# The Relative Effectiveness of Proprioceptive Exercises as an Adjunct to Cervical Spine Manipulation in the Treatment of Chronic Cervical Spine Pain and Disability associated with Whiplash Injury

**By**

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A dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology in the department of Chiropractic at Durban Institute of Technology.

**I, Nicole Moulder, do hereby declare that this dissertation is representative of my own work.**

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# Dedication

This work is dedicated to my wonderful parents, Vi and Keith, whose love, support and encouragement throughout my life have allowed me to get to where I am today. I love you both very much and am eternally grateful.

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I would like to tell my grandparents how much their love and faith in me means. To gran and grandpa in heaven, I hope you continue to watch over me and know you are sorely missed.

To my friends, you have enriched my life more than you will ever know. Thank-you for all your encouragement and believing in me when things got hard. A special thanks to my friend Lauren, my boyfriend Darryn and sister Lauren – you all mean the world to me. To my classmates, I couldn’t think of better people with whom to spend those long years of study. Best of luck with your practices and may your dreams and ambitions become a reality.

Finally, I would like to thank God Almighty for always bringing all His joy, love and support into my life.

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## Abstract

Whiplash injuries or whiplash-associated disorders (WAD) are a controversial clinical entity, often resulting in chronic pain with a poor response to conventional therapeutics.

The literature encompasses a broad spectrum of presentations, ranging from relatively minor complaints to severe incapacitation, the only common factor being neck pain. A wide variety of interventions are available to treat patients with whiplash injuries. Unfortunately, there is a paucity of adequate clinical trials, and reports of efficacy remain largely anecdotal. Of the treatments available anti-inflammatories, mobilisation, manipulation and active exercise have been identified as the options with the most scientifically established validity. Chiropractic manipulation is thought to restore mobility and normalise mechanoreceptive and proprioceptive input. Injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganised neck proprioceptive activity. The proprioceptive system of the neck has learning capabilities and can possibly be improved by rehabilitation techniques.

This was a comparative, randomised, controlled clinical trial. Thirty patients meeting the research criteria were utilized for the study. Stratified convenience sampling was used and every odd numbered applicant within an age stratum was allocated to Group 1 and vice-versa for Group 2. Those patients in Group 1 received cervical manipulation and proprioceptive exercises for their WAD, whilst

those in Group 2 received cervical manipulation alone. Group 1 formed the experimental group and Group 2 the control group.

At the initial consultation, the patient completed the CMCC Neck Disability Index to assess the subjective findings. Objective findings included Pressure Algometer readings and Head Repositioning Accuracy (HRA) measurements. These subjective and objective measurements were assessed before treatments 1 and 4 and at the 7$^{th}$ follow-up visit.

Inter-group analysis showed no statistically significant differences for the CMCC Neck Disability Index and the HRA scores. However statistically significant differences ($p<0.05$) between the two groups were seen for the Pressure Algometer readings. This indicated a significant reduction in tenderness for those subjects receiving both manipulation and proprioceptive exercises. Intra-group analysis of the results indicated that both treatment groups improved significantly ($p<0.05$) between the initial and final consultation for all three measures.

It can be concluded that manipulation is effective in treating pain and disability in WAD patients and proprioceptive exercises are a valuable adjunct to manipulation in further reducing pain and tenderness.

It is recommended that this study be repeated with a larger sample size, to validate these findings.

## Definitions

| | |
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| Adhesion: | A fibrous band or structure by which parts adhere abnormally (Bergmann 1993). |
| Adjustment: | The chiropractic adjustment is a specific form of direct articular manipulation utilising either long or short leverage techniques with specific contacts. It is characterised by a dynamic thrust of controlled velocity, amplitude and direction (Bergmann1993). |
| Fixation: | The state by which an articulation has become temporarily immobilised in a position which it may normally occupy during any phase of physiological movement (Bergmann 1993). |
| Kinesthesia: | The sense by which movement, weight, position etc. are perceived, commonly used to refer specifically to the perception of changes in the angles of joints (Bergmann 1993). |
| Myofascial Trigger Point: | A hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction and autonomic phenomena (Travell and Simons 1999). |
| Isokinetic exercise: | Exercise using a constant speed of movement of the body part (Bergmann 1993). |
| Isometric exercise: | Exercise consisting of muscular contractions without movement of the involved parts of the body (www.medical-dictionary.com/results.php). |
| Proprioception: | Sensory perception of movement or position within the body (Bergmann 1993). |
| Saccade: | Rapid eye movement to redirect the line of sight (www.medical-dictionary.com/results.php). |
| Tonus: | The slight continuous contraction of a muscle, which in skeletal muscle aids in the maintenance of posture (Bergmann 1993). |

# Chapter 1

## 1.0 Introduction

## 1.1 The Problem and its Setting

Whiplash injuries are thought to occur in as many as one-fifth of all MVA's in the United States and Canada. South Africa may have a higher incidence of whiplash injuries due to the exceptionally high road accident rate when compared with international norms (Burger 1996:478). The incidence rate is higher among female subjects and people aged 20-24 years (Teasell and Shapiro 1998: 72, Spitzer et al. 1995).

Whiplash injuries or whiplash-associated disorders (WAD) often result in chronic pain with a poor response to conventional therapeutics. Manipulation, exercise and anti-inflammatories have been identified as the options with scientifically established validity in the management of WAD (Spitzer et al. 1995)

Patients with WAD have a distortion of the posture control system as a result of disorganised neck proprioceptive activity. It would therefore appear that proprioceptive rehabilitative exercises would benefit WAD sufferers (Revel et al. 1994, Gimse et al. 1996).

Spinal manipulation has also been shown to have a significant effect on proprioceptive-dependent abilities in subjects with chronic neck pain (Rogers 1997).

This suggests that a combination of manipulation and proprioceptive rehabilitation may offer an improved treatment protocol for WAD (Fitz-Ritson 1995).

## 1.2 Statement of the Problem

The purpose of this investigation is to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective and objective measures, in the treatment of whiplash-associated disorders.

### 1.2.1 The First Subproblem

The first objective will be to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective measures, for pain and disability.

### 1.2.2 The Second Subproblem

The second objective will be to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of objective measures, for pain and proprioceptive function.

## Chapter Two

## 2.0 Review of Related Literature

### 2.1 Introduction

Many chronic whiplash patients are the antithesis of the ‘ideal patient’. Expectations of the medical system are often very high and as a result patients may continually, and often aggressively, seek different medical opinions and treatment. The chronic pain patient’s symptoms are often attributed to ‘secondary gain’ or compensation neurosis (Tollison and Satterthwaite 1992:309). A broad spectrum of presentations is found, ranging from relatively minor complaints to severe incapacitation (Yochum and Rowe 1996:681). The patient is often distressed because there is usually no objective display of an injury to account for the pain (Taylor and Twomey 1993).

There are currently very few options, in terms of treatment for whiplash injury patients, that have been thoroughly researched and most treatments appear to be based on clinical experience and anecdotal evidence only (Spitzer et al. 1995). There is considerable inconsistency about diagnostic criteria, indications for therapeutic intervention, rehabilitation and the appropriate role of clinicians at all phases of the syndrome (Spitzer et al. 1995).

The following literature review discusses the various aspects associated with whiplash injuries and highlights possible treatment protocols.

## 2.2 Definition of 'Whiplash'

In 1995 a multi-disciplinary review panel (The Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders (WAD)) developed the following definition for WAD: "Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck. It may result from rear end or side-impact motor vehicle collisions but can also occur during diving or other mishaps. The impact may result in bony or soft tissue injuries, which may in turn lead to a variety of clinical manifestations" (Spitzer et al. 1995). This syndrome is also commonly referred to as 'Cervical Acceleration/Deceleration Syndrome (CADS)' (Foreman and Croft 1995: 2-3).

The term 'whiplash' applies to a complex and variable set of clinical manifestations, which makes it difficult to define. There is usually a history of a minor or moderately severe rear-end collision. The patient presents with some combination of a large variety of symptoms, the only common factor being neck pain. Radiographs of the cervical spine are generally normal, except for the possible loss of physiologic cervical lordosis (White and Panjabi 1990:230).

### 2.2.1 Signs and Symptoms of WAD

A delay in onset of symptoms of several hours following impact is characteristic of whiplash injuries. The clinical picture of WAD is dominated by head, neck, and upper thoracic pain and is often associated with a variety of poorly explained symptoms (Teasell and Shapiro 1998:73). This may be due to damage to the sympathetic nerve fibres causing nausea, vertigo, visual and auditory symptoms and occasionally Horner's syndrome (Bland 1994:402).

Neck pain is the most commonly reported symptom after WAD incident, followed by headache (Foreman and Croft 1995:311-313, Norris and Watt 1983). Head injury may occur as the brain is forced forward and backward in the skull (Bland 1994:403).

With very severe extension, the oesophagus and larynx are stretched, resulting in dysphagia and hoarseness, and temporomandibular joints are sprained as the head is jerked away from the mandible, resulting in difficulty in chewing and limited opening of the mouth (Bland 1994:402).

Other common symptoms attributed to WAD include musculoskeletal problems such as low back pain, shoulder and interscapular pain and thoracic pain. Local tenderness and referred pain are two hallmark features of WAD. Neurological complications may result in paraesthesias, weakness, thoracic outlet syndrome and arm pain (Teasell and Shapiro 1998:75, Hildingsson and Toolanen 1990, Norris and Watt 1983).

### 2.2.2 Grades of WAD

Spitzer et al. 1995 proposed a classification of WAD on a system of two axes, namely a clinical-anatomic axis and a time axis. The purpose of this classification was to facilitate the evaluation of original research and to be unambiguous and helpful to the clinician.

The clinical-anatomic axis has five grades that correspond roughly to severity. Grade 0 refers to no complaint about the neck and no physical signs. Grade I involves a neck complaint of pain, stiffness or tenderness only, with no objective signs. Grade II refers to neck complaints and musculoskeletal signs, including decreased range of motion and point tenderness. Grade III involves neck complaints and neurological signs, including decreased or absent deep tendon reflexes, weakness and sensory deficits. Grade IV is the most severe grade and refers to neck complaints and fracture or dislocation.

The time axis classifies patients within each grade as those less than 4 days from the time of injury, those 4 – 21 days from the date of the injury, those from 22 – 45 days, those from 46 – 180 days and those with durations more than 6 months. The time axis guides the clinical management of WAD. Patients who are symptomatic 6 months or more after the injury are designated as chronic. In those patients whose complaints exceed 45 days, vigorous clinical intervention is deemed necessary to prevent chronicity (Spitzer et al. 1995).

## 2.3 Incidence and Prevalence of WAD

The incidence of WAD is difficult to determine as there are often suspicious circumstances involving monetary gain through litigation (Foreman and Croft 1995:1). Estimates obtained in a Canadian survey suggest that whiplash injuries occur in as many as one-fifth of all rear-end MVA's (Teasell and Shapiro 1998:72). These figures are similar to those of the United States National Safety Council in 1971, where whiplash injuries were reported in one-quarter of all rear-end collisions (Foreman and Croft 1995:85).

To the authors knowledge the literature revealed no South African statistics on the incidence of WAD; however, South Africa may have a higher incidence of whiplash injury due to the proportionately higher number of motor vehicle accidents on South African roads (Burger 1996:478). Statistics from the Road Accident Fund (RAF) show 181,83 fatal accidents per 100 000 vehicles in South Africa compared to 21,51 per 100 000 for Canada in 1992. This figure has dropped in recent years, possibly due to the implementation of safety campaigns,

in particular the Arrive Alive Campaign (www.raf.co.za/aboutraf/roadsafety.html). In South Africa, in 1999, the number of major accidents totaled 21079 and minor accidents totaled 59783 (www.transport.gov.za/search/index.html).
Whiplash injury usually results from the collision of two automobiles but also can result from contact sports such as football or high-velocity sports such as skiing (Hertling and Kessler 1990:516).

The incidence of whiplash injury among female sufferers is more than 1.5 times greater than among male sufferers (Spitzer et al. 1995). Women generally have slimmer, less muscular necks, which, theoretically, are less able to resist damaging acceleration forces generated at the time of impact. Another theory suggests woman may be more likely to seek medical treatment for their condition (Teasell and Shapiro 1998:73).

The age-specific incidence rates for WAD reveal the highest incidence of WAD for both genders occurs in the 20 – 24 age group (Spitzer et al. 1995). Foreman and Croft (1995:84) found that the incidence of WAD was greatest between the ages of 20 to 40 years, which coincides with the age of the highest proportion of licensed drivers on the roads. Young children are less frequently injured because they are more resistant to injury and because their heads are usually protected by the relatively high seat backs. With an increase in age, the elasticity of tissues decreases as does range of motion and strength of muscles in the cervical spine.

The potential for injury is increased because the neck is less resilient (Foreman and Croft 1995:84).

Seatbelt and shoulder harness use have reduced the number of serious injuries and fatalities in accidents, however, neck injuries have been found three times more likely to occur by using restraint systems. The seat belt abruptly restrains the decelerating trunk of the occupant while the head's inertia carries it forward unrestrained, resulting in a tremendous bending moment at the cervicothoracic junction (Foreman and Croft 1995:297).

Rearend collisions are associated with a higher rate of relapse or recurrence of symptoms in whiplash subjects, as the biomechanical potential for ligamentous damage is greater from this direction of impact (Spitzer et al. 1995). Head-on collisions result in flexion injuries, which are usually limited by the chin striking the chest (Foreman and Croft 1995:85).

## 2.4 Prognosis and Outcome of WAD

Many physicians believe that the 'whiplash syndrome' is demonstrated only by a group of hysterical, neurotic and dishonest people (Mcnab 1982). However, an interesting observation on the significance of litigation neurosis comes from a follow-up of these patients after settlement of court action (Mcnab 1982).

Mcnab (1982) conducted a retrospective review of 266 medicolegal cases involving WAD and found that even 2 years after settlement 45% continued to have symptoms, which suggests that many whiplash injuries are genuinely chronic in nature.

Hildingsson and Toolanen (1990) performed a follow-up study on 93 WAD cases. They found that after 2 years, 42% of the subjects had fully recovered, 15% had mild discomfort and 43% still had major complaints that interfered with their capacity to work (no p-values stated).

In a study by Radanov et al. (1991), 78 patients, referred 7.2 (SD 4.5) days after they had sustained whiplash injury, were referred for psychological assessment and testing. Six months later, 57 patients were fully recovered and 21 still had persisting symptoms. Analysis showed that psychosocial factors, negative affectivity and personality traits were not significant in predicting which of those patients would continue to have symptoms. However, initial neck pain intensity, age and injury-related cognitive impairment were significant factors predicting illness behavior. This study shows that psychosocial factors have little power to explain the course of recovery from whiplash.

The long-term prognosis of WAD injuries was investigated by Gargan and Bannister (1990), where they reviewed 43 WAD patients after a mean of 10.8 years. Of these, only 12% had recovered completely and 48% had mild symptoms. Residual symptoms were intrusive in 28% and severe in 12%. It appears that most patients have reached their final state within 2 years of injury.

## 2.5 Clinically Relevant Anatomy of the Cervical Spine

The neck is the most mobile segment of the spine. It enables the head to be positioned to receive from the environment all needed sensory information except touch (Bland 1994:3-4). Motions of the head are therefore inseparably linked with motions of the neck, and this linkage is a critical concept in both normal and pathological states (Hertling and Kessler 1990:453).

The cervical vertebra can be categorized as either typical or atypical. The typical vertebrae comprise C3-C6, and the atypical vertebrae comprise C1, C2 and C7 (Foreman and Croft 1995:262). Each vertebrae consists of two major parts – the anterior vertebral body, composed of a cortical shell and cancellous core, which is the major weight bearing structure of the vertebra, and the posterior vertebral arch. The vertebral arch is composed of the pedicle, which joins the arch to the body and to which the superior articular process is attached. This superior process articulates with the inferior process by means of the articular facet joint and the transverse and spinous processes (Hertling and Kessler 1990:453).

The facet / zygapophysial joints are true diarthrodial joints, with articular cartilage and a loose capsule lined with synovial membrane (Gatterman 1990:14). They are clinically important for at least two reasons. First, facets have been found to be a direct source of pain and second, they are important stabilizing structures (White and Panjabi 1990:39).

The size and mass of the vertebrae increase from the first cervical to the last lumbar vertebra. This is a mechanical adaption to the progressively increasing compressive loads to which the vertebrae are subjected. The intervertebral discs separate the bodies of the typical vertebrae and are thicker anteriorly, resulting in the normal cervical lordosis (White and Panjabi 1990:29-60). They consist of an outer annulus fibrosis, made of fibrocartilage, and an inner nucleus pulposis, composed of a proteoglycan gel (Bland 1994:61).

The occipitoatlantal joint ( C0-C1) and the atlanto-axial joint ( C1-C2) are atypical joints as they have no intervertebral discs, no facet joints and have different movement to the rest of the cervical joints. The occipitoatlantal joint allows for flexion and extension and the atlanto-axial joint accounts for 50% of the rotation in the cervical spine (Gatterman 1990). The atlas (C1) lacks a body but has an anterior and posterior arch. The axis (C2) has an odontoid process or dens projecting cephalad from its body (Foreman and Croft 1995:265).
The vertebra prominens (C7) is considered atypical as the vertebral artery normally does not pass through its transverse foramen and it has a prominent

spinous process. This prominence is due to the attachment of numerous ligaments and muscles to this spinous process (Gatterman 1990:207).

The ligaments are vital for the structural stability of the spinal system. Their principal role is to prevent excessive motion (Hertling and Kessler 1990:469). The ligaments must protect the spinal cord in traumatic situations in which high loads are applied at fast speeds. In these highly dynamic situations (e.g. whiplash), not only is the displacement to be restricted within safe limits, but large amounts of energy suddenly applied to the spine must be absorbed (White and Panjabi 1990:19). The ligaments are also the principle tensile load-bearing elements and, along with the apophysial capsules, provide the central nervous system with information in regard to posture and movement (Hertling and Kessler 1990:469).

The ligaments that are most commonly found injured in major whiplash injuries are the anterior and posterior longitudinal ligaments, the capsular ligaments, the ligamentum nuchae and the ligamentum flavum (Foreman and Croft 1995:296). The anterior and posterior longitudinal ligaments attach to the anterior and posterior aspects of the vertebral bodies respectively. The anterior longitudinal ligament serves to limit extension and the thinner posterior longitudinal ligament limits excessive flexion (Foreman and Croft 1995:277). The capsular ligaments provide flexion stability in the cervical spine. The ligamentum flavum has the highest percentage of elastic fibers of any tissue in the body. This is an important factor in a sudden flexion to extension situation as the high elasticity of the ligament, together with its pre-tension, minimizes the chances of any impingement of the spinal cord (White and Panjabi 1990:21-23). The ligamentum nuchae is thought to play a major proprioceptive role in the appropriate functioning of the erector spinae muscles. Damage to this structure may be a factor in some whiplash-type injuries (White and Panjabi 1990:291), possibly resulting in abnormal muscle responses and tone.

A high degree of finely coordinated muscle balance is required to support and move the head on the neck. This is achieved by paired lateral groups of muscles attached to the skull, spinous processes and transverse processes. The deep cervical muscles operate with the sternocleidomastoid and other anterior neck muscles to help resist any sudden or accidental backward movement of the skull. The various deep suboccipital muscles serve to balance the skull on the upper end of the spine (Bland 1994:69).

The skin, muscles, tendons, ligaments, periosteum, intervertebral disc and facet joints of the neck are extensively innervated by nerves that may relay sensory information to the central nervous system (Bolton 1997). There are a number of morphologically specialized nerve endings and receptors found in the neck. The muscle spindle is the most common encapsulated nerve ending in the neck and is found in the deeper portions of the muscle. The Golgi tendon organ is found in musculotendinous junctions at origins and insertions of neck muscles. Pacinian corpuscles are in muscle adjacent to tendons and the fibrous material of the facet joints (Bolton 1997). The muscle spindle receptors occur in particularly high densities in the intervertebral muscles of the neck, and relatively high densities in the large, dorsal muscles of the neck. Afferents from these muscles are known to have profound effects on postural reflexes (Taylor and McCloskey 1988)

There are intrinsic joint receptors that were classified by Wyke in 1967, namely types I – IV. Types I and II have been associated with segmental manipulation and reflex performance (Wyke 1985). Type I is a thinly encapsulated globular corpuscle that is a low threshold, slow adapting, static and dynamic mechanoreceptor. It is involved in tonic reflexogenic effects on neck, limb, jaw and eye muscles. It is also involved in postural and kinesthetic sensation and pain suppression. Type II is a thickly encapsulated conical corpuscle that is a low threshold, rapidly adapting, dynamic mechanoreceptor. It is involved in phasic reflexogenic effects on neck, limb, jaw and eye muscles and is involved in pain suppression (Wyke 1985).

## 2.6 Clinically Relevant Biomechanics of the Cervical Spine

The neck consists of several joints and is an area that sacrifices stability for mobility and is thus vulnerable to injury (Magee 1992:34).

Motion occurs in the cervical spine in three dimensions. The elements primarily responsible for the mobility of the spine are the discs and facet joints. The other passive elements (e.g., ligaments, bone) also exert an influence on motion, but probably are more influential at the end of range of motion. Active elements (e.g., muscles and ligaments) can also affect the kinematics of the spine (Bland 1994:374). Flexion – extension occurs at both the occipito-atlantal and the atlanto-axial articulations. The average combined range of motion at this complex is 23 degrees flexion and extension. Most of the axial rotation in the upper cervical spine takes place at the C1-2 articulation (Bland 1994:374). Approximately 60% of the axial rotation of the entire cervical spine and occiput is found in the upper region (C0-C2). Lateral bending is a very complex motion and only occurs at C0-C1 in the upper cervical spine (Bland 1994:374).

In the middle and lower cervical spine (C2-C7), lateral bending is partially constrained by the uncinate processes; and axial rotation is constrained by the uncinate processes and facet joints (Bland 1994:374). However, most of the motion in flexion / extension is in the central region. The C5 – C6 interspace is generally considered to have the largest range. There may be some causal relationship between this observation and the incidence of cervical spondylosis at that interspace (White and Panjabi 1990:97).

When the cervical spine is positioned in slight lordosis, there is good passive stability from the facet joints and supporting ligaments. When the cervical lordosis is lost or the cervical curve is reversed, passive stability is lost, and the segmental muscles must go into constant contraction to stabilize the spine. Normally, the facet joints are able to bear approximately one third each of the compressive forces of the spine, however, when the cervical lordosis is lost, the entire compressive force is borne by the disc, causing excessive pressure and flattening (Hertling and Kessler 1990:504-505). This is relevant to the patient with whiplash injury, where loss of cervical lordosis is a common radiographic finding.

### 2.6.1 Biomechanics of whiplash

The understanding of what happens to the cervical spine during low-velocity, rear-end collisions is limited, despite a wealth of experimental studies on the biomechanics of the cervical spine. Most of these studies focus on the injury mechanisms in severe cervical spine injuries (Spitzer et al. 1995).

The mechanism of whiplash injury is acceleration of the head and neck relative to the body. The most common mechanism of injury is an automobile at rest struck from behind (Hertling and Kessler 1990:516). The patient’s head is thrown backward in a violent, unrestrained hyperextension of the neck. Recoil follows, and the head extends forward in extreme flexion. This is limited by the chin striking the chest or steering wheel (Bland 1994:402). If the head does not strike anything, the injury is produced solely by inertial forces (Tollison and Satterwaite 1993:15).

