherapist must always strive to investigate new ways of addressing poor cervical proprioception as this could mean preventing or even help improving chronic pain.

6.1 Recommendations:

1) A larger sample group would be necessary for a double-blind study to further investigate the effect of recruitment training of the deep cervical flexors on cervical proprioception. The first step to solving this would be to establish a correlation between a reduced ability to control the neck musculature and neck proprioception. Based on the results of this study, there does seem to be a link. This would however require confirmation through further investigation using a randomized, controlled trial.

2) It is recommended that future studies take into account the sequence of testing, and consider the possibility that performing the proprioceptive test after the cranio-cervical-flexion test may have a negative affect on the outcome measures

3) It is the researchers recommendation that should further investigations of this nature be embarked on that care be taken in collecting demographic data regarding the activities of participants of the study and severity of the whiplash injury and to compare this to their outcome measures. It is also important to record the levels of pain experienced by the subjects. This could shed light on the effect of activities of daily living as well as severity of injury on cervical proprioception.

6.2 Limitations of the study:

1) It would have been interesting to assess the demographic data of the patients participating in this study and the impact of this on any outcome measures.
2) It is possible that the deep cervical flexors could fatigue by evaluating cervical proprioception prior to examining the recruitment ability of the deep cervical flexors. It would have been interesting to establish whether this did impact the outcome measures or not.
3) The levels of pain of the subjects participating in this study were not recorded. This is a limitation as pain inhibits the local stabilising muscles.

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APPENDIX 1

CONSENT FORM:

This practice is participating in research studies. Do you consent to participate? Participation would require you to undertake two tests. Test one: you should have to lie on your back with a device similar to that of a blood pressure cuff under your head. You will be asked to nod your head to a specific reading on the device. This would be repeated 5 times. Test two: would involve you sitting on a chair with a laser pointer attached to a band around your head. You would be asked to turn your head 10 times to the left and right and look upwards 10 times. The test results will be anonymous. You have full right not to participate in this study. By not participating you will in no way influence your treatment at this practice. You may refuse participation at any time, with no recourse, even if you sign this consent form.

I _____ consent to Merle Snyckers using my test results for the purpose of research in partial fulfilment of the requirements for the Orthopaedic Manipulative Therapy Masters degree (Coursework).

Signed:_____

Date: _____

APPENDIX 2

Dear sir/madam

I am Merle Snyckers from the University of the Witwatersrand medical school. I am investigating a link between poor muscle control and position sense of the neck in people suffering from symptoms resulting from whiplash injuries.

WHY AM I DOING THIS? Research has shown that the neck muscles may be affected by whiplash injuries as can neck position sense, but no correlation between these symptoms has been established. If one does exist, this may impact on the way physiotherapists approach their planning of treatment.

WHAT DO I EXPECT FROM PARTICIPANTS IN THE STUDY?

You fall under the inclusion criteria for this study. I require your permission to participate in two tests and to use the results of your tests so that I can compare them to other people with similar injuries. The specific tests to be compared include the following: You will lie on your back with an inflatable cushion under your head. You will be asked to nod your head and hold that position for ten seconds and this would be repeated five times. Secondly, you will wear a laser pointer on your head and sit in front of a target. Close your eyes and turn your head, with you eyes closed try and relocate your initial position. I will mark the spot that the laser pointer makes on the target. This will be repeated 20 times. These tests are routinely done in the examination of your injuries so nothing regarding your assessment or treatment will change. All I would need is permission to compare your results to others.

THE BENEFIT TO YOU: By doing these tests, I as the physiotherapist will have a clearer picture of the extent of your injuries. This will enhance the quality of my treatment to you. By allowing me to compare your results to others you will be helping us as physiotherapists better understand the effect of our current treatments.

MAY I DECLINE: Of course. You are under no obligation to participate in this study. You may at any time change your mind regarding your participation without giving any reasons. Not taking part or withdrawing from this study will carry no penalty of any sort.

CONFIDENTIALITY: The results of these tests would remain completely confidential. This confidentiality is achieved by the physiotherapist (Merle Snyckers) tabulating your results. Your name would not appear on these tables at all. The consent form that you sign would be kept in your file so no one else would be able to link your name with the table of results.

There are no negative side effects to this testing and should you experience discomfort at any stage during these tests, the proceedings will stop and your participation would be complete as pain during testing is a contra-indication to the study.

TIME FRAME: The tests take about 15 minutes to complete.

If you have any queries, more information may be obtained from Merle Snyckers at the following telephone number:
(012) 329 7510.

If you are happy to participate, please read and sign the consent form attached.

APPENDIX 3

APPENDIX 4