The neck is unable to adequately compensate for the rapidity of head and torso movement resulting from the acceleration forces generated at the time of impact. This is particularly true when the impact is unexpected and the victim is unable to brace for it (Tollison and Satterwaite 1992:293). The duration of this event, including neck flexion, is approximately 20 milliseconds. Because a protective muscular counteraction requires 50 milliseconds, it is likely that injuries will occur (Gimse et al. 1996). The neck flexor muscles may contract forcefully to counter the sudden neck extension on impact. However, by the time they react, the neck may actually be moving into flexion such that the muscle contraction may paradoxically augment forward force, throwing the spine into further flexion (Tollison and Satterwaite 1992:294). Head injury may also occur as the brain is forced forward and backward in the skull, with consequent cerebral concussion, contrecoup, cerebral contusion and headache (Bland 1994:403).

When the physiological limits of cervical structures are exceeded, anatomical disruption of the soft tissues of the neck (including muscles, ligaments and joint capsules) results (Teasell and Shapiro 1998:72). In general, it can be said that in a whiplash injury, the lower cervical segments (C4-C7) receive the brunt of the damage most of the time. However the majority of whiplash patients have some degree of upper cervical pain, which would not be consistent with the sparing of that area (Foreman and Croft 1995:73). In contrast to most authors, Tollison and Satterwaite (1992:16) state that the upper cervical spine is the most vulnerable area in whiplash injuries and that flexion-extension injury to the atlanto-occipital joint or upper neck sprain is more common than injury between C4 to C7.

Many studies have been conducted to study the effects of whiplash on the spine and supporting soft tissues. By using dummies, laboratory animals, cadavers and occasionally human volunteers exposed to full-scale crash testing, researchers have formulated mathematical models that help quantify the forces that the skull and spine are subjected to at varying collision speeds. Other variables include sizes of vehicles, road conditions, direction of impact, seat back height and stiffness, seatbelt use, head restraints and air bags (Foreman and Croft 1995:2).

## 2.7 Radiological findings in WAD

Exclusion of fractures and dislocations is a first priority in the acute whiplash injury, although radiographs often appear normal. A minimum of frontal, lateral and oblique projections should performed, and once scrutinized for any contra-indications, flexion-extension studies can be done. Radiographs may provide the clinician with information regarding contraindications to manipulation, retropharyngeal haematomas and, when stress views are done, segmental instability (Yochum and Rowe 1996:681).

Following acute whiplash injury, radiographs of the cervical spine are often reported as showing a loss of the normal lordotic curve or a flattening of the normal curve. Radiologists often say this change is characteristic of muscle spasm but this interpretation is incorrect. The neck acts like a bow: if the major muscles of the neck go into spasm, the curve would be exaggerated, not flattened (Mennell 1992:123). According to Yochum and Rowe (1996:684), altered patterns of lordosis may occur as a result of posterior ligamentous injury, muscle spasm or patient positioning. A kyphosis in the cervical spine is suggestive of disruption of the posterior ligamentous complex and may be associated with a higher incidence of disc degeneration at this level a few years later (Yochum and Rowe 1996:684).

In a study by Hildingsson and Toolanen (1990), of the 88 WAD patients, 45 showed normal radiographs, 7 showed degenerative spondylosis and a loss of lordosis or kyphosis was seen in 33 cases. Spondylosis with a straight or kyphotic curve was seen in 3 of the cases.

Hohl (1974) demonstrated a normal lordotic cervical curve in 42%, a loss of lordosis in 35%, a reversed/kyphotic curve in 9% and a sharp reversal in 14% of 146 WAD patients in his study. A significantly higher incidence of degenerative changes occurred in the patients with sharp reversal of the normal cervical curvature ($p<0.05$).

Restricted post-traumatic cervical motion has been shown to develop a high incidence of degenerative changes in the following five years. Degenerative disc disease may be demonstrated as early as 3 months following injury (Yochum and Rowe 1996:689).

## 2.8 Current Available Treatment for WAD

A wide variety of interventions are available to treat patients with whiplash injuries. Unfortunately, there is a paucity of adequate clinical trials, and reports of efficacy remain largely anecdotal. No treatment consistently cures the pain of whiplash injuries (Teasell and Shapiro 1998:78). Most therapeutic interventions currently used in patients with WAD have not been evaluated in a scientifically rigorous manner, and those that have show little or no evidence of efficacy (Spitzer et al. 1995). In the broad spectrum of spine problems, this is one of the most difficult syndromes to manage (White and Panjabi 1990:235).

Medical treatment of WAD typically involves the use of soft collars, analgesics and anti-inflammatories, rest and traction (White and Panjabi 1990:235, Bland 1994:403). Spitzer et al. (1995) found that the use of soft collars may promote inactivity, which can delay recovery in patients with WAD. Collars should not be worn for longer than 72 hours. Prescription of rest in the first few days is a common recommendation for WAD, however, cumulative evidence suggests that prolonged periods of rest are detrimental to recovery in WAD. There is weak evidence that traction is of short-term benefit to WAD sufferers (Spitzer et al. 1995).

Analgesics and non-steroidal anti-inflammatory drugs combined with other treatment modalities were associated with short-term benefit for WAD grades I and II that presented in the acute phase or less than 72 hours post-collision. Although commonly prescribed, muscle relaxants were shown to have no benefit to the WAD sufferer.

Surgery is not indicated for Grades I and II. It is to be restricted to the rare WAD Grade III with persistent arm pain, that does not respond to conservative management or, with rapidly progressing neurologic deficit (Spitzer et al. 1995). Surgical intervention is of little or no use in most WAD patients as cervical disc herniation is an unlikely source of pain (Tollison and Satterthwaite 1992:313).

Of the active treatments available, mobilisation, manipulation and active exercise were identified as the options with the most scientifically established validity. However, only the short-term efficacy of mobilisation and manipulation was established. No studies addressing the long-term benefits of manipulation have been performed. It was recommended that manipulation only be performed by qualified personnel (Spitzer et al. 1995). The independent benefit of exercise could not be established, but was recommended as an adjunct to other therapies (Spitzer et al. 1995).

## 2.9 Cervical Spine manipulation

The source of the neck pain in WAD patients is a common debate. However, recent studies have shown that as many as 85% of WAD patients have their pain originating from the cervical facet joints (Yochum and Rowe 1996:681). One study by Lord et al. (1996) investigated the prevalence of cervical zygapophysial joint pain among 68 patients with chronic neck pain after whiplash injury. Two different local anaesthetics and a placebo injection of normal saline were administered in random order and under double-blinded conditions. A positive diagnosis was made if the patients' pain was completely and reproducibly relieved by each local anaesthetic but not by the placebo injection. Overall, the prevalence of cervical zygapophysial joint pain was 60% (95% confidence interval). In a similar study by Barnsley et al. (1995), painful facet joints were identified in 54% of 50 WAD patients. These studies support the theory that facet joints are a common source of pain in the WAD patient.

An articular fixation is any physical or functional mechanism that produces a loss of segmental mobility within a normal physiological range of motion (Schafer and Faye 1989:2). The fixation in a facet joint may be the result of adhesions in the joint capsule and capsular ligaments, caused by some traumatic injury to these ligaments (Bergmann 1990:150). Chiropractic manipulation is thought to reduce this fixation by breaking these adhesions, stretching the affected tissue, restoring mobility and normalising mechanoreceptive and proprioceptive input. It is also postulated that it does so without triggering an inflammatory reaction and the reoccurrence of fibrosis (Bergmann 1990:150).

Manipulation therapy has been shown to improve pain tolerance. Spinal manipulative treatments show a consistent reflex response of multireceptor origin and may cause clinically observed benefits, including a reduction of pain and a decrease in hypertonicity of muscles (Davis 2001, Tollison and Satterthwaite 1992:311).

In a study by Cassidy et al. (1992) the immediate effects of manipulation on pain and range of motion in the cervical spine were assessed. It was the only accepted study on the effects of manipulation in WAD by the Quebec Task Force in 1995, as their criteria included only randomised, controlled trials. Fifty patients with unilateral neck pain were assessed using the 101-point numerical rating scale (NRS-101) and a goniometric examination. Each patient then received a single, rotational manipulation to the same side as the pain from an experienced chiropractor. Within 5 minutes, the patient repeated the NRS-101 questionnaire and the goniometer readings. The results showed an increase in all planes of post-treatment ROM and a decrease in post-treatment pain scores, thus supporting the clinical efficacy of manipulation for neck pain.

A small study on 10 WAD patients and 9 controls involved the effects of a 6-week regimen of chiropractic manipulation with an Activator Instrument on neck pain, ROM and cervical finite helical axis parameters (FHAP). Mean pain scores decreased from 44.1 to 10.5 and mean ROM increased from 234° to 297° ($p<.0001$). They concluded that spinal manipulative therapy may be beneficial to patients with whiplash injury, and future studies with large sample sizes are warranted (Osterbauer et al.1992).

A retrospective study was undertaken to determine the effects of chiropractic in a group of 28 patients who had been referred with chronic WAD. The severity of patients' symptoms was assessed before and after treatment using the Gargan and Bannister (1990) classification. Improvement was seen in 93% ($p<0.001$) of the patients following chiropractic treatment (Woodward et al. 1996).

In a local study by Kruger (2000), the effect of manipulation of the cervical spine was compared to a placebo treatment, for the treatment of subacute and chronic whiplash injury. The experimental group showed significant improvement ($p=0.05$) for all ranges of motion except flexion. No conclusions could be drawn in terms of pain, discomfort or disability as no significant inter-group changes were found.

## 2.10 Proprioception and WAD

Pain is not the only sequela to whiplash. Because the cervical spine is richly supplied with mechanoreceptors and muscle spindles, chronic pain can play a major role in locomotor system dysfunction and in its perpetuation associated with whiplash trauma. Hypertonicity of the muscles, autonomic reflexes and over-excitation of proprioceptors affecting the central nervous system play a pre-eminent role in the genesis of disequilibrium and chronic postural instability from whiplash-induced injury. As a result of disorganized proprioceptive activity, a whiplash injury can cause distortion of the posture control system, including oculomotor dysfunction (Davis 2001).

A tonic coupling between the horizontal component of eye position and dorsal neck muscle activity has been demonstrated in animals and humans (Andre-Deshays et al. 1988). Andre-Deshays et al. (1991) found subsequently that eye-head coupling is present not only in the fixation period but also during saccades (rapid eye movements) and that a phasic activity or suppression related to saccadic eye velocity is present in dorsal neck muscle EMG.
Damage to neck muscles is associated with a transient disturbance to posture. It is now recognised that neck afferents are involved in three postural related reflexes: Firstly, the cervico-collic reflex, which involves activation of neck muscles when they are stretched, as occurs when the head is displaced with respect to the body. In asymptomatic subjects the cervico-collic reflex is

integrated with the vestibulocollic and optokinetic reflexes to assist in the maintenance of head position. Secondly, the tonic neck reflex involves alteration in limb muscle activity when the body moves with respect to the head and acts to maintain a stable posture. Thirdly, the cervico-ocular reflex, together with the vestibulo-ocular and optokinetic reflexes, serve to assist in maintaining eye position (Bolton 1997).

In a review of the literature, Fitz-Ritson (1995) concluded that subjects with scoliosis and paraspinal muscular imbalances had inappropriate proprioception into brainstem nuclei. The vestibular nuclear complex receives converging proprioceptive signals from the labyrinth and oculomotor apparatus and efferent projections from that part of the vestibular nuclear complex are directed to the spinal cord, and contribute to neck muscle control. The “phasic” component of the muscles in the cervical region is believed to be complementary to the vestibular-ocular reflex (Fitz-Ritson 1995).

Revel et al. (1994) investigated the effect of proprioceptive rehabilitation in 60 patients with neck pain in a randomised, controlled trial. They used a system of exercises involving the techniques of eye-head coupling. The experimental group showed a significant improvement (p=0.005) over the control group in terms of pain and proprioceptive function. They concluded that these exercises should be used to treat patients with chronic neck pain.  The results showed that the proprioceptive system of the neck has learning capabilities and can be improved by rehabilitation techniques.

Gimse et al. (1996) used neuropsychological and otoneurological tests to evaluate patients with a history of WAD in a controlled study. The control group was closely matched to the whiplash group with respect to age, sex, education and occupation. The whiplash group deviated significantly from the control group on measures of eye movements during reading, on smooth pursuit eye movements with the head in normal position, and with the body turned to the left or right. Clinical, caloric and neurophysiological tests showed no injury to the vestibular system or to the CNS. Test results thus suggest that injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganised neck proprioceptive activity.

It would therefore appear that the proprioceptive rehabilitative exercises mentioned above (Revel et al. 1994) would benefit WAD sufferers, which was found to improve the head-repositioning abilities of the proprioceptive system.

## 2.11 Combined Manipulation and Proprioceptive exercises

Rogers (1997) conducted a controlled trial investigating the effects of spinal manipulation on proprioception in subjects with chronic neck pain. The results indicated a 41% improvement in head-repositioning skill in the manipulation group compared to 12% in the control group, which was significant (p<.0.05). There was also an improvement of 44% in visual analogue scores in the manipulation group as opposed to a 12% improvement in the control group. The study was however weakened by the small sample size of 10 subjects and lack of randomisation. This evidence together with the findings of Revel et al. (1994) suggests that a combination of manipulation and proprioceptive rehabilitation may offer an improved treatment protocol for WAD.

Cervical spine adjustments have been found to have a significant effect on the tone of the lumbo-pelvic musculature, presumably by facilitating tonic neck reflexes involving intersegmental spinal pathways (Nansel et al. 1993). These observations may go a long way towards explaining the postural instability experienced by WAD patients, especially when wearing cervical support collars or in poorly illuminated environments (Wyke 1985). Postural disturbances have been observed as a result of soft-tissue injury, which provides a visual clue of reflexogenic activity (Colloca 1997, Nansel et al.1993). Thus cervical spine manipulation in the WAD patient may have a positive effect on posture and proprioception as well as pain levels.

Tonic muscle responses correspond with head-on-body position and are cervical in origin, and phasic muscle responses correspond to head-on-trunk movement and are derived from both the neck and the vestibular apparatus (Taylor and

McCloskey 1988). Isometric exercises are sometimes given to WAD patients to rehabilitate the neck (Foreman and Croft 1995:462); however, these address only the slow tonic muscles (Fitz-Ritson 1995). It appears that exercises that also address the phasic component of cervical proprioception are needed for treatment of WAD.

The combination of proprioceptive rehabilitation and neck manipulation in WAD sufferers was investigated by Fitz-Ritson (1995). Thirty chronic MVA patients with neck pain were selected for the study. The control group received manipulation and standard exercises (stretching/ isometric/ isokinetic). For the experimental group, he utilised exercises developed over a number of years that require use of the “phasic” component of the cervical spine muscles along with chiropractic manipulation. The results of the pre and post CMCC Neck Disability Index assessment (Appendix F) suggested that this approach was indeed superior ($p>0.001$), but the study had a number of shortcomings. These included a small sample size of 15 and non-uniformity in terms of gender, age and the number of MVA related whiplash injuries. The author suggested further studies address these shortcomings.

This study will therefore attempt to address previous shortcomings by stratifying the ages of subjects and limiting the number of WAD incidents. This will possibly contribute to the management protocol of WAD.

# Chapter Three

## 3.0 Materials and Methods

## 3.1 Introduction

This chapter includes a detailed description of the research methodology and a plan for the statistical analysis thereafter.

## 3.2 Subjects

### 3.2.1 Sampling

This study utilized stratified convenience sampling, as a specific diagnosis of WAD was required. Advertisements were placed at local gyms, technikons, universities, panel-beaters, newspapers, sports clubs, insurance brokers and via pamphlet distribution in the greater Durban area.

Patients with WAD then phoned in, enquiring about the study, after which they were interviewed telephonically. The interview was conducted to determine whether they met the inclusion criteria, in terms of their age, and nature, chronicity and location of their complaint.

### 3.2.2 Inclusion Criteria

The following inclusion criteria were adhered to, in order to increase homogeneity in the study, and ensure all patients accepted into the study suffered from WAD.

a) The patient had to be between the ages of 18 and 60 years. Fitz-Ritson (1995) used a similar age range of 19 – 57 years. He discovered a shortcoming in his study whereby the two groups were not similarly matched in terms of age distribution. This study was therefore stratified for age so as to equally distribute the subjects in each group as follows: 18 – 29 yrs, 30 – 44 yrs, 45 – 60 yrs. Applicants were then selected to consecutively fill these strata i.e.: every even number applicant within an age stratum was allocated to Group 2 and vice-versa for Group 1.

b) The number of whiplash injuries per subject was also limited. This is due to the findings of Fitz-Ritson (1995) where patients with a greater number of WAD incidents responded less well to treatment. This study therefore only included subjects with a history of no more than two WAD incidents.

c) Chronic was defined as 6 weeks and longer after the initial injury (Kruger 2000). All subjects had to have had a whiplash injury at least 6 weeks prior to acceptance into the study. For the purposes of this study, all subjects had to have had a whiplash injury less than 15 years previously.

d) Subjects had to present with neck pain and cervical spine fixation complexes identified using Motion Palpation techniques as described by Schafer and Faye (1989:79-139). In addition, patients had to have any 2 of the following 8 possible signs and symptoms of WAD:

- headaches
- limitation of neck movement
- upper thoracic pain
- tenderness to palpation over the neck musculature
- low back pain
- dizziness / vertigo
- tinnitus
- visual disturbances

Adapted from Foreman and Croft (1995:96), Teasell and Shapiro (1998:73-75).

### 3.2.3 Exclusion Criteria

The exclusion criteria were:

a) Subjects with any contra-indications to manipulation (Foreman and Croft 1995:469, Bergmann et al. 1993:133) were not included in the study as both treatments involved cervical spine manipulation.

These contra-indications included: vertebrobasilar insufficiency, aneurysm, disc prolapse with neurological deficit, fracture, dislocation, bone tumours and bone infections.

Relative contra-indications included: atherosclerosis, anti-coagulant therapy, advanced osteoarthritis, inflammatory arthritis, joint instability, osteomyelitis, osteomalacia and space occupying lesions.

b) Patients were asked not to alter their lifestyle in terms of exercise, regular activities and medication use. Should they have needed to do so, they would have been excluded from the study.

c) Subjects that were receiving any other form of physical therapy or treatment for their WAD were excluded from the study. This included the use of cervical collars, analgesics or anti-inflammatory medication.

d) Applicants without cervical spine radiographs following the whiplash injury were excluded from the study. Patients who had had radiological examination for the condition were asked to present either a radiologist's report or X-rays to confirm the absence of fractures, instability and other contra-indications to cervical spine manipulation. Radiographic examination is recommended for all patients with WAD (Yochum and Rowe 1996:681).

### 3.2.4 Subject Acceptance

Those patients considered suitable for the study after the interview by the researcher were informed, and an initial consultation was then scheduled for the patient. At the initial consultation, the purpose of the study was explained to the patient and a case history, relevant physical examination and regional examination of the cervical spine performed (Appendices A, B and C). During this process, they were screened for compliance with the inclusion and exclusion criteria. Those then accepted into the study were asked to read a patient information letter (Appendix D) and sign an informed consent form (Appendix E).

## 3.3 Procedures

Thirty patients meeting the research criteria were utilized for the study. Stratified convenience sampling was used and every odd numbered applicant within an age stratum was allocated to Group 1 and vice-versa for Group 2. This allowed all patients an equal chance of falling into either group. Those patients in Group 1 received cervical manipulation and proprioceptive exercises for their WAD, whilst those in Group 2 received cervical manipulation alone. Group 1 formed the experimental group and Group 2 the control group.

At the initial consultation, the patient completed the CMCC Neck Disability Index (Appendix F).

Motion Palpation technique was carried out during the cervical regional examination, as referenced in Schafer and Faye (1989:79-139) in order to determine the level, the side and the direction of the loss of motion of the fixated joint.

After the area of joint dysfunction had been identified and recorded on the regional exam, the initial pressure algometer readings were taken. Following these readings, the patients Head Repositioning Accuracy (HRA) measurements were taken.

These subjective and objective measurements were assessed before treatments 1 and 4 and at the 7th follow-up visit.

### 3.3.1 Control Group - Group 2 : Cervical Spine Manipulation

The control group was motion palpated to identify the side and level of the lesion/s (Schafer and Faye 1989:79-139) and they were manipulated using a rotary adjustment. The patients were generally supine for the manipulations, unless they felt uncomfortable in that position, in which case they were placed in a seated position. A maximum of three fixations were manipulated at each visit.

The control group was positioned for their adjustment, the skin slack taken up and the joint moved to its end position. A high-velocity, low-amplitude, specifically directed force was then delivered from this end position (Haldeman 1992:485).

The adjustment techniques that were used are as described by Bergmann et al. (1993:253-292):

- For restricted rotation at segments C0 – C1, the hypothenar-occiput contact (supine) and/or the index contact (seated) were used.
- For restricted rotation at segments C1 - C2, the index – atlas contact (supine or seated) and/or the thumb-atlas contact (supine) were used.
- For restricted rotation at segments C2 – C7, the index contact (supine or seated) and/or the thumb-web contact (supine) were used.

If a technique was unsuccessful, another was used for that particular fixation. Success of an adjustment was based on an audible cracking sound and post manipulative manual cervical endplay assessment (Haldeman 1992:485).

### 3.3.2 Experimental Group – Group 1: Manipulation and Proprioceptive exercises

The patients in Group 1 received the same cervical spine manipulative therapy as those in Group 2.

However, prior to manipulation, they received the exercise protocol used by Fitz-Ritson (1995).

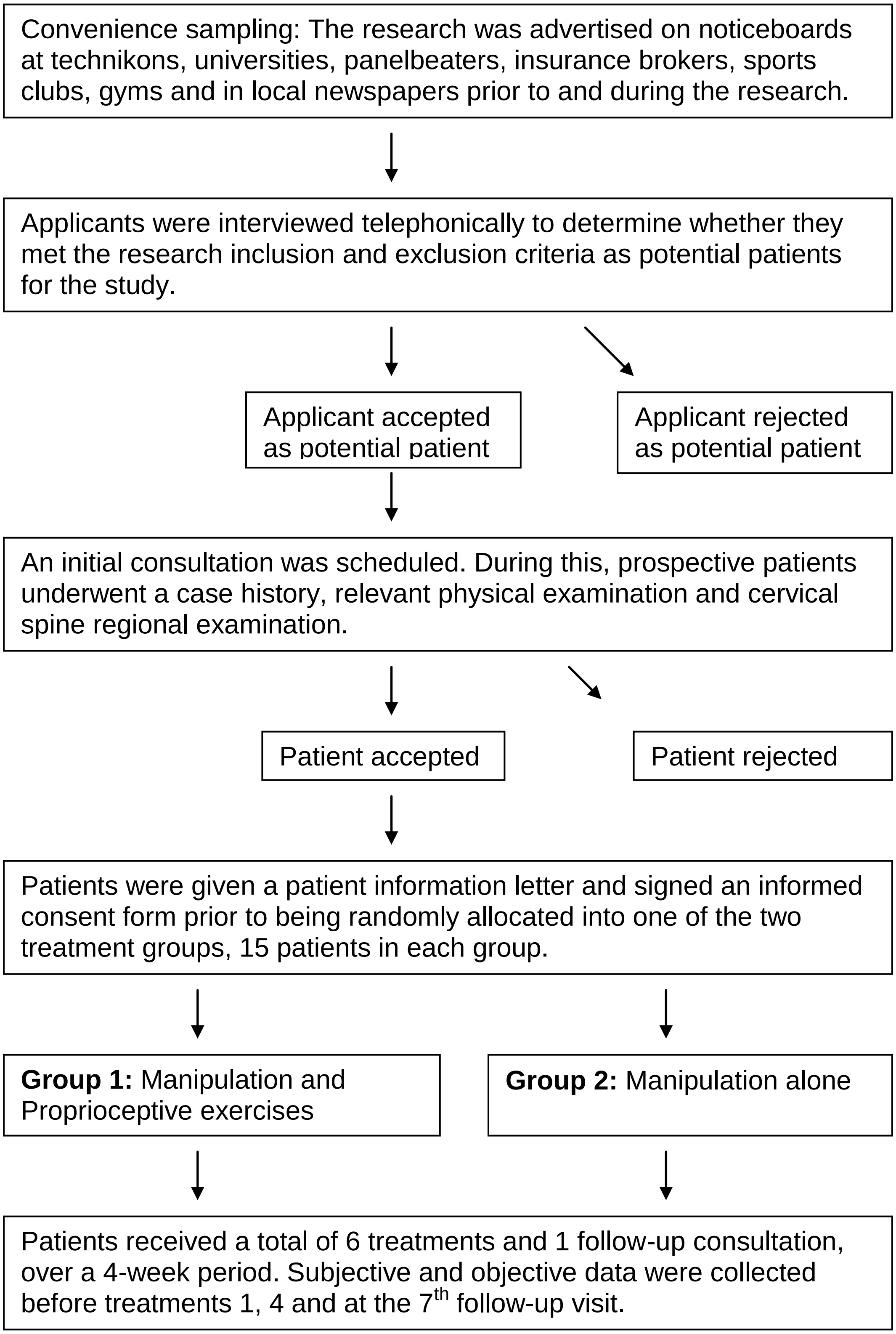
Each patient in Group 1 received an exercise sheet (Appendix H) depicting these proprioceptive exercises (Murphy 2000). They also each received a high density foam mat upon which to perform the exercises at home.

These exercises involved co-ordination of head, eye and body movements. In the study by Fitz-Ritson (1995), patients exercised for a minimum of four times weekly, for 8 weeks. Due to time restraints, the treatment period was condensed to 4 weeks. This was divided into two phases, each phase lasting 2 weeks. Each phase included 8 exercises which the patient had to perform daily. 5 – 10 repetitions of each exercise were recommended. Patients were instructed to begin slowly and focus on the components of the exercise. At the beginning of the 4$^{th}$ treatment i.e.: after the first 2 weeks of treatment, patients received phase 2 of their exercise protocol, which they performed for the remainder of the treatment period.

If any pain or discomfort was experienced whilst performing these exercises, patients were asked to reduce the number of repetitions of that exercise until they could achieve the exercise within a pain-free zone. They were then asked to slowly increase the number of repetitions of that exercise over the two-week period until a minimum of 5 repetitions could be performed. They were informed prior to acceptance onto the study of potential side-effects (Appendix D).

Patients performed the exercises before manipulation of their cervical spine and daily at home between treatment sessions. Those patients that admitted non-compliance were excluded from the study.

### 3.3.3 Flowchart (Critical Path)



## 3.4 <u>Materials</u>

### 3.4.1 Objective Measurements

Two forms of objective measurements were utilized namely: pain tolerance of specific areas of the articular pillar (Pressure Algometer) and testing head repositioning accuracy (HRA). (Appendix G)

#### 3.4.1.1 Pressure Algometer

A Pressure Algometer was utilized to determine and quantify localized tenderness by measurement of the pressure threshold of each patient.

Pressure threshold is referred to as the minimum pressure (force) that induces pain or discomfort (Fisher 1987). The Pressure Algometer is a force gauge, which measures force in kilograms per square centimeter. Fisher (1987) concluded in his study, using 50 volunteers, that changes in pressure threshold, obtained under clinical conditions, can be regarded as reliable data and also correlates well with changes in clinical status. The higher the reading on the algometer, the less tender the underlying structure and thus the greater the patient's pain tolerance.

Patients were informed of what to expect in terms of sensation prior to measurements being taken using the algometer. The algometer was applied over the most tender area of the articular pillar on the left and right sides as predetermined at the first consultation by tenderness to palpation. The instrument was held perpendicular to the skin and slow steady pressure applied. When the patient felt the first sensation of pain or discomfort, he/she said “stop” and the algometer was removed. The reading was recorded and subsequent measurements on visits 4 and 7 were taken at the same level on the articular pillar, as determined by palpation on the initial visit.

#### 3.4.1.2 Head Repositioning Accuracy

This was measured using a method devised and piloted by Revel et al. (1991) and utilized again by Rogers (1997). The patient was seated with a backrest, facing a target 120 centimeters away. They were blindfolded, wearing a helmet on top of which a laser pointer was fixed. The helmet was light-weight, stable and adjustable to fit the patients’ head. They were instructed to find a comfortable ‘neutral’ posture for their head. The projection of the light beam on the target represented the head-neck reference position and this was marked on the target. After several (approximately 8 – 10) seconds of concentration on this position, the patient performed a maximal rotation of the head to the left and then tried to relocate the reference position. The distance between the reference point and the point on which the light beam stopped indicated the error of repositioning (to the nearest 0.5 cm). This was then repeated for right rotation. Patients were not allowed to practice their repositioning skills, and only one reading per side was taken at visits 1, 4 and 7.

Revel et al. (1991) demonstrated that subjects with chronic neck pain performed this task significantly less accurately than healthy subjects, indicating an alteration in neck proprioception in the symptomatic group. A threshold value (4.5°) for accuracy was identified, with a discriminant value of 89% for symptomatic vs. asymptomatic subjects. They concluded that this test allows a discriminant classification of healthy and symptomatic subjects, justifies proprioceptive rehabilitation programs and allows a quantitative evaluation of their results.

HRA scores were used again in a study by Rogers (1997) to determine whether spinal manipulation or stretching exercises, as isolated interventions, had any effect on proprioception-dependent performance of subjects with chronic neck pain. The study was performed on 20 subjects with chronic neck pain whose pain levels (visual analogue scores) and HRA scores were assessed at baseline and at each of the 6 follow-up sessions. The results showed a correlation between pain levels and head repositioning ability, with the manipulation group demonstrating a mean reduction of 44% in visual analogue score and a 41%

improvement in HRA scores, while the stretching group only had a 9% mean reduction in visual analogue scores and a 12% improvement in HRA scores.

For the purposes of this study, only left and right rotation of the head was performed and the error of repositioning measured. The resulting two measurements were then averaged to produce a single number per subject for each session.

### 3.4.2 Subjective measurements

The CMCC Neck Disability Index was used to measure subjective pain intensity in this study.

#### 3.4.2.1 The CMCC Neck Disability Index

This questionnaire (Appendix F) was used to indicate the degree to which patients' neck pain interfered with their daily lives and activities, particularly those suffering from whiplash-type injuries. It consisted of 10 questions, including ratings of pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. Each question was scored at a maximum of 5 points and a minimum of 0 points. The patient answered these questions, receiving a total score out of 50 and this was calculated as a percentage.

The reliability and validity of the CMCC Neck Disability Index has been assessed in only 48 subjects, 70 % of whom had sustained whiplash injury within the past 4 to 6 weeks. However, it has been shown to demonstrate a high degree of test-retest reliability and internal consistency (Vernon and Mior 1991). It is applicable to a wide age range, is unaffected by gender, and has an acceptable level of validity.

Fitz-Ritson (1995) used the CMCC Neck Disability Index as his only outcome measure. The same questionnaire was used in this research to enable better comparison of the results.

## 3.5 Statistical Analysis

### 3.5.1 Introduction

A sample of 30 patients were utilized in this study, with $n_1 = 15$ and $n_2 = 15$. The Durban Institute of Technology research statistician was consulted with regards to the manner in which data was to be analyzed. The appropriate parametric and non-parametric tests were used to analyze the variables due to the small sample size of 15 patients per group. The SPSS statistical package was used for analysis of the data obtained from the CMCC Neck Disability Index, the Pressure Algometer and the HRA scores.

### 3.5.2 Inter-group comparison (manipulation and exercises versus manipulation alone)

Tests of Normality, namely the Kolmogorov-Smirnov test and Shapiro-Wilk test, were run to show whether the data did or did not exhibit trends of normality. Mann-Whitney U test, a non-parametric test and the Independent Samples T-test, a parametric test, was used to compare the manipulation and exercises group versus the manipulation alone group with regard to the CMCC Neck Disability Index, the Pressure Algometer and the HRA readings.

This test was used to determine whether any significant difference existed between the 2 groups for each of the variables, at the $\alpha = 0.05$ level of significance.

Hypothesis Testing

The null hypothesis ($H_0$) stated that there was no difference between the manipulation and proprioceptive exercise group, and the manipulation only group with respect to each of the variables.

The alternative hypothesis ($H_1$) stated that there was a difference.

$\alpha$ was set at a 0.05 level of significance.

- $H_0$: There was no mean difference between the groups.
- $H_1$: There was a mean difference between the groups.
- $\alpha = 0.05$ = level of significance of the test.

Decision rule

The null hypothesis ($H_0$) is rejected at the $\alpha$ level of significance if $p < 0.05$ where p was the observed level of significance or probability value. Failing this, the null hypothesis ($H_0$) was accepted at the same level of significance ($p \geq 0.05$).

### 3.5.3 Intra-group comparison (manipulation and exercises group and manipulation alone group)

Descriptive Statistics were generated to identify trends in the data. The Anova test, a parametric test and Friedman's T-test, a non-parametric test, compares three or more paired groups. These tests coupled with the Multiple Comparison Procedure (parametric) and the Wilcoxon test (non-parametric) were used to determine whether any significant improvement occurred within each group with regards to the CMCC Neck Disability Index, the Pressure Algometer and the HRA readings, between the 1$^{st}$, 4$^{th}$ and 7$^{th}$ consultations. The Multiple

Comparison Procedure and Wilcoxon test was used as a post-hoc test to determine which group differed from which other group, if the p value was small.

Hypothesis Testing

The null hypothesis ($H_0$) stated that there was no improvement between consultations with regards to the CMCC Neck Disability Index, Pressure Algometer and HRA readings. The alternative hypothesis ($H_1$) stated that there was an improvement between consultations with regards to the variables of interest.

Decision rule

The null hypothesis was rejected at the $\alpha = 0.05$ level of significance if $p < 0.05$ where p was the observed level or probability value. Otherwise, the null hypothesis was accepted at the $\alpha$ level of significance.

# Chapter Four

## 4.0 Results

## 4.1 Introduction

This chapter will represent the data and attempt to analyse the data in tabular form in order to accept or reject the hypotheses. The subjective and objective findings of both groups are discussed. Demographic data, accident related data and patient data were also highlighted.

## 4.2 Demographic Data

**Table 4.2.1 Age distribution**

| Age range | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| 18 – 29 yrs | 9 | 10 | 19 | 63.3 % |
| 30 – 44 yrs | 3 | 1 | 4 | 13.3 % |
| 45 – 60 yrs | 3 | 4 | 7 | 23.3 % |
| **Mean age** | 32.53 | 32.4 | 32.47 | |

**Table 4.2.2 Gender distribution**

| Gender | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **Female** | 9 | 10 | 19 | 63.3 % |
| **Male** | 6 | 5 | 11 | 36.7 % |

**Table 4.2.3 Race distribution**

| Race | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **White** | 14 | 12 | 26 | 86.7 % |
| **Indian** | 1 | 2 | 3 | 10 % |
| **Coloured** | 0 | 1 | 1 | 3.3 % |

**Table 4.2.4 Number of WAD incidents**

| No. of WAD | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **1 WAD** | 10 | 9 | 19 | 63.3 % |
| **2 WAD** | 5 ( 4 male ) | 6 ( 5 male ) | 11 | 36.7 % |

**Table 4.2.5 Time elapsed since most recent WAD**

| Time frame | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **< 8 weeks** | 2 | 4 | 6 | 20 % |
| **8 wk – 6 mo** | 0 | 1 | 1 | 3.3 % |
| **6 mo – 1 yr** | 1 | 3 | 4 | 13.3 % |
| **1 yr – 2 yr** | 7 | 0 | 7 | 23.3 % |
| **2 yr – 5 yr** | 4 | 5 | 9 | 30 % |
| **5 yr – 15 yr** | 1 | 2 | 3 | 10 % |

**Table 4.2.6 Type of whiplash injury (most recent)**

| Type | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **MVA** | 13 | 12 | 25 | 83.3 % |
| **Motorcycle** | 0 | 1 | 1 | 3.3 % |
| **Watersports** | 1 | 1 | 2 | 6.7 % |
| **Diving** | 0 | 1 | 1 | 3.3 % |
| **Rugby tackle** | 0 | 0 | 0 | 0 % |
| **Boat accident** | 1 | 0 | 1 | 3.3 % |

**Table 4.2.7 Direction of collision (MVA only)**

| Direction | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| **Rear** | 7 | 4 | 11 | 44 % |
| **Front** | 3 | 3 | 6 | 24 % |
| **Side** | 1 | 4 | 5 | 20 % |
| **Roll** | 2 | 0 | 2 | 8 % |
| **Spin** | 0 | 1 | 1 | 4 % |

**Table 4.2.8 Position in car (most recent MVA)**

| Position | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| **Driver** | 10 | 9 | 19 | 76 % |
| **Passenger front** | 1 | 3 | 4 | 16 % |
| **Passenger back** | 2 | 0 | 2 | 8 % |

**Table 4.2.9 Seatbelt use (most recent MVA)**

| Seatbelt | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| **On** | 4 | 8 | 12 | 48 % |
| **Off** | 9 | 4 | 13 | 52 % |

**Table 4.2.10 Head Position (most recent MVA)**

| Head position | Group 1 (n = 13) | Group 2 (n = 12) | Total | % |
|---|---|---|---|---|
| **Forward** | 12 | 9 | 21 | 84 % |
| **Left** | 1 | 0 | 1 | 4 % |
| **Right** | 0 | 3 | 3 | 12 % |

**Table 4.2.11 Injuries other than WAD (most recent MVA)**

| Injuries | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **None** | 10 | 14 | 24 | 80 % |
| **Bumped head only** | 2 | 0 | 2 | 6.7 % |
| **Bumped head – confusion** | 1 | 0 | 2 | 6.7 % |
| **Bumped head – concussion** | 1 | 1 | 1 | 3.3 % |
| **Dislocated AC joint** | 1 | 0 | 1 | 3.3 % |

**Table 4.2.12 Subjective location of cervical spine pain**

| Location | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **Sub-occipital** | 10 | 8 | 18 | 60 % |
| **Mid-cervical** | 3 | 4 | 7 | 23.3 % |
| **Lower cervical** | 1 | 1 | 2 | 6.7 % |
| **Entire c-spine** | 1 | 2 | 3 | 10 % |

**Table 4.2.13 Distribution of signs and symptoms**

| Signs and symptoms | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **Neck pain** | 15 | 15 | 30 | 100 % |
| **C-spine fixation** | 15 | 15 | 30 | 100 % |
| **Headaches** | 13 | 15 | 28 | 93.3 % |
| **Limited neck movement** | 10 | 11 | 21 | 70 % |
| **Upper thoracic pain** | 10 | 11 | 21 | 70 % |
| **Tenderness to palpation** | 11 | 11 | 22 | 73.3 % |
| **Low back pain** | 8 | 2 | 10 | 33.3 % |
| **Dizziness / vertigo** | 3 | 1 | 4 | 13 % |
| **Tinnitus** | 0 | 0 | 0 | 0 % |
| **Visual disturbances** | 1 | 0 | 1 | 3.3 % |

**Table 4.2.14 Radiographic findings**

| Radiographic findings | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **Normal** | 2 | 4 | 6 | 20 % |
| **Loss of lordosis** | 11 | 10 | 21 | 70 % |
| **Kyphosis** | 2 | 0 | 2 | 6.7 % |
| **Scoliosis** | 0 | 1 | 1 | 3.3 % |

## 4.3 <u>Results of Data Analysis</u>

### 4.3.1 Subjective data (CMCC Neck Disability Index)

### 4.3.1.1 Inter-group Comparison

4.3.1.1.1 Tests for normality

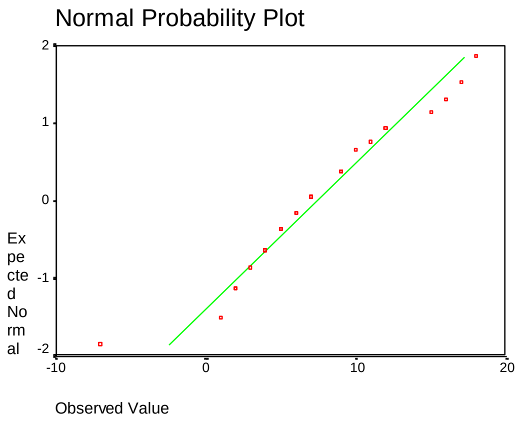
Before conducting the two independent sample T-Tests, we check if the assumption of normality and equal variances of both populations is false. Also note that this test is fairly robust to the assumption of normality. A test for non-normality in the table below suggests both sets of data are not significantly non-normal. (the p value, which equals 0.389, is not less than 0.05). Evidence of this is also portrayed in the normal probability plot below.

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| NDI13 | .108 | 30 | .200* | .964 | 30 | .389 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction



#### 4.3.1.1.2 Comparison of drop in CMCC NDI scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| NDI13 | 1 | 15 | 8.8667 | 5.16674 | 1.33405 |
| | 2 | 15 | 5.7333 | 5.17503 | 1.33619 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| NDI13 | Equal variances assumed | .096 | .759 | 1.659 | 28 | .108 | 3.1333 | 1.88814 | -.73435 | 7.00102 |
| | Equal variances not assumed | | | 1.659 | 28.000 | .108 | 3.1333 | 1.88814 | -.73435 | 7.00102 |

**Test Statistics**[b]

| | NDI13 |
|---|---|
| Mann-Whitney U | 80.000 |
| Wilcoxon W | 200.000 |
| Z | -1.354 |
| Asymp. Sig. (2-tailed) | .176 |
| Exact Sig. [2*(1-tailed Sig.)] | .187[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

The group statistics reflected above indicates that group 1 definitely has a bigger drop on average than group 2 with an average drop of 8.87 compared to group 2 with an average drop of 5.17. This drop is, however, **not significant**, as the p value in the table below is only 0.108 (for both equal and non-equal variances).

The independent sample T-tests results above are backed up when as a check we also conduct the equivalent non-parametric procedure (The Mann- Whitney U Test) and yield a p value equal to 0.187, also **not significant**.

Since the p-value is $\geq 0.05$, the null hypothesis is accepted. Therefore we conclude that there is not enough evidence to suggest that the CMCC Neck Disability Index scores have shown a significantly different drop between groups 1 and 2 at a $\alpha = 0.05$ level of significance.

From here on instead of going through the complete procedure above for all tests we have simply calculated both the parametric and equivalent non-parametric tests in all cases and if the results agree we concluded accordingly. However, if they disagreed then we ran the appropriate assumption diagnostics and applied the correct test.

#### 4.3.1.1.3 Comparison of final treatment score means of group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| NDI3 | 1 | 15 | 6.53 | 5.514 | 1.424 |
| | 2 | 15 | 7.80 | 6.144 | 1.586 |

<u>Parametric</u>

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| NDI3 | Equal variances assumed | .584 | .451 | -.594 | 28 | .557 | -1.27 | 2.132 | -5.633 | 3.100 |
| | Equal variances not assumed | | | -.594 | 27.680 | .557 | -1.27 | 2.132 | -5.635 | 3.102 |

<u>Non-parametric</u>

**Test Statistics[b]**

| | NDI3 |
|---|---|
| Mann-Whitney U | 101.000 |
| Wilcoxon W | 221.000 |
| Z | -.480 |
| Asymp. Sig. (2-tailed) | .631 |
| Exact Sig. [2*(1-tailed Sig.)] | .653[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Although Group 1 has a mean, which is lower (6.53) compared to Group 2 (7.80), the difference is **not significant**:

Independent 2 sample parametric t- test at a 5% significance level yields a p value = 0.557

Independent 2 sample non-parametric Mann-Whitney test at a $\alpha$ = 0.05 significance level yields a p value = 0.653

Therefore both population means from group 1 and 2 are **not significantly different**.

### 4.3.1.2 Intra-group Comparison

#### 4.3.1.2.1 Group 1

**Descriptives**[a]

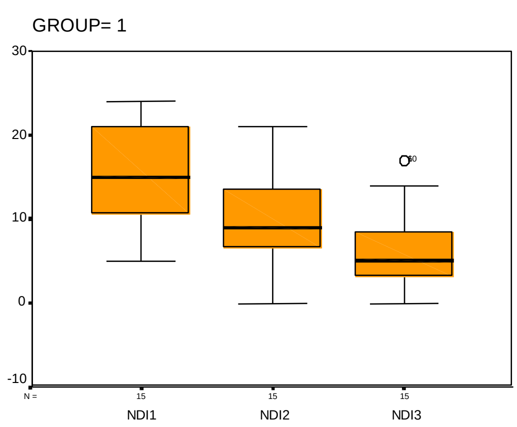
NDI

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 15.4000 | 6.44537 | 1.66419 | 11.8307 | 18.9693 | 5.00 | 24.00 |
| 2 | 15 | 9.7333 | 5.73793 | 1.48153 | 6.5558 | 12.9109 | .00 | 21.00 |
| 3 | 15 | 6.5333 | 5.51448 | 1.42383 | 3.4795 | 9.5872 | .00 | 17.00 |
| Total | 45 | 10.5556 | 6.86412 | 1.02324 | 8.4933 | 12.6178 | .00 | 24.00 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for a reduction in mean values over time:
At stage 1 we have a mean = 15.40
At stage 2 we have a mean = 9.73
At stage 3 we have a mean = 6.53

This trend relationship is also highlighted in a box and whisker plot below.



4.3.2.1.1.1 Comparison of group 1's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric

**ANOVA[a]**

NDI

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 604.844 | 2 | 302.422 | 8.651 | .001 |
| Within Groups | 1468.267 | 42 | 34.959 | | |
| Total | 2073.111 | 44 | | | |

a. GROUP = 1

Non-parametric (Friedman's test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 25.481 |
| df | 2 |
| Asymp. Sig. | .000 |

a. Friedman Test

b. GROUP = 1

Anova p value: 0.001
Friedman p value: 0.000

Both the parametric Analysis of Variance Test and the equivalent non-parametric Friedman test yield the same conclusion, reject $H_0$ and conclude there is a **significant difference** between means.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the parametric test are utilised, as the data is not significantly non-normal.

## Parametric

**Multiple Comparisons[a]**

Dependent Variable: NDI
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | 5.6667* | 2.15897 | .032 | .4215 | 10.9119 |
| | 3 | 8.8667* | 2.15897 | .001 | 3.6215 | 14.1119 |
| 2 | 1 | -5.6667* | 2.15897 | .032 | -10.9119 | -.4215 |
| | 3 | 3.2000 | 2.15897 | .310 | -2.0452 | 8.4452 |
| 3 | 1 | -8.8667* | 2.15897 | .001 | -14.1119 | -3.6215 |
| | 2 | -3.2000 | 2.15897 | .310 | -8.4452 | 2.0452 |

*. The mean difference is significant at the .05 level.

a. GROUP = 1

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

## Non-Parametric

## Wilcoxon Tests for Matched Pairs

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI2 - NDI1 | Negative Ranks | 13[a] | 7.00 | 91.00 |
| | Positive Ranks | 0[b] | .00 | .00 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. NDI2 < NDI1

b. NDI2 > NDI1

c. NDI1 = NDI2

d. GROUP = 1

**Test Statistics[b,c]**

| | NDI2 - NDI1 |
|---|---|
| Z | -3.186[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI1 | Negative Ranks | 15[a] | 8.00 | 120.00 |
| | Positive Ranks | 0[b] | .00 | .00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI1

b. NDI3 > NDI1

c. NDI1 = NDI3

d. GROUP = 1

**Test Statistics[b,c]**

| | NDI3 - NDI1 |
|---|---|
| Z | -3.414[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI2 | Negative Ranks | 10[a] | 6.20 | 62.00 |
| | Positive Ranks | 1[b] | 4.00 | 4.00 |
| | Ties | 4[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI2

b. NDI3 > NDI2

c. NDI2 = NDI3

d. GROUP = 1

**Test Statistics[b,c]**

| | NDI3 - NDI2 |
|---|---|
| Z | -2.584[a] |
| Asymp. Sig. (2-tailed) | .010 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

#### 4.3.2.1.2 Group 2

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| NDI1 | .334 | 15 | .000 | .749 | 15 | .001 |
| NDI2 | .169 | 15 | .200* | .939 | 15 | .368 |
| NDI3 | .215 | 15 | .060 | .902 | 15 | .100 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

**Test of Homogeneity of Variances[a]**

NDI

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 1.257 | 2 | 42 | .295 |

a. GROUP = 2

The test for normality shows that stage 1 (visit 1) and stage 3 (visit 3) scores are significantly non-normal by their low p values as indicated above. The non-parametric test will tend to prove more accurate in this case but both analysis are reported on for comparative purposes. The test for homogeneity of variance does not however show significantly different variances (p value = 0.295).

**Descriptives[a]**

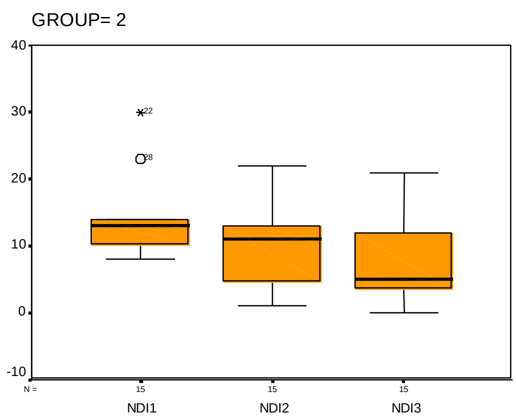
NDI

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 | 15 | 13.5333 | 5.78010 | 1.49241 | 10.3324 | 16.7342 | 8.00 | 30.00 |
| 2 | 15 | 9.8000 | 6.51591 | 1.68240 | 6.1916 | 13.4084 | 1.00 | 22.00 |
| 3 | 15 | 7.8000 | 6.14352 | 1.58625 | 4.3978 | 11.2022 | .00 | 21.00 |
| Total | 45 | 10.3778 | 6.47474 | .96520 | 8.4326 | 12.3230 | .00 | 30.00 |

a. GROUP = 2

The Mean values above indicate there is a definite trend for a reduction in mean values over time:
At stage 1 we have a mean = 13.53
At stage 2 we have a mean = 9.8
At stage 3 we have a mean = 7.8

This trend relationship is also highlighted in a box and whisker plot below.



4.3.2.1.2.1 Comparison of group 2's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric

**ANOVA[a]**

NDI

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 254.044 | 2 | 127.022 | 3.354 | .045 |
| Within Groups | 1590.533 | 42 | 37.870 | | |
| Total | 1844.578 | 44 | | | |

a. GROUP = 2

Non-parametric (Friedman's test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.552 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 2

Anova p value: 0.045
Friedman p value: 0.002

Both the parametric Analysis of Variance Test and the equivalent non-parametric Friedman test yield the same conclusion, reject $H_0$ and conclude we have a **significant difference** between means.

As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. If the results differ, the non-parametric test results will be utilised as the data is considered non-normal.

Parametric

**Multiple Comparisons[a]**

Dependent Variable: NDI
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | 3.7333 | 2.24707 | .232 | -1.7259 | 9.1926 |
| | 3 | 5.7333* | 2.24707 | .038 | .2741 | 11.1926 |
| 2 | 1 | -3.7333 | 2.24707 | .232 | -9.1926 | 1.7259 |
| | 3 | 2.0000 | 2.24707 | .650 | -3.4592 | 7.4592 |
| 3 | 1 | -5.7333* | 2.24707 | .038 | -11.1926 | -.2741 |
| | 2 | -2.0000 | 2.24707 | .650 | -7.4592 | 3.4592 |

*. The mean difference is significant at the .05 level.

a. GROUP = 2

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI2 - NDI1 | Negative Ranks | 9[a] | 7.72 | 69.50 |
| | Positive Ranks | 4[b] | 5.38 | 21.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. NDI2 < NDI1

b. NDI2 > NDI1

c. NDI1 = NDI2

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI2 - NDI1 |
|---|---|
| Z | -1.682[a] |
| Asymp. Sig. (2-tailed) | .093 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI1 | Negative Ranks | 14[a] | 7.93 | 111.00 |
| | Positive Ranks | 1[b] | 9.00 | 9.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI1

b. NDI3 > NDI1

c. NDI1 = NDI3

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI3 - NDI1 |
|---|---|
| Z | -2.901[a] |
| Asymp. Sig. (2-tailed) | .004 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI2 | Negative Ranks | 11[a] | 8.00 | 88.00 |
| | Positive Ranks | 4[b] | 8.00 | 32.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI2

b. NDI3 > NDI2

c. NDI2 = NDI3

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI3 - NDI2 |
|---|---|
| Z | -1.595[a] |
| Asymp. Sig. (2-tailed) | .111 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

### 4.3.2 Objective data ( Algometer readings )

Three paired t-tests were run for each group to see if the left and the right hand side results were significantly different at a 5 % significance level.

## Group 1 – Algometer reading 1

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR1L - AR1R | -.0800 | .28335 | .07316 | -.2369 | .0769 | -1.093 | 14 | .293 |

a. GROUP = 1

## Group 2 – Algometer reading 1

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR1L - AR1R | .0467 | .23258 | .06005 | -.0821 | .1755 | .777 | 14 | .450 |

a. GROUP = 2

## Group 1 – Algometer reading 2

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR2L - AR2R | -.0733 | .28149 | .07268 | -.2292 | .0826 | -1.009 | 14 | .330 |

a. GROUP = 1

## Group 2 – Algometer reading 2

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR2L - AR2R | .0067 | .21536 | .05561 | -.1126 | .1259 | .120 | 14 | .906 |

a. GROUP = 2

## Group 1 – Algometer reading 3

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR3L - AR3R | -.1133 | .49261 | .12719 | -.3861 | .1595 | -.891 | 14 | .388 |

a. GROUP = 1

Group 2 – Algometer reading 3

**Paired Samples Test[a]**

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | Upper | | | |
| Pair 1 | AR3L - AR3R | .0133 | .20307 | .05243 | -.0991 | .1258 | .254 | 14 | .803 |

a. GROUP = 2

The above tables all show p values not less than 0.05 which suggests that all measures from the left and the right are not significantly different. Therefore for the purpose of all further analysis both left and right readings were averaged out and analysis run on this new data.

### 4.3.2.1 Inter-group Comparison

4.3.2.1.1 Comparison of increase in Algometer scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| AR31 | 1 | 15 | .5900 | .22850 | .05900 |
| | 2 | 15 | .3033 | .33936 | .08762 |

<u>Parametric</u>

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | 95% Confidence Interval of the Difference Lower | Upper |
| AR31 | Equal variances assumed | .411 | .527 | 2.714 | 28 | .011 | .2867 | .10563 | .07028 | .50305 |
| | Equal variances not assumed | | | 2.714 | 24.530 | .012 | .2867 | .10563 | .06890 | .50444 |

Non-Parametric

**Test Statistics**[b]

| | AR31 |
|---|---|
| Mann-Whitney U | 42.500 |
| Wilcoxon W | 162.500 |
| Z | -2.914 |
| Asymp. Sig. (2-tailed) | .004 |
| Exact Sig. [2*(1-tailed Sig.)] | .003[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

The increase in Group1's algometer reading is significantly higher than in Group 2.
Both parametric and non-parametric tests yield **significant** p values 0.011 and 0.003 in both cases respectively.

4.3.2.1.2 Comparison of final treatment algometer score means of group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| AR3 | 1 | 15 | 1.8567 | .42840 | .11061 |
| | 2 | 15 | 1.5267 | .39860 | .10292 |

Parametric

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| AR3 | Equal variances assumed | .099 | .755 | 2.184 | 28 | .037 | .3300 | .15109 | .02051 | .63949 |
| | Equal variances not assumed | | | 2.184 | 27.856 | .038 | .3300 | .15109 | .02044 | .63956 |

Non – Parametric

**Test Statistics[b]**

| | AR3 |
|---|---|
| Mann-Whitney U | 59.000 |
| Wilcoxon W | 179.000 |
| Z | -2.222 |
| Asymp. Sig. (2-tailed) | .026 |
| Exact Sig. [2*(1-tailed Sig.)] | .026[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Both the unpaired t-test and the Mann Whitney U test yield the same results namely that the algometer reading at final stage for group1 is significantly higher than group 2 at a 5% level of significance.

Since the p-value is < 0.05, the null hypothesis is rejected. Therefore we conclude that there is enough evidence to suggest that the Algometer scores have shown a **significantly different** increase between groups 1 and 2 at a $\alpha$ = 0.05 level of significance.

### 4.3.2.2 Intra-group Comparison

#### 4.3.2.2.1 Group 1

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| AR1 | .133 | 15 | .200* | .963 | 15 | .739 |
| AR2 | .160 | 15 | .200* | .961 | 15 | .716 |
| AR3 | .131 | 15 | .200* | .966 | 15 | .799 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 1

**Test of Homogeneity of Variances[a]**

ALG

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| .131 | 2 | 42 | .877 |

a. GROUP = 1

All stages do not show significant departures from normality and significantly different variances and hence Anova may be the appropriate test here but we still do the equivalent non-parametric test namely the Friedman test.

**Descriptives[a]**

ALG

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 | 15 | 1.2667 | .39446 | .10185 | 1.0482 | 1.4851 | .70 | 2.05 |
| 2 | 15 | 1.5433 | .39725 | .10257 | 1.3233 | 1.7633 | .95 | 2.35 |
| 3 | 15 | 1.8567 | .42840 | .11061 | 1.6194 | 2.0939 | 1.20 | 2.75 |
| Total | 45 | 1.5556 | .46640 | .06953 | 1.4154 | 1.6957 | .70 | 2.75 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for an increase in mean values over time:
At stage 1 we have a mean = 1.27
At stage 2 we have a mean = 1.54
At stage 3 we have a mean = 1.86

4.3.2.2.1.1 Comparison of group 1's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric (Anova test)

**ANOVA[a]**

ALG

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 2.614 | 2 | 1.307 | 7.891 | .001 |
| Within Groups | 6.957 | 42 | .166 | | |
| Total | 9.571 | 44 | | | |

a. GROUP = 1

Non-Parametric (Friedman Test)

**Test Statistics**[a,b]

| | |
|---|---|
| N | 15 |
| Chi-Square | 24.667 |
| df | 2 |
| Asymp. Sig. | .000 |

a. Friedman Test

b. GROUP = 1

Both Anova and Friedman yield the same results namely that all three means are **significantly different** at a 5% level of significance.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the parametric test are utilised, as the data is not significantly non-normal.

Parametric

**Multiple Comparisons**[a]

Dependent Variable: ALG

Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| 1 | 2 | -.2767 | .14861 | .163 | -.6377 | .0844 |
| | 3 | -.5900* | .14861 | .001 | -.9511 | -.2289 |
| 2 | 1 | .2767 | .14861 | .163 | -.0844 | .6377 |
| | 3 | -.3133 | .14861 | .100 | -.6744 | .0477 |
| 3 | 1 | .5900* | .14861 | .001 | .2289 | .9511 |
| | 2 | .3133 | .14861 | .100 | -.0477 | .6744 |

*. The mean difference is significant at the .05 level.

a. GROUP = 1

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

Non-Parametric

Wilcoxon test for matched pairs procedure

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR2 - AR1 | Negative Ranks | 1[a] | 5.50 | 5.50 |
| | Positive Ranks | 13[b] | 7.65 | 99.50 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. AR2 < AR1

b. AR2 > AR1

c. AR1 = AR2

d. GROUP = 1

**Test Statistics[b,c]**

| | AR2 - AR1 |
|---|---|
| Z | -2.956[a] |
| Asymp. Sig. (2-tailed) | .003 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR1 | Negative Ranks | 0[a] | .00 | .00 |
| | Positive Ranks | 15[b] | 8.00 | 120.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. AR3 < AR1

b. AR3 > AR1

c. AR1 = AR3

d. GROUP = 1

**Test Statistics[b,c]**

| | AR3 - AR1 |
|---|---|
| Z | -3.413[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR2 | Negative Ranks | 1[a] | 5.50 | 5.50 |
| | Positive Ranks | 12[b] | 7.13 | 85.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR2

b. AR3 > AR2

c. AR2 = AR3

d. GROUP = 1

**Test Statistics[b,c]**

| | AR3 - AR2 |
|---|---|
| Z | -2.798[a] |
| Asymp. Sig. (2-tailed) | .005 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

The follow up pairwise comparison of means using non-parametric procedures results in:
The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

#### 4.3.2.2.2 Group 2

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| AR1 | .260 | 15 | .007 | .760 | 15 | .001 |
| AR2 | .199 | 15 | .114 | .912 | 15 | .144 |
| AR3 | .127 | 15 | .200* | .934 | 15 | .308 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

**Test of Homogeneity of Variances[a]**

ALG

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 1.519 | 2 | 42 | .231 |

a. GROUP = 2

Stage 1 shows significant departures from normality and stage 2 comes very close to being significantly non-normal. Both tests are applied but Friedman's test is more appropriate here.

**Descriptives[a]**

ALG

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 | 15 | 1.2233 | .28402 | .07333 | 1.0660 | 1.3806 | .95 | 2.10 |
| 2 | 15 | 1.4233 | .29330 | .07573 | 1.2609 | 1.5858 | 1.00 | 2.10 |
| 3 | 15 | 1.5267 | .39860 | .10292 | 1.3059 | 1.7474 | 1.00 | 2.50 |
| Total | 45 | 1.3911 | .34613 | .05160 | 1.2871 | 1.4951 | .95 | 2.50 |

a. GROUP = 2

The Mean values above indicate there is a definite trend for an increase in mean values over time:
At stage 1 we have a mean = 1.22
At stage 2 we have a mean = 1.42
At stage 3 we have a mean = 1.53

#### 4.3.2.2.2.1 Comparison of group 2's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric (Anova test)

**ANOVA[a]**

ALG

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .713 | 2 | .357 | 3.287 | .047 |
| Within Groups | 4.558 | 42 | .109 | | |
| Total | 5.271 | 44 | | | |

a. GROUP = 2

Non-Parametric (Friedman Test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.473 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 2

Both Anova and Friedman yield the same results with p Values less than 0.05, therefore all three means are significantly different.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the non-parametric test are utilised, as the data is significantly non-normal.

## Parametric

**Multiple Comparisons**[a]

Dependent Variable: ALG
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | -.2000 | .12029 | .231 | -.4922 | .0922 |
| | 3 | -.3033* | .12029 | .040 | -.5956 | -.0111 |
| 2 | 1 | .2000 | .12029 | .231 | -.0922 | .4922 |
| | 3 | -.1033 | .12029 | .669 | -.3956 | .1889 |
| 3 | 1 | .3033* | .12029 | .040 | .0111 | .5956 |
| | 2 | .1033 | .12029 | .669 | -.1889 | .3956 |

*. The mean difference is significant at the .05 level.

a. GROUP = 2

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

## Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks**[d]

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR2 - AR1 | Negative Ranks | 2[a] | 3.50 | 7.00 |
| | Positive Ranks | 12[b] | 8.17 | 98.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. AR2 < AR1

b. AR2 > AR1

c. AR1 = AR2

d. GROUP = 2

**Test Statistics**[b,c]

| | AR2 - AR1 |
|---|---|
| Z | -2.867[a] |
| Asymp. Sig. (2-tailed) | .004 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR1 | Negative Ranks | 1[a] | 1.50 | 1.50 |
| | Positive Ranks | 12[b] | 7.46 | 89.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR1
b. AR3 > AR1
c. AR1 = AR3
d. GROUP = 2

**Test Statistics[b,c]**

| | AR3 - AR1 |
|---|---|
| Z | -3.082[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR2 | Negative Ranks | 5[a] | 5.40 | 27.00 |
| | Positive Ranks | 8[b] | 8.00 | 64.00 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR2
b. AR3 > AR2
c. AR2 = AR3
d. GROUP = 2

**Test Statistics[b,c]**

| | AR3 - AR2 |
|---|---|
| Z | -1.295[a] |
| Asymp. Sig. (2-tailed) | .195 |

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

### 4.3.3 Objective data (Head Repositioning Accuracy)

#### 4.3.3.1 Inter-group Comparison

The HRA left and right readings were averaged to produce a single score per patient at visits 1, 4 and 7.

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| HRA13 | .152 | 15 | .200* | .933 | 15 | .302 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 1

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| HRA13 | .174 | 15 | .200* | .942 | 15 | .403 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

The tests for normality show that both data sets are not significantly non-normal (both p values are large).

#### 4.3.3.1.1 Comparison of drop in HRA scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| HRA13 | 1 | 15 | 5.1167 | 4.56781 | 1.17940 |
| | 2 | 15 | 4.4667 | 3.57804 | .92385 |

<u>Parametric</u>

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| HRA13 | Equal variances assumed | 1.647 | .210 | .434 | 28 | .668 | .6500 | 1.49816 | -2.41884 | 3.71884 |
| | Equal variances not assumed | | | .434 | 26.481 | .668 | .6500 | 1.49816 | -2.42679 | 3.72679 |

Non-parametric

**Test Statistics[b]**

| | HRA13 |
|---|---|
| Mann-Whitney U | 104.000 |
| Wilcoxon W | 224.000 |
| Z | -.353 |
| Asymp. Sig. (2-tailed) | .724 |
| Exact Sig. [2*(1-tailed Sig.)] | .744[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Group statistics shows that the mean drop in HRA score in group 1 is 5.11 where in group 2 it is 4.67. This difference is however, **not significant** according to the results of both parametric and non-parametric tests, the p values in each case respectively of 0.668 and 0.744.

Since the p-value is $\geq$ 0.05, the null hypothesis is accepted. Therefore we conclude that there is not enough evidence to suggest that the HRA scores have shown a significantly different drop between groups 1 and 2 at a $\alpha = 0.05$ level of significance.

### 4.3.3.2 Intra-group Comparison

4.3.3.2.1 Group 1

**Test of Homogeneity of Variances[a]**

HRA

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 3.264 | 2 | 42 | .048 |

a. GROUP = 1

The test for equality of variances yield significantly different variances (p value = 0.048), therefore the Anova test would not be appropriate here and the non-parametric Friedman's Test is used.

**Descriptive Statistics[a]**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| HRA1 | 15 | 10.7167 | 4.38429 | 4.50 | 20.00 |
| HRA2 | 15 | 8.4167 | 3.55777 | 4.00 | 15.50 |
| HRA3 | 15 | 5.6000 | 2.21359 | 2.00 | 11.00 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for a decrease in mean values over time:
At stage 1 we have a mean = 10.72
At stage 2 we have a mean = 8.42
At stage 3 we have a mean = 5.60

4.3.3.2.1.1 Comparison of group 1's HRA means at visits 1, 4 and 7 using non-parametric testing

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.644 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 1

The Friedman test is outlined above yielding a p value =0.002, therefore we have **significantly different** means at a 5% level of significance

As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. A non-parametric test is utilised, as the data is significantly non-normal.

<u>Non-Parametric</u>

<u>Wilcoxon test for matched pairs procedure</u>.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA2 - HRA1 | Negative Ranks | 10[a] | 9.70 | 97.00 |
| | Positive Ranks | 5[b] | 4.60 | 23.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA2 < HRA1
b. HRA2 > HRA1
c. HRA1 = HRA2
d. GROUP = 1

**Test Statistics[b,c]**

| | HRA2 - HRA1 |
|---|---|
| Z | -2.104[a] |
| Asymp. Sig. (2-tailed) | .035 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA1 | Negative Ranks | 13[a] | 7.77 | 101.00 |
| | Positive Ranks | 1[b] | 4.00 | 4.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA1
b. HRA3 > HRA1
c. HRA1 = HRA3
d. GROUP = 1

**Test Statistics[b,c]**

| | HRA3 - HRA1 |
|---|---|
| Z | -3.047[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA2 | Negative Ranks | 12[a] | 9.50 | 114.00 |
| | Positive Ranks | 3[b] | 2.00 | 6.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA2
b. HRA3 > HRA2
c. HRA2 = HRA3
d. GROUP = 1

**Test Statistics[b,c]**

| | HRA3 - HRA2 |
|---|---|
| Z | -3.068[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

#### 4.3.3.2.1 Group 2

**Test of Homogeneity of Variances[a]**

HRA

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 3.051 | 2 | 42 | .058 |

a. GROUP = 2

The test for equality of variances yield significantly different variances (p value = 0.058), therefore the Anova test would not be appropriate here and the non-parametric Friedman's Test is used.

**Descriptive Statistics[a]**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| HRA1 | 15 | 10.7000 | 4.00803 | 4.00 | 18.00 |
| HRA2 | 15 | 8.1333 | 2.55976 | 4.00 | 13.50 |
| HRA3 | 15 | 6.2333 | 2.45580 | 4.00 | 13.00 |

a. GROUP = 2

The Mean values above indicate there is a definite trend for a decrease in mean values over time:
At stage 1 we have a mean = 10.70
At stage 2 we have a mean = 8.13
At stage 3 we have a mean = 6.23

##### 4.3.3.2.2.1 Comparison of group 2's HRA means at visits 1, 4 and 7 using non-parametric testing

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 14.724 |
| df | 2 |
| Asymp. Sig. | .001 |

a. Friedman Test

b. GROUP = 2

The Friedman test is outlined below yielding a p value =0.001, therefore we have **significantly different** means at a 5% level of significance. As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. A non-parametric test is utilised, as the data is significantly non-normal.

Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA2 - HRA1 | Negative Ranks | 12[a] | 7.54 | 90.50 |
| | Positive Ranks | 2[b] | 7.25 | 14.50 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA2 < HRA1
b. HRA2 > HRA1
c. HRA1 = HRA2
d. GROUP = 2

**Test Statistics[b,c]**

| | HRA2 - HRA1 |
|---|---|
| Z | -2.391[a] |
| Asymp. Sig. (2-tailed) | .017 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA1 | Negative Ranks | 13[a] | 8.00 | 104.00 |
| | Positive Ranks | 1[b] | 1.00 | 1.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA1
b. HRA3 > HRA1
c. HRA1 = HRA3
d. GROUP = 2

**Test Statistics[b,c]**

| | HRA3 - HRA1 |
|---|---|
| Z | -3.237[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA2 | Negative Ranks | 11[a] | 8.91 | 98.00 |
| | Positive Ranks | 4[b] | 5.50 | 22.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA2
b. HRA3 > HRA2
c. HRA2 = HRA3
d. GROUP = 2

**Test Statistics[b,c]**

| | HRA3 - HRA2 |
|---|---|
| Z | -2.161[a] |
| Asymp. Sig. (2-tailed) | .031 |

a. Based on positive ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

# Chapter Five

# 5 Discussion

## 5.1 Introduction

This chapter includes an interpretation of the results seen in Chapter Four. The demographic data is compared to that of previous research, and the analysis of the subjective and objective data is discussed.

The sample utilized for this study consisted of 30 subjects. Statistical analysis therefore was at risk of accepting the incorrect hypotheses (Type II error) due to the relatively small sample size. To decrease the chance of this happening, all data was subjected to tests of normality, which showed whether the data was representative of a normal distribution.

Two important results are taken from this study. Firstly, statistically significant differences were seen between the two groups on inter-group analysis with the objective algometer readings. Secondly, statistically significant changes were seen on intra-group analysis for both subjective and objective readings between visits for both groups.

## 5.2 Demographic Data

The average age of the patients that participated in this study was 32.47 years (Table 4.2.1). The average age of group 1 was 32.53 years and group 2 was 32.4 years. However, 63.3 percent of the subjects fell between the ages of 18 to 29 years and only 13.3 percent fell between the ages of 30 to 44 years. The remaining 23.3 percent fell between the ages of 45 to 60 years. This corresponds with the findings of Spitzer et al. (1995), where the highest incidence of whiplash injury for both genders occurred in the 20 – 24 age group. The ages between the groups were closely matched, as intended by the researcher, by selecting every even numbered subject in a particular age group into group 2.

The gender distribution of the 30 patients in the study was 63.3 percent female and 36.6 percent male (Table 4.2.2). Group 1 and 2 were similarly matched for gender ratios. Females are 1.5 times more likely to experience whiplash injuries than are men (Spitzer et al. 1995). Women have slimmer, less muscular necks, which may be less able to resist damaging acceleration forces. They also may be more likely to seek medical attention than their male counterparts (Teasell and Shapiro 1998).

The race distribution of this study was not representative of South Africa, but perhaps more representative of the patient population attending the clinic. 86.7 percent were white, 10 percent Indian and 3.3 percent coloured (Table 4.2.3).

On the recommendations of Kruger (2000) and Spitzer et al. (1995), certain accident-related data was recorded. The number of WAD incidents was limited to a maximum of two, to create a more uniform sample. The majority of patients (63.3%) had had only one WAD incident (Table 4.2.4) while 36.7 percent had sustained two WAD injuries. This is important to consider, as the prognosis of WAD is poorer following previous whiplash injury (Tollison and Satterthwaite 1992:306, Foreman and Croft 1995:85).

Table 4.2.5 outlines the time frames in which the patients presented to the research following their most recent WAD incident. Twenty percent presented in the early chronic stage, namely between 6 – 8 weeks, where inflammation could be a major source of their pain. Surprisingly, few (16.7 %) presented between 8 weeks and 1 year of the WAD incident, and the majority occurred between 1-2 years (23.3%) and 2-5 years (30%). It is possible that degenerative changes could have occurred in the cervical spine that had begun to be symptomatic only years later.

The majority of whiplash injuries occur in MVA's but a small percentage occur from other types of acceleration / deceleration forces found in contact sports or high-velocity sports (Hertling and Kessler 1990:516). In this study, MVA-related WAD accounted for 83.3% of patients (Table 4.2.6); watersports, such as water-skiing and wakeboarding, was 6.7%; and boating accidents, diving injuries and motorcycle accidents accounting each for 3.3% of the WAD cases. Rugby tackle injuries are also a common source of WAD, however these injuries were not seen in this patient population, possibly due to the small sample size.

Typically, a whiplash injury occurs when a vehicle is struck from the rear or side (Spitzer et al.1995). Of the 25 patients in this study involved in MVA's, 44% had had a rear impact, 20% a side impact, 24% a front impact, 8% rolled and 4% had their vehicle spin out of control (Table 4.2.7). Spitzer et al. 1995 found that of the 3014 study cohort members, 30.7% had had a rear collision, 19.1% a side collision, 14.5% a head-on collision and the remaining 35.8% was classified as missing data or other. There appears to a higher percentage of residual symptoms in WAD patients involved in rear-impact collisions than those in front and side collisions (Foreman and Croft 1995:325). One possible reason for this is that drivers who are struck from the front or side are usually alerted to the impending collision in sufficient time to brace for the impact (Foreman and Croft 1995:74).

Of the 25 WAD patients involved in MVA's in this study, 76% were driving the vehicle at the time of the collision (Table 4.2.8), which corresponds with the findings of Spitzer et al. (1995). Only 48% of the patients in this study were wearing a seatbelt at the time of the accident (Table 4.2.9). This percentage is lower than the 87.6% recorded by Spitzer et al. 1995 but their information was obtained from police reports, where patients may have over-reported as a result of medicolegal claims. Neck injuries are three times more likely to occur in belted drivers than in unbelted drivers. The primary reason for this being that the shoulder harness abruptly restrains the decelerating trunk of the occupant while the heads inertia carries it forward unrestrained, resulting in a tremendous bending moment at the cervicothoracic region (Foreman and Croft 1995:85).

The likelihood of injury is greater when non-symmetrical loads are applied to the spine such as in oblique collisions e.g. vehicle struck in right rear corner or when the occupant’s head is turned during a rear-end collision (Foreman and Croft 1995:85). The three-point or diagonal seatbelt may also add a rotational component to the force during flexion of the head and trunk (Foreman and Croft 1995:85). Table 4.2.10 shows that of the 25 patients involved in MVA’s in this research, 3 had their head turned to the right and 1 had their head turned to the left. The remainder were reported as looking forward, however, a few appeared uncertain when recalling the accident. Only the one patient looking left, however, had a rear collision and he also had the highest initial subjective pain reading on the CMCC Neck Disability Index in Group 1.

Patients often report being temporarily dazed, shaken, confused or disoriented following an MVA. These alterations in consciousness are a component of concussion (Foreman and Croft 1995:120). A patient who strikes his or head during the accident may lose consciousness for a brief period of time. The impact to the head is, essentially, a second, separate accident. Therefore, the structures of the cervical spine are subjected to a second trauma and have almost twice the amount of post-traumatic degeneration (Foreman and Croft 1995:446). Hohl (1974) studied as a subgroup, those patients who had lost consciousness during accidents, 64% experienced degenerative changes within the five year study period, as opposed to 36% of those patients who did not lose consciousness. Table 4.2.11 shows that 80% of the subjects in this study reported no injuries other than WAD at the time of the accident. Of the 5 patients that bumped their heads, 2 were confused and 1 was concussed. All 5 patients showed loss of cervical lordosis on radiographic examination. Another patient dislocated his acromio-clavicular joint after rolling his vehicle.

All the patients entering this study had cervical spine pain. In general, it can be said that in WAD trauma, the lower segments of the cervical spine (C4 – C7) receive the brunt of the damage most of the time (Foreman and Croft 1995:73). However, the subjective location of this pain varied considerably (Table 4.2.12). In fact 60% of the patients had sub-occipital pain, 23.3% had mid-cervical pain and only 6.7% had lower cervical spine pain. The remaining 10% could not pinpoint their pain and stated the pain was along the entire cervical spine. These findings are interesting when one looks at the radiographic findings in these patients (Table 4.2.14). Loss of lordosis and cervical spine kyphosis between segments C4 to C6 was seen in 70% and 6.7% of these patients respectively. The remaining 20% had normal radiographs and 1 patient had a cervical spine scoliosis. It appears that the objective site of the lesion is not necessarily the site at which the patient feels the pain.

Neck pain is the most commonly reported symptom after WAD trauma (88 – 100% of the time). It may be immediate, but it is generally delayed in onset and usually occurs within 72 hours (Foreman and Croft 1995:311). For the purposes of this study, all patients had to present with neck pain and cervical spine fixations. Headache is the second most frequently reported symptom in WAD injury. The studies utilized by Spitzer et al. 1995 show an incidence between 54 – 66% but this study shows an incidence of 93.3% (Table 4.2.13). However, it is possible that those with more severe symptoms are more likely to seek medical attention.

Limited neck movement and upper thoracic pain occurred in 70% of the subjects in this research. Similarly, Hildingsson and Toolanen (1990) found neck stiffness in 69% of their 93 subjects. Low back pain is a common symptom in WAD and according to Foreman and Croft (1995:299) is more likely to occur in side impact accidents, where the seat offers little protection to lateral bending forces. In this study 33.3% suffered low back pain, however no correlation was seen between vector of impact and incidence of low back pain. Hohl (1974) and Gargan and Bannister (1990) showed an incidence of LBP of 35% and 42% respectively.

Point tenderness is considered a musculoskeletal sign in a Grade II WAD injury (Spitzer et al. 1995). However, Foreman and Croft (1995:328) state tenderness to palpation may be present in all cases and is not particularly specific from a diagnostic standpoint. 73.3% of the subjects had point tenderness in their cervical spine. According to Travell and Simons (1999:451), experiencing forceful head movement in an automobile accident can produce extreme neck flexion and muscle strain. This strain activates trigger points in head and neck muscles, especially the posterior cervical muscles. Automobile impact from any direction is likely to activate semispinalis capitis trigger points (Travell and Simons 1999:452).

Other symptoms included dizziness and vertigo, seen in 13% of the research patients and 3.3% had visual disturbances (Table 4.2.13). Gargan and Bannister (1990) showed similar findings with 19% of their patients presenting with vertigo and 2% with visual disturbances. Auditory disturbances such as tinnitus are often seen in WAD, however no such cases were seen in this research.

## 5.3 Discussion of Data Analysis

### 5.3.1 The first objective

The first objective was to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective measures, for pain and disability.

#### 5.3.1.1 Inter-group analysis (CMCC Neck Disability Index)

Subjectively no statistically significant differences were seen between Group 1 and Group 2 for the CMCC Neck Disability Index. The group statistics indicate that group 1 definitely has a bigger average drop in score for the CMCC Neck Disability Index than group 2. This drop is, however, not statistically significant. Both groups are considered to have improved equally in terms of subjective measurements. Proprioceptive exercises as an adjunct to manipulation do not significantly alter the patients perception of his or her pain or disability as compared to manipulation alone.

#### 5.3.1.2 Intra-group analysis

Statistically significant changes were seen between visits for subjective measurements in both groups.

For the proprioceptive exercises and manipulation group, the mean scores between visits 1 and 4 and between visits 1 and 7 show a significant improvement. No significant change was seen between visits 4 and 7. Therefore the patients improvement was more marked in the first 2 weeks of the treatment program.

For the manipulation only group, the mean scores between visits 1 and 7 show a significant improvement. No significant changes were seen between visits 1 and 4 or visits 4 and 7. The patients therefore improved gradually over the treatment program.

Proprioceptive exercises, as an adjunct to manipulation did not appear to play a more important role in the patients subjective perception of their pain and disability as compared to manipulation alone. However, they may have served to provide the patient with more rapid pain relief.

### 5.3.2 The second objective

The second objective was to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of objective measures, for pain and proprioceptive function

5.3.2.1.1 Inter-group Analysis (Algometer Readings)

Statistically significant differences were seen between the two groups for objective algometer readings.

The increase in group1's algometer reading is significantly higher than in group 2 and the algometer reading at final stage for group 1 is significantly higher than that of group 2 at a 5% level of significance.

The null hypothesis is rejected and we conclude that there is enough evidence to suggest that there is a significant objective improvement in pain and tenderness in the proprioceptive exercise and manipulation group as compared to manipulation alone.

A possible explanation for this may be the fact that semispinalis capitis muscle overlies the articular pillars of the cervical spine. The trigger points in this muscle, according to Travell and Simons (1999:452), are almost always activated in a whiplash injury. As the algometer reading was taken on the most tender cervical articular pillar of the patient, it is likely that these active trigger points as well as a fixation were present at that level. To treat these trigger points, Travell and Simons (1999:469) suggest a combination of stretches and exercise therapy, which includes posture training.

It is then possible that the proprioceptive exercises utilised in this research caused inactivation of these trigger points, resulting in reduced tenderness over the articular pillar and therefore an improved algometer reading.

#### 5.3.2.1.2 Intra-group Analysis (Algometer Readings)

Statistically significant differences were seen for both treatment groups between visits 1 and 7. No significant differences were seen for either group between visits 1 and 4 or visits 4 and 7 using parametric testing. However, non-parametric testing showed significant changes between both these visits for group 1 and between visits 1 and 4 for group 2.

Therefore both groups improved significantly over the whole treatment program in terms of objective pain and tenderness. However, group 1's overall improvement was significantly higher than that of group 2 as is seen on inter-group testing.

#### 5.3.2.2.1 Inter-group Analysis (HRA readings)

The HRA left and right readings were averaged to produce a single score per patient at visits 1, 4 and 7 as per Rogers (1997).

No significant differences were seen between the two groups for objective HRA readings. Group statistics shows that the mean drop in HRA score in group 1 is greater than in group 2. This difference is however, not significant and the null hypothesis is accepted.

Therefore we conclude that there is not enough evidence to suggest that the proprioceptive exercises as an adjunct to manipulation have an active role in improving objective proprioceptive function as compared to manipulation alone.

5.3.2.2.2 Intra-group Analysis

Both groups show statistically significant differences between visits. Non-parametric testing was used only, as the data was non-normal. All visits for both groups showed statistically significant improvement. Interestingly, group 1 showed its greatest improvement between visits 4 and 7. This could imply the exercises are more effective over a prolonged use.

There is therefore an improvement in proprioceptive function for both manipulation and proprioceptive exercises and for manipulation alone. This could possibly be attributed to the positive effects of manipulation on proprioceptive function as described by Rogers (1997) as both groups received manipulative therapy.

## 5.4 <u>Limitations</u>

In this study, although an original sample size of 60 was intended, sufficient patients were not seen within the time frame. A sample size of 30 was utilised which resulted in mainly non-parametric testing being used. Tests of normality were conducted on the data, which limited the possibility of accepting the incorrect hypothesis or a Type II error. A larger sample size however would have allowed the correct use of parametric testing and been more representative of a population of WAD sufferers.

In terms of data collection, bias may have occurred either on the part of the patient or the researcher.

Patients may have answered questionnaires so as to please the researcher. However, the reverse is possibly also true, where the patient pays closer attention to his / her pain levels due being more informed than prior on the research, and in doing so, is more aware of pain or disability.

Algometer readings, although considered an objective reading, are subject to the speed and release of the pressure by the researcher. Faster application of the algometer could result in an overshoot and therefore a higher reading after the patients' signal.

A few problems were seen with the HRA readings. Firstly, only left and right readings were taken for standardisation purposes. However, flexion and extension data and perhaps even lateral flexion data would have been valuable for comparison with previous research. Most patients had some form of extension or flexion displacement on rotation seen the chart. Secondly, additional readings on either side would have also led to a more accurate average score, but only one reading was taken each side per data collection session. And thirdly, lining up the laser on the patients' head to be perpendicular to the chart was open to error from the researcher. This could have caused angular displacement of the beam on the target and possibly a slightly inaccurate reading.

Another major limitation of this study was the assumption that patients in Group 1 were performing their exercises in an unsupervised setting. Patients were told to perform exercises daily, however, they needed only do them at least four times weekly, thus allowing some degree of non-compliance. Exercises were repeated in front of the researcher during treatments; however, these exercises may have been performed incorrectly, if at all, in the home environment.

## 5.5 Discussion of Statistical Analysis

The results of this study differ slightly from those found by Fitz-Ritson (1995) who also compared manipulation and phasic exercises to manipulation alone. He found a significant difference between the two groups for the CMCC Neck Disability Index, whereas in this research, there was a difference but it was not considered statistically significant at the 5% level of significance. The algometer readings in this research however, show a statistically significant difference between groups, but this reading was not used in the research by Fitz-Ritson (1995).

Correlations between the two researches were seen on intra-group testing. His manipulation alone group improved by 7.4% which was statistically significant at the $p > 0.05$ level. His exercise and manipulation group improved by 48.3%, which was highly significant at the $p > 0.001$ level. However, he stated that his samples were non-uniform in terms of gender, age and number of WAD incidents and may have been responsible for the minimal improvement of the manipulation only group and the remarkable improvement of the exercise and manipulation group. However in this research, where these confounders were eliminated, similar findings were seen on intra-group testing. Between visits 1 and 7, the manipulation only group improved at a $p < 0.05$ level of significance, which was statically significant, whereas the exercise and manipulation group improved at a $p = 0.001$ level of significance which was highly significant.

Rogers et al. (1997) compared whether cervical spine manipulation as an isolated intervention had any effect on proprioception-dependent performance of subjects with chronic neck pain, compared with effects achieved through stretching exercises. He utilised the same methods of head repositioning accuracy (HRA) as in this research. However, he repeated this for flexion and extension in addition to rotation.

His manipulation group (group 1) showed a significant improvement with a mean baseline score of 35.5 to an ending score of 21 (Table 5.5.1). In this research, the mean baseline of group 1 was 10.72 and for group 2 it was 10.70, and an ending score of 5.60 and 6.23 respectively (Table 5.5.2).

Table 5.5.1

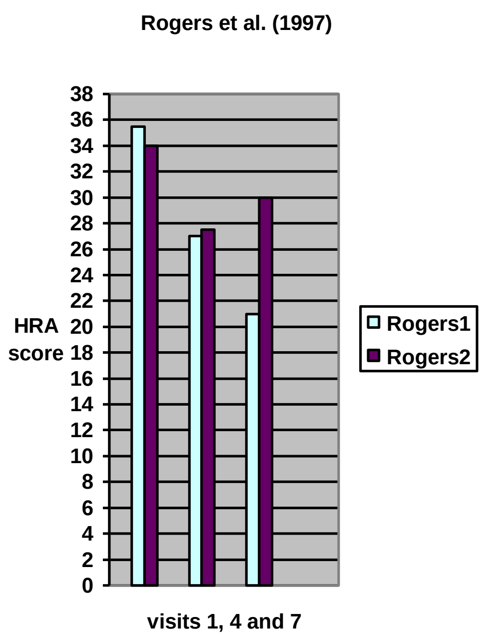
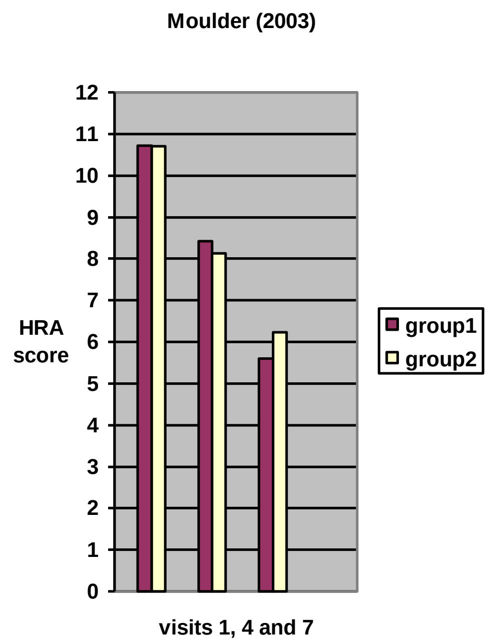



Table 5.5.2




There was a significant improvement between visits for both groups but no significant inter-group difference. The results of both these studies suggest that spinal manipulation may impact the complex process of proprioceptive sensibility.

# Chapter Six

## 5 Conclusions and Recommendations

### 6.1 Conclusions

The results of this study suggest that the use of manipulation and proprioceptive exercises can have beneficial effects on pain, tenderness and proprioceptive function in patients suffering with WAD.

Both groups improved significantly over the whole treatment period for all measurements. The use of proprioceptive exercises as an adjunct to spinal manipulation appears to play an important role in reducing the patients' tenderness over the articular pillar of their cervical spine. The exercises combined with manipulation also appeared to have had a more rapid positive effect on the patients pain perception as compared to manipulation alone, with most patients benefiting within the first two weeks of treatment.

The proprioceptive function of patients in this study was vastly improved, however, there was no significant difference between the two groups which could imply that manipulation had the greatest effect on proprioceptive abilities in these WAD patients. This may be due to stimulation of the articular mechanoreceptors as described by Wyke (1980). The exercises appeared to further improve the proprioceptive abilities of the WAD patient, but not at a significant level.

## 6.2 Recommendations

One of the weaknesses of this study is its relatively small sample size. This increases the risk of accepting the incorrect hypothesis (Type II error). A sample size of at least thirty should be utilized to allow more accurate parametric testing. Future attempts should also be made to create a sample group that is more representative of the general population.

Unfortunately, the long-term benefits of this treatment protocol could not be established in this study. The long-term benefit of manipulation in WAD is one of the areas that has been identified as lacking in sufficient randomised controlled trials. This study is weakened by the fact there was no placebo control group. A blinded study would help eliminate researcher bias. The lack of experience of the researcher and the adjusting techniques utilised may also have played a role in the outcome of this study. Further studies need to address these issues.

There is no certainty that the exercises utilised in this research actually stimulate the phasic component of the cervical musculature. Different exercises that require rapid eye, head and trunk co-ordination may have more positive results in improving WAD patients' pain and proprioceptive function.

Patients with a previous history of neck pain and those involved in head-on collisions were not excluded from this study. However, the diagnosis of WAD is a controversial issue in itself. Future studies should attempt to lay out more defined criteria to create a more uniform sample.

Based on the results of this study, it is the author's hope that larger, more comprehensive investigations be done to validate these findings.

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**Appendix A**

**TECHNIKON NATAL CHIROPRACTIC DAY CLINIC**
**CASE HISTORY**

Patient:.......................................... Date: ................

File # :.......................... Age : ................

Sex :............... Occupation:..................................................

Intern :.........................................Signature:.................................

**FOR CLINICIANS USE ONLY:**
Initial visit
Clinician:...................................... Signature:.................................

| **Case History:** |
|---|
| |

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

**Case Status:**

**PTT:**..........................................................................................

**Signature:**.................................................... **Date:**..........................
**Conditional:**
**Reason for Conditional:**..................................................................

**Signature:**.................................................... **Date:**..........................

**All Conditions met in Visit No:**.........................................................

**To be signed into PTT:**......................................................................

**Signature:**............................................. **Date:**.................................

**Signed off:**.................................................................................

**Intern's Case History:**

1. **Source of History:**

2. **Chief Complaint : (patient's own words):**

3. **Present Illness:**

| | Complaint 1 | Complaint 2 |
|---|---|---|
| Location | | |
| Onset : Initial: | | |
| ▸ Recent: | | |
| Cause: | | |
| Duration | | |
| Frequency | | |
| Pain (Character) | | |
| Progression | | |
| Aggravating Factors | | |
| ▸ Relieving Factors | | |
| Associated S & S | | |
| Previous Occurrences | | |
| Past Treatment | | |
| **Outcome:** | | |

4. **Other Complaints:**

5. **Past Medical History:**

▸ General Health Status

Childhood Illnesses

Adult Illnesses

- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

**6. Current health status and life-style:**

- Allergies
- Immunizations
- Screening Tests incl. xrays

- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:

- Tobacco
- Alcohol
- Social Drugs

**7. Immediate Family Medical History:**

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

## 8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

## 9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

Appendix B

TECHNIKON NATAL

## TECHNIKON NATAL CHIROPRACTIC DAY CLINIC

### PHYSICAL EXAMINATION

Patient:____________________File#: ____________________Date:__________
Clinician:____________________Signature:____________________
Intern:____________________Signature:____________________

**1. VITALS**

Pulse rate:
Respiratory rate:
Blood pressure: R L
Temperature:
Height:
Weight:

**2. GENERAL EXAMINATION**

General Impression:
Skin:
Jaundice:
Pallor:
Clubbing:
Cyanosis (Central/Peripheral):
Oedema:
Lymph nodes
- Head and neck:
- Axillary:
- Epitrochlear:
- Inguinal:

Urinalysis:

**3. CARDIOVASCULAR EXAMINATION**

1) Is this patient in **Cardiac Failure** ?
2) Does this patient have signs of **Infective Endocarditis** ?
3) Does this patient have **Rheumatic Heart Disease ?**

**Inspection**
- Scars
- Chest deformity:
- Precordial bulge:
- Neck -JVP:

**Palpation:**
- Apex Beat (character + location):
- Right or left ventricular heave:
- Epigastric Pulsations:
- Palpable P2:
- Palpable A2:

Pulses:
- General Impression:
- Radio-femoral delay:
- Carotid:
- Radial:
- Dorsalis pedis:
- Posterior tibial:
- Popliteal:
- Femoral:

**Percussion:** - borders of heart

**Auscultation:** - heart valves (mitral, aortic, tricuspid, pulmonary)
- Murmurs (timing,systolic/diastolic, site, radiation, grade).

## 4. RESPIRATORY EXAMINATION

1) Is this patient in **Respiratory Distress** ?

**Inspection**
- Barrel chest:
- Pectus carinatum/cavinatum:
- Left precordial bulge:
- Symmetry of movement:
- Scars:

**Palpation**
- Tracheal symmetry:
- Tracheal tug:
- Thyroid Gland:
- Symmetry of movement (ant + post)
- Tactile fremitus:

**Percussion**
- Percussion note:
- Cardiac dullness:
- Liver dullness:

**Auscultation**
- Normal breath sounds bilat.:
- Adventitious sounds (crackles, wheezes, crepitations)
- Pleural frictional rub:
- Vocal resonance
  - Whispering pectoriloquy:
  - Bronchophony:
  - Egophony:

## 5. ABDOMINAL EXAMINATION

1) Is this patient in **Liver Failure** ?

**Inspection**
- Shape:
- Scars:
- Hernias:

**Palpation**
- Superficial:
- Deep = Organomegally:

- Masses (intra- or extramural)
- Aorta:

**Percussion**
- Rebound tenderness:
- Ascites:
- Masses:

**Auscultation**
- Bowel sounds:
- Arteries (aortic, renal, iliac, femoral, hepatic)

**Rectal Examination**
- Perianal skin:
- Sphincter tone & S4 Dermatome:
- Obvious masses:
- Prostate:
- Appendix:

## 6. G.U.T EXAMINATION

External genitalia:
Hernias:
Masses:
Discharges:

## 7. NEUROLOGICAL EXAMINATION

**Gait and Posture**
- Abnormalities in gait:
- Walking on heels (L4-L5):
- Walking on toes (S1-S2):
- Rombergs test (Pronator Drift):

**Higher Mental Function**
- Information and Vocabulary:
- Calculating ability:
- Abstract Thinking:

**G.C.S.**:
- Eyes:
- Motor:
- Verbal:

**Evidence of head trauma:**

**Evidence of Meningism:**
- Neck mobility and Brudzinski's sign:
- Kernigs sign:

**Cranial Nerves:**

I Any loss of smell/taste:
Nose examination:

II External examination of eye:
- Visual Acuity:
- Visual fields by confrontation:

- Pupillary light reflexes = Direct:
  = Consensual:
- Fundoscopy findings:

III Ocular Muscles:
Eye opening strength:

IV Inferior and Medial movement of eye:

V
a. Sensory - Ophthalmic:
- Maxillary:
- Mandibular:
b. Motor - Masseter:
- Jaw lateral movement:
c. Reflexes - Corneal reflex
- Jaw jerk

VI Lateral movement of eyes

VII
a. Motor - Raise eyebrows:
- Frown:
- Close eyes against resistance:
- Show teeth:
- Blow out cheeks:
b. Taste - Anterior two-thirds of tongue:

VIII General Hearing:
Rinnes = L: R:
Webers lateralisation:
Vestibular function - Nystagmus:
- Rombergs:
- Wallenbergs:
Otoscope examination:

IX & X Gag reflex:
Uvula deviation:
Speech quality:

XI Shoulder lift:
S.C.M. strength:

XII Inspection of tongue (deviation):

**Motor System:**

a. Power
- Shoulder = Abduction & Adduction:
  = Flexion & Extension:
- Elbow = Flexion & Extension:
- Wrist = Flexion & Extension:

| | |
|---|---|
| - Forearm | = Supination & Pronation: |
| - Fingers | = Extension (Interphalangeals & M.C.P's): |
| - Thumb | = Opposition: |
| - Hip | = Flexion & Extension: |
| | = Adduction & Abduction: |
| - Knee | = Flexion & Extension: |
| - Foot | = Dorsiflexion & Plantar flexion: |
| | = Inversion & Eversion: |
| | = Toe (Plantarflexion & Dorsiflexion): |

b. Tone
- Shoulder:
- Elbow:
- Wrist:
- Lower limb - Int. & Ext. rotation:
- Knee clonus:
- ankle clonus:

c. Reflexes
- Biceps:
- Triceps:
- Supinator:
- Knee:
- Ankle:
- Abdominal:
- Plantar:

**Sensory System:**

a. Dermatomes
- Light touch:
- Crude touch:
- Pain:
- Temperature:
- Two point discrimination:

b. Joint position sense
- Finger:
- Toe:

c. Vibration:
- Big toe:
- Tibial tuberosity:
- ASIS:
- Interphalangeal Joint:
- Sternum:

**Cerebellar function:**

Obvious signs of cerebellar dysfunction:

= Intention Tremor:
= Nystagmus:
= Truncal Ataxia:

Finger-nose test (Dysmetria):
Rapid alternating movements (Dysdiadochokinesia):
Heel-shin test:
Heel-toe gait:
Reflexes:
Signs of Parkinsons:

**8.** <u>**SPINAL EXAMINATION:**</u>(See Regional examination)

Obvious Abnormalities:
Spinous Percussion:
R.O.M:
Other:

**9.** <u>**BREAST EXAMINATION:**</u>

Summon female chaperon.

**Inspection**
- Hands rested in lap:
- Hands pressed on hips:
- Arms above head:
- Leaning forward:

**Palpation**
- masses:
- tenderness:
- axillary tail:
- nipple:
- regional lymph nodes:

## Appendix C

**TECHNIKON NATAL CHIROPRACTIC DAY CLINIC**
**REGIONAL EXAMINATION - *CERVICAL SPINE***

Patient: ______________________________ File: ____________

Date: ______________ Intern/Resident: ______________________________

Clinician: ______________________________ Sign: ________________

**OBSERVATION:**

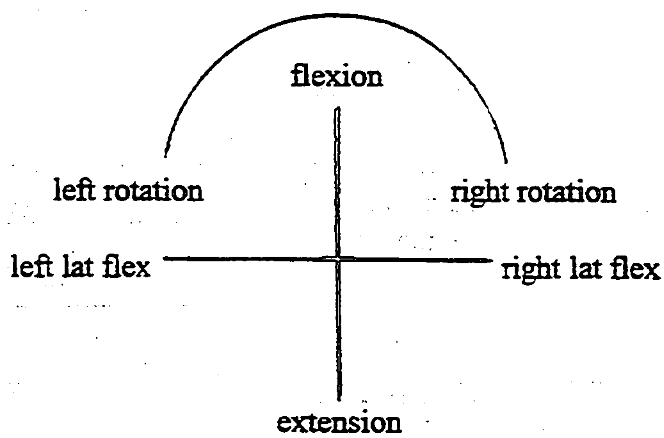
Posture
Swellings
Scars
Discolouration
Hair Line
Bony & Soft Tissue Contours

Shoulder position:
Left:
Right:
Muscle spasm
Facial expression

**RANGE OF MOTION:**

Flexion (45'):
L/R Rotation (70'):

Extension (70'):
L/R Lat Flex (45'):




**PALPATION:**

Lymph Nodes
Thyroid Gland

Trachea

**ORTHOPAEDIC EXAMINATION:**

Tenderness

Trigger Points: SCM, Scalenii, Post Cervicals, Trapezius, Lev Scap

Doorbell sign
Kemp's test
Cervical distraction
Halstead's test
Hyperabduction test
Shoulder abduction test

Cervical compression
Lateral compression
Adson's test
Costoclavicular test
Eden's test
Shoulder depression test

Dizziness rotation test
Brachial plexus tension

Lhermitte's sign

NEUROLOGICAL EXAMINATION:

| Dermatomes | Left | Right | Myotomes | Left | Right | Reflexes | Left | Right |
|---|---|---|---|---|---|---|---|---|
| C2 | | | C1 | | | C5 | | |
| C3 | | | C2 | | | C6 | | |
| C4 | | | C3 | | | C7 | | |
| C5 | | | C4 | | | | | |
| C6 | | | C5 | | | | | |
| C7 | | | C6 | | | | | |
| C8 | | | C7 | | | | | |
| T1 | | | C8 | | | | | |
| | | | T1 | | | | | |

VASCULAR:

| | Left | Right |
|---|---|---|
| Blood Pressure | | |
| Carotid arts. | | |
| Subclavian arts. | | |
| Wallenberg's test | | |

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:

Right: Motion palpation:
Joint Play:

Basic Exam: Shoulder:
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

Upper T horacics:
Motion Palpation:
Joint Play:

Basic Exam: Thoracic Spine:
Case History:

ROM: Motion Palp:
Active:
Passive:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

## Appendix D

# LETTER OF INFORMATION

Dear Patient

Welcome to this research study on whiplash injuries. I am comparing the effect of chiropractic manipulation and proprioceptive exercises to manipulation alone. Both are widely recognised treatments for neck pain in whiplash injuries. Manipulation is commonly used by chiropractors and is a safe and relatively risk-free rehabilitation and is taught at the Technikon Natal. Possible complications to manipulation include vertigo and vascular complications. Proprioceptive exercises, involving head, eye and body coordinated movements, may have side effects such as post-exercise tenderness and stiffness.

All treatment is free of charge and on a voluntary basis. There is no compensation for being on this research; however, possible benefits to you include relief from pain and disability. It will be conducted at the Technikon Natal Chiropractic Day Clinic. Be assured that all information will be regarded as strictly confidential, as data will be placed on anonymous spreadsheets, and you have the right to reject the use of anything with which you do not feel comfortable. The study will consist of two groups of 30, equally and randomly divided. To participate in this study the following criteria will be required:

a. You must be between the age of 20 – 35 years of age.
b. Your whiplash injury must have occurred at least 6 weeks ago.
c. You must be experiencing some degree of neck pain, stiffness or tenderness.
d. If any contraindications to cervical spine manipulation or exercises are suspected on examination, you may not be included in this study.
e. You may not take any NSAID (eg. aspirin, ibuprofen), anti-spasmodic or analgesic drug therapy, neither allopathic nor homoeopathic, for three days before and during the treatment period, as this may influence the results.
f. No other manual therapy may be undertaken during the research period.
g. You are required not to change your lifestyle or level of activity during the research to avoid bias results.

You will receive 6 chiropractic treatments and one follow-up treatment over a 4 week period. Your initial treatment will take approximately two hours, and thereafter one hour each. All treatments will be performed under the supervision of a qualified chiropractor and the researcher has been trained in the last 2 years in spinal manipulative therapy. You will remain in the study as long as you commit to the appointment schedule and there will be no adverse consequences if you decide to stop participating in the research. If for any reason the researcher thinks it is in your best interests to terminate your participation in the research, she has the authority to do so. If there are any unusual findings by the researcher you will be informed of these. At this point I also remind you that there are no right or wrong answers and I appeal to you to be as accurate and honest as possible in your responses to all questions.

Yours sincerely

Nicole Moulder (Researcher to be contacted at 2042205)
Dr B. Kruger (Supervisor to be contacted at 2042205)

## Appendix E

# LETTER OF INFORMED CONSENT

Technikon Natal
Date:______________________________

**Title of research project:** The purpose of this investigation is to evaluate the relative effectiveness of proprioceptive exercises as an adjunct to cervical spine manipulation in the treatment of whiplash-associated disorders.

**Name of supervisor:** Dr B. Kruger
**Name of research student:** Nicole Moulder

**Please tick correct box**

Group 1 will receive manipulation and proprioceptive exercises ☐

Group 2 will receive manipulation only ☐

| **Please circle the appropriate answer** | **Yes** | **No** |
|---|---|---|
| 1. Have you read the research information sheet? | **Yes** | **No** |
| 2. Have you had time to ask questions regarding this study? | **Yes** | **No** |
| 3. Have you received satisfactory answers to your questions? | **Yes** | **No** |
| 4. Have you had an opportunity to discuss this study? | **Yes** | **No** |
| 5. Have you received enough information about this study? | **Yes** | **No** |
| 6. Who have you spoken to? ________________________ | | |
| 7. Do you understand the implications of your involvement in this study? | **Yes** | **No** |
| 8. Do you understand that you are free to withdraw from this study?<br>a) at any time<br>b) without having to give any reason for withdrawing, and<br>c) without affecting your future health care. | **Yes** | **No** |
| 9. Do you agree to voluntarily participate in this study? | **Yes** | **No** |

**If you have signed no to any of the above, please obtain the information before signing.**

**Please print in block letters:**

Patient name:____________________________________ Sign:________________

Research Student name:________________________ Sign:________________

Witness:_____________________________________

# CMCC NECK DISABILITY INDEX

Patient Name:______________________________ File no.:______________ Date:______________

This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only ONE box as it applies to you. We realize you may consider that two of the statements in any one section could relate to you, but please just mark the box which most closely describes your problem.

**Section 1 - Pain Intensity**

- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

**Section 2 - Personal Care (Washing, Dressing ...)**

- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain..
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of self care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

**Section 3 - Lifting**

- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights but it gives extra pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned .
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

**Section 4 - Reading**

- ☐ I can read as much as I want to without pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I cannot read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

**Section 5 - Headaches**

- ☐ I have no headaches at all.
- ☐ I have slight headaches which come infrequently.
- ☐ I have moderate headaches which come infrequently.
- ☐ I have moderate headaches which come frequently.
- ☐ I have severe headaches which come frequently.
- ☐ I have headaches almost all the time.

**Section 6 - Concentration**

- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have fair degree of difficulty in concentrating when I want to.
- ☐ I have a lot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

**Section 7 - Work**

- ☐ I can do as much work as I want to .
- ☐ I can do only my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I cannot do any work at all.

**Section 8 - Driving**

- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I like with moderate pain in my neck.
- ☐ I cannot drive my car as long as I want because of moderate pain in my neck.
- ☐ I can hardly drive at all because of severe pain in my neck..
- ☐ I cannot drive at all.

**Section 9 - Sleeping**

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (<1 hour sleep loss).
- ☐ My sleep is mildly disturbed (1-2 hours sleep loss).
- ☐ My sleep is moderately disturbed (2-3 hours sleep loss).
- ☐ My sleep is greatly disturbed (3-5 hours sleep loss).
- ☐ My sleep is completely disturbed (5-7 hours sleep loss).

**Section 10 - Recreation**

- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities, with some pain in my neck.
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck.
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I cannot do any recreation activities at all.

Vernon/Hagino, modified from Foubister et al.,Physiotherapy, 1980

**Appendix G**

Name:______________________________ File no: ________________

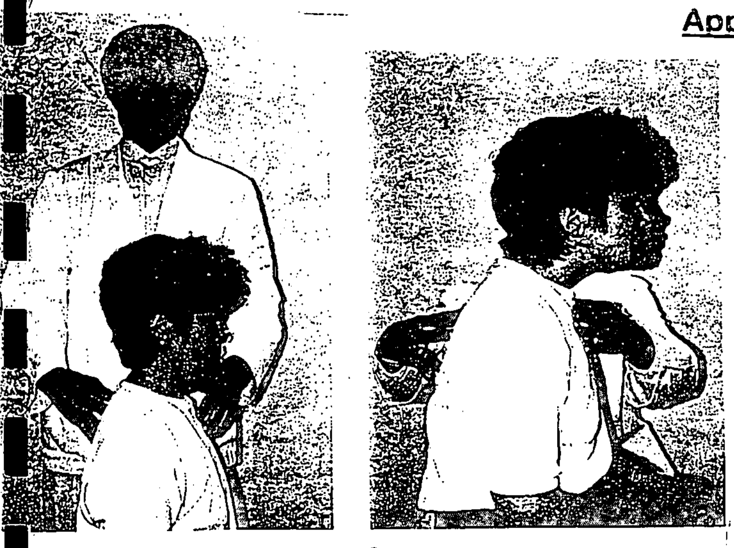
Group:________________________

## ALGOMETER READINGS

| Visit | One | Four | Seven |
|---|---|---|---|
| Left | | | |
| Right | | | |

## HEAD REPOSITIONING ACCURACY (HRA) READINGS

| Visit | One | Four | Seven |
|---|---|---|---|
| Left rotation | | | |
| Right rotation | | | |




–4. Occiput-atlas-axis flexion and extension. The physician stabilizes the upper body while the patient moves the d and neck forward.

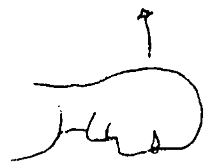
# Level 1 exercises

Before you start the exercises, practice gliding your head forwards and backwards on your neck ('Funky Chicken').

Each exercise is done daily.
5 – 10 reps of each exercise is recommended
Begin exercises slowly and focus on the components of each exercise.

e 10–8. Prone extension with chin in.

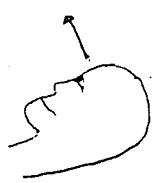
1.



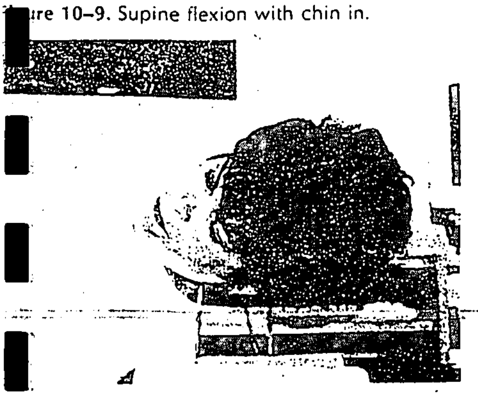
Lying face down
Move head backwards,
Keeping chin in

ıre 10–9. Supine flexion with chin in.

2.

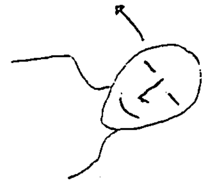


Lying face up
Move head forwards,
Keeping chin in



ıre 10–10. Side posture, chin in, lateral flexion.

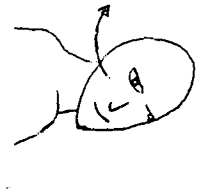
3.



Lying on side
Bend head to shoulder,
Keeping chin in
Repeat on other side

10–11. Prone, extension, chin in, rotation with eyes ... head.

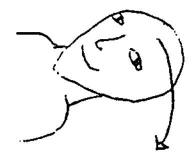
4.



Lying face down,
Keeping chin in,
Rotate head to one side,
lead by the eyes.
Repeat on other side.

Figure 10–12. Supine, flexion, chin in, rotation with eyes leading head.

5.



Lying face up,
Keeping chin in and
head flexed, rotate
head from side to sid
lead by eyes.

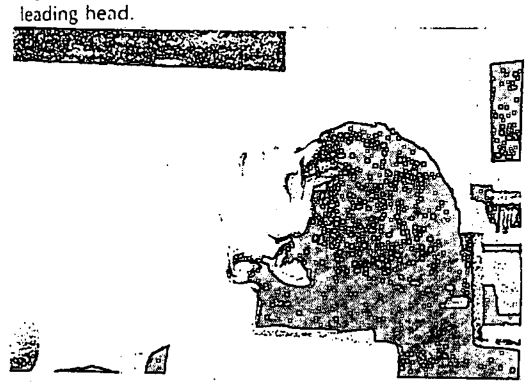
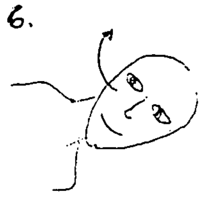


Figure 10–13. Side posture, lateral flexion, chin in, rotation with eyes leading.

6.



Lying on side,
Keeping chin in,
Bend head towards
shoulder, while
rotating head to that
side, lead by eyes

7.

Standing upright,
Focus your eyes
on your hand as you
move it forward,
repeat with other hand

Figure 10–14. Eyes and head focused on hands, with slow left-to-right movements.

# Level 2 exercises

Each exercise is done daily.
5 – 10 reps of each exercise is recommended.

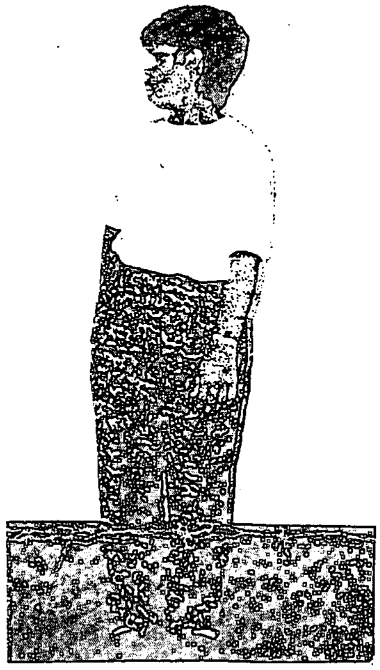
1

Figure 10–15. Patient balancing on foam and slowly moving from side to side.

2.

Repeat no's 1, 2, 4 and 5 of level 1 exercises

3.



igure 10–20. Full body rotation with eyes leading the ead.

4.

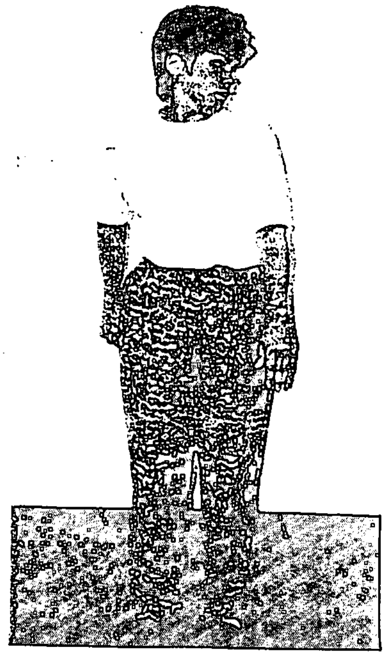
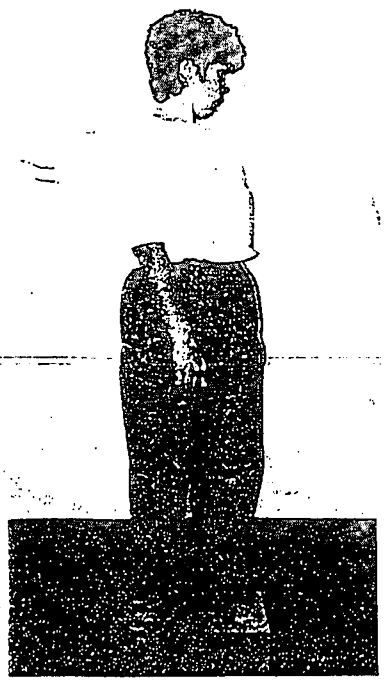


Figure 10–21. Body rotation right, eyes leading head left.

5.

Figure 10–22. Eyes and head focused on hands, with left-to-right movements.

6.



ure 10–23. Patient standing on foam, full body rotation h eyes leading the head.

7.

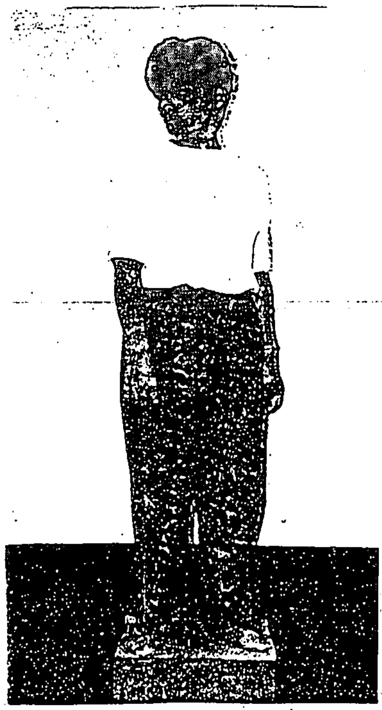


Figure 10–24. Patient standing on foam, body rotation left, eyes leading head right.

8.

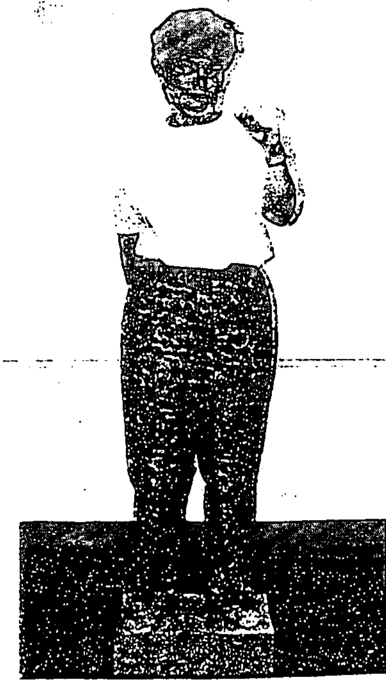


Figure 10–25. Patient standing on foam, eyes and head cused on hand with fast left-right movement.

# The Relative Effectiveness of Proprioceptive Exercises as an Adjunct to Cervical Spine Manipulation in the Treatment of Chronic Cervical Spine Pain and Disability associated with Whiplash Injury

**By**

**Nicole Moulder**

A dissertation submitted in partial compliance with the requirements for the Master's Degree in Technology in the department of Chiropractic at Durban Institute of Technology.

**I, Nicole Moulder, do hereby declare that this dissertation is representative of my own work.**

Nicole Moulder　　**Date** 04/04/03

Approved for final submission

**Date** 4/4/03.

Dr. B. Kruger, M.Tech.Chiro.C.C.S.P.
Supervisor

## Dedication

This work is dedicated to my wonderful parents, Vi and Keith, whose love, support and encouragement throughout my life have allowed me to get to where I am today. I love you both very much and am eternally grateful.

## Acknowledgements

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## Abstract

Whiplash injuries or whiplash-associated disorders (WAD) are a controversial clinical entity, often resulting in chronic pain with a poor response to conventional therapeutics.

The literature encompasses a broad spectrum of presentations, ranging from relatively minor complaints to severe incapacitation, the only common factor being neck pain. A wide variety of interventions are available to treat patients with whiplash injuries. Unfortunately, there is a paucity of adequate clinical trials, and reports of efficacy remain largely anecdotal. Of the treatments available anti-inflammatories, mobilisation, manipulation and active exercise have been identified as the options with the most scientifically established validity. Chiropractic manipulation is thought to restore mobility and normalise mechanoreceptive and proprioceptive input. Injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganised neck proprioceptive activity. The proprioceptive system of the neck has learning capabilities and can possibly be improved by rehabilitation techniques.

This was a comparative, randomised, controlled clinical trial. Thirty patients meeting the research criteria were utilized for the study. Stratified convenience sampling was used and every odd numbered applicant within an age stratum was allocated to Group 1 and vice-versa for Group 2. Those patients in Group 1 received cervical manipulation and proprioceptive exercises for their WAD, whilst

those in Group 2 received cervical manipulation alone. Group 1 formed the experimental group and Group 2 the control group.

At the initial consultation, the patient completed the CMCC Neck Disability Index to assess the subjective findings. Objective findings included Pressure Algometer readings and Head Repositioning Accuracy (HRA) measurements. These subjective and objective measurements were assessed before treatments 1 and 4 and at the $7^{th}$ follow-up visit.

Inter-group analysis showed no statistically significant differences for the CMCC Neck Disability Index and the HRA scores. However statistically significant differences ($p<0.05$) between the two groups were seen for the Pressure Algometer readings. This indicated a significant reduction in tenderness for those subjects receiving both manipulation and proprioceptive exercises. Intra-group analysis of the results indicated that both treatment groups improved significantly ($p<0.05$) between the initial and final consultation for all three measures.

It can be concluded that manipulation is effective in treating pain and disability in WAD patients and proprioceptive exercises are a valuable adjunct to manipulation in further reducing pain and tenderness.

It is recommended that this study be repeated with a larger sample size, to validate these findings.

## Definitions

| | |
|---|---|
| Adhesion: | A fibrous band or structure by which parts adhere abnormally (Bergmann 1993). |
| Adjustment: | The chiropractic adjustment is a specific form of direct articular manipulation utilising either long or short leverage techniques with specific contacts. It is characterised by a dynamic thrust of controlled velocity, amplitude and direction (Bergmann1993). |
| Fixation: | The state by which an articulation has become temporarily immobilised in a position which it may normally occupy during any phase of physiological movement (Bergmann 1993). |
| Kinesthesia: | The sense by which movement, weight, position etc. are perceived, commonly used to refer specifically to the perception of changes in the angles of joints (Bergmann 1993). |
| Myofascial Trigger Point: | A hyperirritable spot in skeletal muscle that is associated with a hypersensitive palpable nodule in a taut band. The spot is painful on compression and can give rise to characteristic referred pain, referred tenderness, motor dysfunction and autonomic phenomena (Travell and Simons 1999). |
| Isokinetic exercise: | Exercise using a constant speed of movement of the body part (Bergmann 1993). |
| Isometric exercise: | Exercise consisting of muscular contractions without movement of the involved parts of the body (www.medical-dictionary.com/results.php). |
| Proprioception: | Sensory perception of movement or position within the body (Bergmann 1993). |
| Saccade: | Rapid eye movement to redirect the line of sight (www.medical-dictionary.com/results.php). |
| Tonus: | The slight continuous contraction of a muscle, which in skeletal muscle aids in the maintenance of posture (Bergmann 1993). |

## Table of Contents

**Chapter 4**

# Chapter 1

## 1.0 Introduction

## 1.1 The Problem and its Setting

Whiplash injuries are thought to occur in as many as one-fifth of all MVA's in the United States and Canada. South Africa may have a higher incidence of whiplash injuries due to the exceptionally high road accident rate when compared with international norms (Burger 1996:478). The incidence rate is higher among female subjects and people aged 20-24 years (Teasell and Shapiro 1998: 72, Spitzer et al. 1995).

Whiplash injuries or whiplash-associated disorders (WAD) often result in chronic pain with a poor response to conventional therapeutics. Manipulation, exercise and anti-inflammatories have been identified as the options with scientifically established validity in the management of WAD (Spitzer et al. 1995)

Patients with WAD have a distortion of the posture control system as a result of disorganised neck proprioceptive activity. It would therefore appear that proprioceptive rehabilitative exercises would benefit WAD sufferers (Revel et al. 1994, Gimse et al. 1996).

Spinal manipulation has also been shown to have a significant effect on proprioceptive-dependent abilities in subjects with chronic neck pain (Rogers 1997).

This suggests that a combination of manipulation and proprioceptive rehabilitation may offer an improved treatment protocol for WAD (Fitz-Ritson 1995).

## 1.2 Statement of the Problem

The purpose of this investigation is to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective and objective measures, in the treatment of whiplash-associated disorders.

### 1.2.1 The First Subproblem

The first objective will be to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective measures, for pain and disability.

### 1.2.2 The Second Subproblem

The second objective will be to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of objective measures, for pain and proprioceptive function.

# Chapter Two

## 2.0 Review of Related Literature

### 2.1 Introduction

Many chronic whiplash patients are the antithesis of the 'ideal patient'. Expectations of the medical system are often very high and as a result patients may continually, and often aggressively, seek different medical opinions and treatment. The chronic pain patient's symptoms are often attributed to 'secondary gain' or compensation neurosis (Tollison and Satterthwaite 1992:309). A broad spectrum of presentations is found, ranging from relatively minor complaints to severe incapacitation (Yochum and Rowe 1996:681). The patient is often distressed because there is usually no objective display of an injury to account for the pain (Taylor and Twomey 1993).

There are currently very few options, in terms of treatment for whiplash injury patients, that have been thoroughly researched and most treatments appear to be based on clinical experience and anecdotal evidence only (Spitzer et al. 1995). There is considerable inconsistency about diagnostic criteria, indications for therapeutic intervention, rehabilitation and the appropriate role of clinicians at all phases of the syndrome (Spitzer et al. 1995).

The following literature review discusses the various aspects associated with whiplash injuries and highlights possible treatment protocols.

## 2.2 Definition of 'Whiplash'

In 1995 a multi-disciplinary review panel (The Scientific Monograph of the Quebec Task Force on Whiplash-Associated Disorders (WAD)) developed the following definition for WAD: "Whiplash is an acceleration-deceleration mechanism of energy transfer to the neck. It may result from rear end or side-impact motor vehicle collisions but can also occur during diving or other mishaps. The impact may result in bony or soft tissue injuries, which may in turn lead to a variety of clinical manifestations" (Spitzer et al. 1995). This syndrome is also commonly referred to as 'Cervical Acceleration/Deceleration Syndrome (CADS)' (Foreman and Croft 1995: 2-3).

The term 'whiplash' applies to a complex and variable set of clinical manifestations, which makes it difficult to define. There is usually a history of a minor or moderately severe rear-end collision. The patient presents with some combination of a large variety of symptoms, the only common factor being neck pain. Radiographs of the cervical spine are generally normal, except for the possible loss of physiologic cervical lordosis (White and Panjabi 1990:230).

### 2.2.1 Signs and Symptoms of WAD

A delay in onset of symptoms of several hours following impact is characteristic of whiplash injuries. The clinical picture of WAD is dominated by head, neck, and upper thoracic pain and is often associated with a variety of poorly explained symptoms (Teasell and Shapiro 1998:73). This may be due to damage to the sympathetic nerve fibres causing nausea, vertigo, visual and auditory symptoms and occasionally Horner's syndrome (Bland 1994:402).

Neck pain is the most commonly reported symptom after WAD incident, followed by headache (Foreman and Croft 1995:311-313, Norris and Watt 1983). Head injury may occur as the brain is forced forward and backward in the skull (Bland 1994:403).

With very severe extension, the oesophagus and larynx are stretched, resulting in dysphagia and hoarseness, and temporomandibular joints are sprained as the head is jerked away from the mandible, resulting in difficulty in chewing and limited opening of the mouth (Bland 1994:402).

Other common symptoms attributed to WAD include musculoskeletal problems such as low back pain, shoulder and interscapular pain and thoracic pain. Local tenderness and referred pain are two hallmark features of WAD. Neurological complications may result in paraesthesias, weakness, thoracic outlet syndrome and arm pain (Teasell and Shapiro 1998:75, Hildingsson and Toolanen 1990, Norris and Watt 1983).

### 2.2.2 Grades of WAD

Spitzer et al. 1995 proposed a classification of WAD on a system of two axes, namely a clinical-anatomic axis and a time axis. The purpose of this classification was to facilitate the evaluation of original research and to be unambiguous and helpful to the clinician.

The clinical-anatomic axis has five grades that correspond roughly to severity. Grade 0 refers to no complaint about the neck and no physical signs. Grade I involves a neck complaint of pain, stiffness or tenderness only, with no objective signs. Grade II refers to neck complaints and musculoskeletal signs, including decreased range of motion and point tenderness. Grade III involves neck complaints and neurological signs, including decreased or absent deep tendon reflexes, weakness and sensory deficits. Grade IV is the most severe grade and refers to neck complaints and fracture or dislocation.

The time axis classifies patients within each grade as those less than 4 days from the time of injury, those 4 – 21 days from the date of the injury, those from 22 – 45 days, those from 46 – 180 days and those with durations more than 6 months. The time axis guides the clinical management of WAD. Patients who are symptomatic 6 months or more after the injury are designated as chronic. In those patients whose complaints exceed 45 days, vigorous clinical intervention is deemed necessary to prevent chronicity (Spitzer et al. 1995).

## 2.3 Incidence and Prevalence of WAD

The incidence of WAD is difficult to determine as there are often suspicious circumstances involving monetary gain through litigation (Foreman and Croft 1995:1). Estimates obtained in a Canadian survey suggest that whiplash injuries occur in as many as one-fifth of all rear-end MVA's (Teasell and Shapiro 1998:72). These figures are similar to those of the United States National Safety Council in 1971, where whiplash injuries were reported in one-quarter of all rear-end collisions (Foreman and Croft 1995:85).

To the authors knowledge the literature revealed no South African statistics on the incidence of WAD; however, South Africa may have a higher incidence of whiplash injury due to the proportionately higher number of motor vehicle accidents on South African roads (Burger 1996:478). Statistics from the Road Accident Fund (RAF) show 181,83 fatal accidents per 100 000 vehicles in South Africa compared to 21,51 per 100 000 for Canada in 1992. This figure has dropped in recent years, possibly due to the implementation of safety campaigns, in particular the Arrive Alive Campaign (www.raf.co.za/aboutraf/roadsafety.html). In South Africa, in 1999, the number of major accidents totaled 21079 and minor accidents totaled 59783 (www.transport.gov.za/search/index.html). Whiplash injury usually results from the collision of two automobiles but also can result from contact sports such as football or high-velocity sports such as skiing (Hertling and Kessler 1990:516).

The incidence of whiplash injury among female sufferers is more than 1.5 times greater than among male sufferers (Spitzer et al. 1995). Women generally have slimmer, less muscular necks, which, theoretically, are less able to resist damaging acceleration forces generated at the time of impact. Another theory suggests woman may be more likely to seek medical treatment for their condition (Teasell and Shapiro 1998:73).

The age-specific incidence rates for WAD reveal the highest incidence of WAD for both genders occurs in the 20 – 24 age group (Spitzer et al. 1995). Foreman and Croft (1995:84) found that the incidence of WAD was greatest between the ages of 20 to 40 years, which coincides with the age of the highest proportion of licensed drivers on the roads. Young children are less frequently injured because they are more resistant to injury and because their heads are usually protected by the relatively high seat backs. With an increase in age, the elasticity of tissues decreases as does range of motion and strength of muscles in the cervical spine.

The potential for injury is increased because the neck is less resilient (Foreman and Croft 1995:84).

Seatbelt and shoulder harness use have reduced the number of serious injuries and fatalities in accidents, however, neck injuries have been found three times more likely to occur by using restraint systems. The seat belt abruptly restrains the decelerating trunk of the occupant while the head's inertia carries it forward unrestrained, resulting in a tremendous bending moment at the cervicothoracic junction (Foreman and Croft 1995:297).

Rearend collisions are associated with a higher rate of relapse or recurrence of symptoms in whiplash subjects, as the biomechanical potential for ligamentous damage is greater from this direction of impact (Spitzer et al. 1995). Head-on collisions result in flexion injuries, which are usually limited by the chin striking the chest (Foreman and Croft 1995:85).

## 2.4 Prognosis and Outcome of WAD

Many physicians believe that the 'whiplash syndrome' is demonstrated only by a group of hysterical, neurotic and dishonest people (Mcnab 1982). However, an interesting observation on the significance of litigation neurosis comes from a follow-up of these patients after settlement of court action (Mcnab 1982).

Mcnab (1982) conducted a retrospective review of 266 medicolegal cases involving WAD and found that even 2 years after settlement 45% continued to have symptoms, which suggests that many whiplash injuries are genuinely chronic in nature.

Hildingsson and Toolanen (1990) performed a follow-up study on 93 WAD cases. They found that after 2 years, 42% of the subjects had fully recovered, 15% had mild discomfort and 43% still had major complaints that interfered with their capacity to work (no p-values stated).

In a study by Radanov et al. (1991), 78 patients, referred 7.2 (SD 4.5) days after they had sustained whiplash injury, were referred for psychological assessment and testing. Six months later, 57 patients were fully recovered and 21 still had persisting symptoms. Analysis showed that psychosocial factors, negative affectivity and personality traits were not significant in predicting which of those patients would continue to have symptoms. However, initial neck pain intensity, age and injury-related cognitive impairment were significant factors predicting illness behavior. This study shows that psychosocial factors have little power to explain the course of recovery from whiplash.

The long-term prognosis of WAD injuries was investigated by Gargan and Bannister (1990), where they reviewed 43 WAD patients after a mean of 10.8 years. Of these, only 12% had recovered completely and 48% had mild symptoms. Residual symptoms were intrusive in 28% and severe in 12%. It appears that most patients have reached their final state within 2 years of injury.

## 2.5 Clinically Relevant Anatomy of the Cervical Spine

The neck is the most mobile segment of the spine. It enables the head to be positioned to receive from the environment all needed sensory information except touch (Bland 1994:3-4). Motions of the head are therefore inseparably linked with motions of the neck, and this linkage is a critical concept in both normal and pathological states (Hertling and Kessler 1990:453).

The cervical vertebra can be categorized as either typical or atypical. The typical vertebrae comprise C3-C6, and the atypical vertebrae comprise C1, C2 and C7 (Foreman and Croft 1995:262). Each vertebrae consists of two major parts – the anterior vertebral body, composed of a cortical shell and cancellous core, which is the major weight bearing structure of the vertebra, and the posterior vertebral arch. The vertebral arch is composed of the pedicle, which joins the arch to the body and to which the superior articular process is attached. This superior process articulates with the inferior process by means of the articular facet joint and the transverse and spinous processes (Hertling and Kessler 1990:453).

The facet / zygapophysial joints are true diarthrodial joints, with articular cartilage and a loose capsule lined with synovial membrane (Gatterman 1990:14). They are clinically important for at least two reasons. First, facets have been found to be a direct source of pain and second, they are important stabilizing structures (White and Panjabi 1990:39).

The size and mass of the vertebrae increase from the first cervical to the last lumbar vertebra. This is a mechanical adaption to the progressively increasing compressive loads to which the vertebrae are subjected. The intervertebral discs separate the bodies of the typical vertebrae and are thicker anteriorly, resulting in the normal cervical lordosis (White and Panjabi 1990:29-60). They consist of an outer annulus fibrosis, made of fibrocartilage, and an inner nucleus pulposis, composed of a proteoglycan gel (Bland 1994:61).

The occipitoatlantal joint ( C0-C1) and the atlanto-axial joint ( C1-C2) are atypical joints as they have no intervertebral discs, no facet joints and have different movement to the rest of the cervical joints. The occipitoatlantal joint allows for flexion and extension and the atlanto-axial joint accounts for 50% of the rotation in the cervical spine (Gatterman 1990). The atlas (C1) lacks a body but has an anterior and posterior arch. The axis (C2) has an odontoid process or dens projecting cephalad from its body (Foreman and Croft 1995:265).
The vertebra prominens (C7) is considered atypical as the vertebral artery normally does not pass through its transverse foramen and it has a prominent

spinous process. This prominence is due to the attachment of numerous ligaments and muscles to this spinous process (Gatterman 1990:207).

The ligaments are vital for the structural stability of the spinal system. Their principal role is to prevent excessive motion (Hertling and Kessler 1990:469). The ligaments must protect the spinal cord in traumatic situations in which high loads are applied at fast speeds. In these highly dynamic situations (e.g. whiplash), not only is the displacement to be restricted within safe limits, but large amounts of energy suddenly applied to the spine must be absorbed (White and Panjabi 1990:19). The ligaments are also the principle tensile load-bearing elements and, along with the apophysial capsules, provide the central nervous system with information in regard to posture and movement (Hertling and Kessler 1990:469).

The ligaments that are most commonly found injured in major whiplash injuries are the anterior and posterior longitudinal ligaments, the capsular ligaments, the ligamentum nuchae and the ligamentum flavum (Foreman and Croft 1995:296). The anterior and posterior longitudinal ligaments attach to the anterior and posterior aspects of the vertebral bodies respectively. The anterior longitudinal ligament serves to limit extension and the thinner posterior longitudinal ligament limits excessive flexion (Foreman and Croft 1995:277). The capsular ligaments provide flexion stability in the cervical spine. The ligamentum flavum has the highest percentage of elastic fibers of any tissue in the body. This is an important factor in a sudden flexion to extension situation as the high elasticity of the ligament, together with its pre-tension, minimizes the chances of any impingement of the spinal cord (White and Panjabi 1990:21-23). The ligamentum nuchae is thought to play a major proprioceptive role in the appropriate functioning of the erector spinae muscles. Damage to this structure may be a factor in some whiplash-type injuries (White and Panjabi 1990:291), possibly resulting in abnormal muscle responses and tone.

A high degree of finely coordinated muscle balance is required to support and move the head on the neck. This is achieved by paired lateral groups of muscles attached to the skull, spinous processes and transverse processes. The deep cervical muscles operate with the sternocleidomastoid and other anterior neck muscles to help resist any sudden or accidental backward movement of the skull. The various deep suboccipital muscles serve to balance the skull on the upper end of the spine (Bland 1994:69).

The skin, muscles, tendons, ligaments, periosteum, intervertebral disc and facet joints of the neck are extensively innervated by nerves that may relay sensory information to the central nervous system (Bolton 1997). There are a number of morphologically specialized nerve endings and receptors found in the neck. The muscle spindle is the most common encapsulated nerve ending in the neck and is found in the deeper portions of the muscle. The Golgi tendon organ is found in musculotendinous junctions at origins and insertions of neck muscles. Pacinian corpuscles are in muscle adjacent to tendons and the fibrous material of the facet joints (Bolton 1997). The muscle spindle receptors occur in particularly high densities in the intervertebral muscles of the neck, and relatively high densities in the large, dorsal muscles of the neck. Afferents from these muscles are known to have profound effects on postural reflexes (Taylor and McCloskey 1988)

There are intrinsic joint receptors that were classified by Wyke in 1967, namely types I – IV. Types I and II have been associated with segmental manipulation and reflex performance (Wyke 1985). Type I is a thinly encapsulated globular corpuscle that is a low threshold, slow adapting, static and dynamic mechanoreceptor. It is involved in tonic reflexogenic effects on neck, limb, jaw and eye muscles. It is also involved in postural and kinesthetic sensation and pain suppression. Type II is a thickly encapsulated conical corpuscle that is a low threshold, rapidly adapting, dynamic mechanoreceptor. It is involved in phasic reflexogenic effects on neck, limb, jaw and eye muscles and is involved in pain suppression (Wyke 1985).

## 2.6 Clinically Relevant Biomechanics of the Cervical Spine

The neck consists of several joints and is an area that sacrifices stability for mobility and is thus vulnerable to injury (Magee 1992:34).

Motion occurs in the cervical spine in three dimensions. The elements primarily responsible for the mobility of the spine are the discs and facet joints. The other passive elements (e.g., ligaments, bone) also exert an influence on motion, but probably are more influential at the end of range of motion. Active elements (e.g., muscles and ligaments) can also affect the kinematics of the spine (Bland 1994:374). Flexion – extension occurs at both the occipito-atlantal and the atlanto-axial articulations. The average combined range of motion at this complex is 23 degrees flexion and extension. Most of the axial rotation in the upper cervical spine takes place at the C1-2 articulation (Bland 1994:374). Approximately 60% of the axial rotation of the entire cervical spine and occiput is found in the upper region (C0-C2). Lateral bending is a very complex motion and only occurs at C0-C1 in the upper cervical spine (Bland 1994:374).

In the middle and lower cervical spine (C2-C7), lateral bending is partially constrained by the uncinate processes; and axial rotation is constrained by the uncinate processes and facet joints (Bland 1994:374). However, most of the motion in flexion / extension is in the central region. The C5 – C6 interspace is generally considered to have the largest range. There may be some causal relationship between this observation and the incidence of cervical spondylosis at that interspace (White and Panjabi 1990:97).

When the cervical spine is positioned in slight lordosis, there is good passive stability from the facet joints and supporting ligaments. When the cervical lordosis is lost or the cervical curve is reversed, passive stability is lost, and the segmental muscles must go into constant contraction to stabilize the spine. Normally, the facet joints are able to bear approximately one third each of the compressive forces of the spine, however, when the cervical lordosis is lost, the entire compressive force is borne by the disc, causing excessive pressure and flattening (Hertling and Kessler 1990:504-505). This is relevant to the patient with whiplash injury, where loss of cervical lordosis is a common radiographic finding.

### 2.6.1 Biomechanics of whiplash

The understanding of what happens to the cervical spine during low-velocity, rear-end collisions is limited, despite a wealth of experimental studies on the biomechanics of the cervical spine. Most of these studies focus on the injury mechanisms in severe cervical spine injuries (Spitzer et al. 1995).

The mechanism of whiplash injury is acceleration of the head and neck relative to the body. The most common mechanism of injury is an automobile at rest struck from behind (Hertling and Kessler 1990:516). The patient's head is thrown backward in a violent, unrestrained hyperextension of the neck. Recoil follows, and the head extends forward in extreme flexion. This is limited by the chin striking the chest or steering wheel (Bland 1994:402). If the head does not strike anything, the injury is produced solely by inertial forces (Tollison and Satterwaite 1993:15).

The neck is unable to adequately compensate for the rapidity of head and torso movement resulting from the acceleration forces generated at the time of impact. This is particularly true when the impact is unexpected and the victim is unable to brace for it (Tollison and Satterwaite 1992:293). The duration of this event, including neck flexion, is approximately 20 milliseconds. Because a protective muscular counteraction requires 50 milliseconds, it is likely that injuries will occur (Gimse et al. 1996). The neck flexor muscles may contract forcefully to counter the sudden neck extension on impact. However, by the time they react, the neck may actually be moving into flexion such that the muscle contraction may paradoxically augment forward force, throwing the spine into further flexion (Tollison and Satterwaite 1992:294). Head injury may also occur as the brain is forced forward and backward in the skull, with consequent cerebral concussion, contrecoup, cerebral contusion and headache (Bland 1994:403).

When the physiological limits of cervical structures are exceeded, anatomical disruption of the soft tissues of the neck (including muscles, ligaments and joint capsules) results (Teasell and Shapiro 1998:72). In general, it can be said that in a whiplash injury, the lower cervical segments (C4-C7) receive the brunt of the damage most of the time. However the majority of whiplash patients have some degree of upper cervical pain, which would not be consistent with the sparing of that area (Foreman and Croft 1995:73). In contrast to most authors, Tollison and Satterwaite (1992:16) state that the upper cervical spine is the most vulnerable area in whiplash injuries and that flexion-extension injury to the atlanto-occipital joint or upper neck sprain is more common than injury between C4 to C7.

Many studies have been conducted to study the effects of whiplash on the spine and supporting soft tissues. By using dummies, laboratory animals, cadavers and occasionally human volunteers exposed to full-scale crash testing, researchers have formulated mathematical models that help quantify the forces that the skull and spine are subjected to at varying collision speeds. Other variables include sizes of vehicles, road conditions, direction of impact, seat back height and stiffness, seatbelt use, head restraints and air bags (Foreman and Croft 1995:2).

## 2.7 Radiological findings in WAD

Exclusion of fractures and dislocations is a first priority in the acute whiplash injury, although radiographs often appear normal. A minimum of frontal, lateral and oblique projections should performed, and once scrutinized for any contra-indications, flexion-extension studies can be done. Radiographs may provide the clinician with information regarding contraindications to manipulation, retropharyngeal haematomas and, when stress views are done, segmental instability (Yochum and Rowe 1996:681).

Following acute whiplash injury, radiographs of the cervical spine are often reported as showing a loss of the normal lordotic curve or a flattening of the normal curve. Radiologists often say this change is characteristic of muscle spasm but this interpretation is incorrect. The neck acts like a bow: if the major muscles of the neck go into spasm, the curve would be exaggerated, not flattened (Mennell 1992:123). According to Yochum and Rowe (1996:684), altered patterns of lordosis may occur as a result of posterior ligamentous injury, muscle spasm or patient positioning. A kyphosis in the cervical spine is suggestive of disruption of the posterior ligamentous complex and may be associated with a higher incidence of disc degeneration at this level a few years later (Yochum and Rowe 1996:684).

In a study by Hildingsson and Toolanen (1990), of the 88 WAD patients, 45 showed normal radiographs, 7 showed degenerative spondylosis and a loss of lordosis or kyphosis was seen in 33 cases. Spondylosis with a straight or kyphotic curve was seen in 3 of the cases.

Hohl (1974) demonstrated a normal lordotic cervical curve in 42%, a loss of lordosis in 35%, a reversed/kyphotic curve in 9% and a sharp reversal in 14% of 146 WAD patients in his study. A significantly higher incidence of degenerative changes occurred in the patients with sharp reversal of the normal cervical curvature ($p<0.05$).

Restricted post-traumatic cervical motion has been shown to develop a high incidence of degenerative changes in the following five years. Degenerative disc disease may be demonstrated as early as 3 months following injury (Yochum and Rowe 1996:689).

## 2.8 Current Available Treatment for WAD

A wide variety of interventions are available to treat patients with whiplash injuries. Unfortunately, there is a paucity of adequate clinical trials, and reports of efficacy remain largely anecdotal. No treatment consistently cures the pain of whiplash injuries (Teasell and Shapiro 1998:78). Most therapeutic interventions currently used in patients with WAD have not been evaluated in a scientifically rigorous manner, and those that have show little or no evidence of efficacy (Spitzer et al. 1995). In the broad spectrum of spine problems, this is one of the most difficult syndromes to manage (White and Panjabi 1990:235).

Medical treatment of WAD typically involves the use of soft collars, analgesics and anti-inflammatories, rest and traction (White and Panjabi 1990:235, Bland 1994:403). Spitzer et al. (1995) found that the use of soft collars may promote inactivity, which can delay recovery in patients with WAD. Collars should not be worn for longer than 72 hours. Prescription of rest in the first few days is a common recommendation for WAD, however, cumulative evidence suggests that prolonged periods of rest are detrimental to recovery in WAD. There is weak evidence that traction is of short-term benefit to WAD sufferers (Spitzer et al. 1995).

Analgesics and non-steroidal anti-inflammatory drugs combined with other treatment modalities were associated with short-term benefit for WAD grades I and II that presented in the acute phase or less than 72 hours post-collision. Although commonly prescribed, muscle relaxants were shown to have no benefit to the WAD sufferer.

Surgery is not indicated for Grades I and II. It is to be restricted to the rare WAD Grade III with persistent arm pain, that does not respond to conservative management or, with rapidly progressing neurologic deficit (Spitzer et al. 1995). Surgical intervention is of little or no use in most WAD patients as cervical disc herniation is an unlikely source of pain (Tollison and Satterthwaite 1992:313).

Of the active treatments available, mobilisation, manipulation and active exercise were identified as the options with the most scientifically established validity. However, only the short-term efficacy of mobilisation and manipulation was established. No studies addressing the long-term benefits of manipulation have been performed. It was recommended that manipulation only be performed by qualified personnel (Spitzer et al. 1995). The independent benefit of exercise could not be established, but was recommended as an adjunct to other therapies (Spitzer et al. 1995).

## 2.9 Cervical Spine manipulation

The source of the neck pain in WAD patients is a common debate. However, recent studies have shown that as many as 85% of WAD patients have their pain originating from the cervical facet joints (Yochum and Rowe 1996:681). One study by Lord et al. (1996) investigated the prevalence of cervical zygapophysial joint pain among 68 patients with chronic neck pain after whiplash injury. Two different local anaesthetics and a placebo injection of normal saline were administered in random order and under double-blinded conditions. A positive diagnosis was made if the patients' pain was completely and reproducibly relieved by each local anaesthetic but not by the placebo injection. Overall, the prevalence of cervical zygapophysial joint pain was 60% (95% confidence interval). In a similar study by Barnsley et al. (1995), painful facet joints were identified in 54% of 50 WAD patients. These studies support the theory that facet joints are a common source of pain in the WAD patient.

An articular fixation is any physical or functional mechanism that produces a loss of segmental mobility within a normal physiological range of motion (Schafer and Faye 1989:2). The fixation in a facet joint may be the result of adhesions in the joint capsule and capsular ligaments, caused by some traumatic injury to these ligaments (Bergmann 1990:150). Chiropractic manipulation is thought to reduce this fixation by breaking these adhesions, stretching the affected tissue, restoring mobility and normalising mechanoreceptive and proprioceptive input. It is also postulated that it does so without triggering an inflammatory reaction and the reoccurrence of fibrosis (Bergmann 1990:150).

Manipulation therapy has been shown to improve pain tolerance. Spinal manipulative treatments show a consistent reflex response of multireceptor origin and may cause clinically observed benefits, including a reduction of pain and a decrease in hypertonicity of muscles (Davis 2001, Tollison and Satterthwaite 1992:311).

In a study by Cassidy et al. (1992) the immediate effects of manipulation on pain and range of motion in the cervical spine were assessed. It was the only accepted study on the effects of manipulation in WAD by the Quebec Task Force in 1995, as their criteria included only randomised, controlled trials. Fifty patients with unilateral neck pain were assessed using the 101-point numerical rating scale (NRS-101) and a goniometric examination. Each patient then received a single, rotational manipulation to the same side as the pain from an experienced chiropractor. Within 5 minutes, the patient repeated the NRS-101 questionnaire and the goniometer readings. The results showed an increase in all planes of post-treatment ROM and a decrease in post-treatment pain scores, thus supporting the clinical efficacy of manipulation for neck pain.

A small study on 10 WAD patients and 9 controls involved the effects of a 6-week regimen of chiropractic manipulation with an Activator Instrument on neck pain, ROM and cervical finite helical axis parameters (FHAP). Mean pain scores decreased from 44.1 to 10.5 and mean ROM increased from 234° to 297° ($p<.0001$). They concluded that spinal manipulative therapy may be beneficial to patients with whiplash injury, and future studies with large sample sizes are warranted (Osterbauer et al.1992).

A retrospective study was undertaken to determine the effects of chiropractic in a group of 28 patients who had been referred with chronic WAD. The severity of patients' symptoms was assessed before and after treatment using the Gargan and Bannister (1990) classification. Improvement was seen in 93% ($p<0.001$) of the patients following chiropractic treatment (Woodward et al. 1996).

In a local study by Kruger (2000), the effect of manipulation of the cervical spine was compared to a placebo treatment, for the treatment of subacute and chronic whiplash injury. The experimental group showed significant improvement ($p=0.05$) for all ranges of motion except flexion. No conclusions could be drawn in terms of pain, discomfort or disability as no significant inter-group changes were found.

## 2.10 Proprioception and WAD

Pain is not the only sequela to whiplash. Because the cervical spine is richly supplied with mechanoreceptors and muscle spindles, chronic pain can play a major role in locomotor system dysfunction and in its perpetuation associated with whiplash trauma. Hypertonicity of the muscles, autonomic reflexes and over-excitation of proprioceptors affecting the central nervous system play a pre-eminent role in the genesis of disequilibrium and chronic postural instability from whiplash-induced injury. As a result of disorganized proprioceptive activity, a whiplash injury can cause distortion of the posture control system, including oculomotor dysfunction (Davis 2001).

A tonic coupling between the horizontal component of eye position and dorsal neck muscle activity has been demonstrated in animals and humans (Andre-Deshays et al. 1988). Andre-Deshays et al. (1991) found subsequently that eye-head coupling is present not only in the fixation period but also during saccades (rapid eye movements) and that a phasic activity or suppression related to saccadic eye velocity is present in dorsal neck muscle EMG.

Damage to neck muscles is associated with a transient disturbance to posture. It is now recognised that neck afferents are involved in three postural related reflexes: Firstly, the cervico-collic reflex, which involves activation of neck muscles when they are stretched, as occurs when the head is displaced with respect to the body. In asymptomatic subjects the cervico-collic reflex is integrated with the vestibulocollic and optokinetic reflexes to assist in the maintenance of head position. Secondly, the tonic neck reflex involves alteration in limb muscle activity when the body moves with respect to the head and acts to maintain a stable posture. Thirdly, the cervico-ocular reflex, together with the vestibulo-ocular and optokinetic reflexes, serve to assist in maintaining eye position (Bolton 1997).

In a review of the literature, Fitz-Ritson (1995) concluded that subjects with scoliosis and paraspinal muscular imbalances had inappropriate proprioception into brainstem nuclei. The vestibular nuclear complex receives converging proprioceptive signals from the labyrinth and oculomotor apparatus and efferent projections from that part of the vestibular nuclear complex are directed to the spinal cord, and contribute to neck muscle control. The "phasic" component of the muscles in the cervical region is believed to be complementary to the vestibular-ocular reflex (Fitz-Ritson 1995).

Revel et al. (1994) investigated the effect of proprioceptive rehabilitation in 60 patients with neck pain in a randomised, controlled trial. They used a system of exercises involving the techniques of eye-head coupling. The experimental group showed a significant improvement (p=0.005) over the control group in terms of pain and proprioceptive function. They concluded that these exercises should be used to treat patients with chronic neck pain.  The results showed that the proprioceptive system of the neck has learning capabilities and can be improved by rehabilitation techniques.

Gimse et al. (1996) used neuropsychological and otoneurological tests to evaluate patients with a history of WAD in a controlled study. The control group was closely matched to the whiplash group with respect to age, sex, education and occupation. The whiplash group deviated significantly from the control group on measures of eye movements during reading, on smooth pursuit eye movements with the head in normal position, and with the body turned to the left or right. Clinical, caloric and neurophysiological tests showed no injury to the vestibular system or to the CNS. Test results thus suggest that injuries to the neck due to whiplash can cause distortion of the posture control system as a result of disorganised neck proprioceptive activity.

It would therefore appear that the proprioceptive rehabilitative exercises mentioned above (Revel et al. 1994) would benefit WAD sufferers, which was found to improve the head-repositioning abilities of the proprioceptive system.

## 2.11 Combined Manipulation and Proprioceptive exercises

Rogers (1997) conducted a controlled trial investigating the effects of spinal manipulation on proprioception in subjects with chronic neck pain. The results indicated a 41% improvement in head-repositioning skill in the manipulation group compared to 12% in the control group, which was significant (p<.0.05). There was also an improvement of 44% in visual analogue scores in the manipulation group as opposed to a 12% improvement in the control group. The study was however weakened by the small sample size of 10 subjects and lack of randomisation. This evidence together with the findings of Revel et al. (1994) suggests that a combination of manipulation and proprioceptive rehabilitation may offer an improved treatment protocol for WAD.

Cervical spine adjustments have been found to have a significant effect on the tone of the lumbo-pelvic musculature, presumably by facilitating tonic neck reflexes involving intersegmental spinal pathways (Nansel et al. 1993). These observations may go a long way towards explaining the postural instability experienced by WAD patients, especially when wearing cervical support collars or in poorly illuminated environments (Wyke 1985). Postural disturbances have been observed as a result of soft-tissue injury, which provides a visual clue of reflexogenic activity (Colloca 1997, Nansel et al.1993). Thus cervical spine manipulation in the WAD patient may have a positive effect on posture and proprioception as well as pain levels.

Tonic muscle responses correspond with head-on-body position and are cervical in origin, and phasic muscle responses correspond to head-on-trunk movement and are derived from both the neck and the vestibular apparatus (Taylor and

McCloskey 1988). Isometric exercises are sometimes given to WAD patients to rehabilitate the neck (Foreman and Croft 1995:462); however, these address only the slow tonic muscles (Fitz-Ritson 1995). It appears that exercises that also address the phasic component of cervical proprioception are needed for treatment of WAD.

The combination of proprioceptive rehabilitation and neck manipulation in WAD sufferers was investigated by Fitz-Ritson (1995). Thirty chronic MVA patients with neck pain were selected for the study. The control group received manipulation and standard exercises (stretching/ isometric/ isokinetic). For the experimental group, he utilised exercises developed over a number of years that require use of the "phasic" component of the cervical spine muscles along with chiropractic manipulation. The results of the pre and post CMCC Neck Disability Index assessment (Appendix F) suggested that this approach was indeed superior ($p>0.001$), but the study had a number of shortcomings. These included a small sample size of 15 and non-uniformity in terms of gender, age and the number of MVA related whiplash injuries. The author suggested further studies address these shortcomings.

This study will therefore attempt to address previous shortcomings by stratifying the ages of subjects and limiting the number of WAD incidents. This will possibly contribute to the management protocol of WAD.

# Chapter Three

## 3.0 Materials and Methods

## 3.1 Introduction

This chapter includes a detailed description of the research methodology and a plan for the statistical analysis thereafter.

## 3.2 Subjects

### 3.2.1 Sampling

This study utilized stratified convenience sampling, as a specific diagnosis of WAD was required. Advertisements were placed at local gyms, technikons, universities, panel-beaters, newspapers, sports clubs, insurance brokers and via pamphlet distribution in the greater Durban area.

Patients with WAD then phoned in, enquiring about the study, after which they were interviewed telephonically. The interview was conducted to determine whether they met the inclusion criteria, in terms of their age, and nature, chronicity and location of their complaint.

### 3.2.2 Inclusion Criteria

The following inclusion criteria were adhered to, in order to increase homogeneity in the study, and ensure all patients accepted into the study suffered from WAD.

a) The patient had to be between the ages of 18 and 60 years. Fitz-Ritson (1995) used a similar age range of 19 – 57 years. He discovered a shortcoming in his study whereby the two groups were not similarly matched in terms of age distribution. This study was therefore stratified for age so as to equally distribute the subjects in each group as follows: 18 – 29 yrs, 30 – 44 yrs, 45 – 60 yrs. Applicants were then selected to consecutively fill these strata i.e.: every even number applicant within an age stratum was allocated to Group 2 and vice-versa for Group 1.

b) The number of whiplash injuries per subject was also limited. This is due to the findings of Fitz-Ritson (1995) where patients with a greater number of WAD incidents responded less well to treatment. This study therefore only included subjects with a history of no more than two WAD incidents.

c) Chronic was defined as 6 weeks and longer after the initial injury (Kruger 2000). All subjects had to have had a whiplash injury at least 6 weeks prior to acceptance into the study. For the purposes of this study, all subjects had to have had a whiplash injury less than 15 years previously.

d) Subjects had to present with neck pain and cervical spine fixation complexes identified using Motion Palpation techniques as described by Schafer and Faye (1989:79-139). In addition, patients had to have any 2 of the following 8 possible signs and symptoms of WAD:

- headaches
- limitation of neck movement
- upper thoracic pain
- tenderness to palpation over the neck musculature
- low back pain
- dizziness / vertigo
- tinnitus
- visual disturbances

Adapted from Foreman and Croft (1995:96), Teasell and Shapiro (1998:73-75).

### 3.2.3 Exclusion Criteria

The exclusion criteria were:

a) Subjects with any contra-indications to manipulation (Foreman and Croft 1995:469, Bergmann et al. 1993:133) were not included in the study as both treatments involved cervical spine manipulation.

These contra-indications included: vertebrobasilar insufficiency, aneurysm, disc prolapse with neurological deficit, fracture, dislocation, bone tumours and bone infections.

Relative contra-indications included: atherosclerosis, anti-coagulant therapy, advanced osteoarthritis, inflammatory arthritis, joint instability, osteomyelitis, osteomalacia and space occupying lesions.

b) Patients were asked not to alter their lifestyle in terms of exercise, regular activities and medication use. Should they have needed to do so, they would have been excluded from the study.

c) Subjects that were receiving any other form of physical therapy or treatment for their WAD were excluded from the study. This included the use of cervical collars, analgesics or anti-inflammatory medication.

d) Applicants without cervical spine radiographs following the whiplash injury were excluded from the study. Patients who had had radiological examination for the condition were asked to present either a radiologist's report or X-rays to confirm the absence of fractures, instability and other contra-indications to cervical spine manipulation. Radiographic examination is recommended for all patients with WAD (Yochum and Rowe 1996:681).

### 3.2.4 Subject Acceptance

Those patients considered suitable for the study after the interview by the researcher were informed, and an initial consultation was then scheduled for the patient. At the initial consultation, the purpose of the study was explained to the patient and a case history, relevant physical examination and regional examination of the cervical spine performed (Appendices A, B and C). During this process, they were screened for compliance with the inclusion and exclusion criteria. Those then accepted into the study were asked to read a patient information letter (Appendix D) and sign an informed consent form (Appendix E).

## 3.3 Procedures

Thirty patients meeting the research criteria were utilized for the study. Stratified convenience sampling was used and every odd numbered applicant within an age stratum was allocated to Group 1 and vice-versa for Group 2. This allowed all patients an equal chance of falling into either group. Those patients in Group 1 received cervical manipulation and proprioceptive exercises for their WAD, whilst those in Group 2 received cervical manipulation alone. Group 1 formed the experimental group and Group 2 the control group.

At the initial consultation, the patient completed the CMCC Neck Disability Index (Appendix F).

Motion Palpation technique was carried out during the cervical regional examination, as referenced in Schafer and Faye (1989:79-139) in order to determine the level, the side and the direction of the loss of motion of the fixated joint.

After the area of joint dysfunction had been identified and recorded on the regional exam, the initial pressure algometer readings were taken. Following these readings, the patients Head Repositioning Accuracy (HRA) measurements were taken.

These subjective and objective measurements were assessed before treatments 1 and 4 and at the $7^{th}$ follow-up visit.

### 3.3.1 Control Group - Group 2 : Cervical Spine Manipulation

The control group was motion palpated to identify the side and level of the lesion/s (Schafer and Faye 1989:79-139) and they were manipulated using a rotary adjustment. The patients were generally supine for the manipulations, unless they felt uncomfortable in that position, in which case they were placed in a seated position. A maximum of three fixations were manipulated at each visit.

The control group was positioned for their adjustment, the skin slack taken up and the joint moved to its end position. A high-velocity, low-amplitude, specifically directed force was then delivered from this end position (Haldeman 1992:485).

The adjustment techniques that were used are as described by Bergmann et al. (1993:253-292):

- For restricted rotation at segments C0 – C1, the hypothenar-occiput contact (supine) and/or the index contact (seated) were used.
- For restricted rotation at segments C1 - C2, the index – atlas contact (supine or seated) and/or the thumb-atlas contact (supine) were used.
- For restricted rotation at segments C2 – C7, the index contact (supine or seated) and/or the thumb-web contact (supine) were used.

If a technique was unsuccessful, another was used for that particular fixation. Success of an adjustment was based on an audible cracking sound and post manipulative manual cervical endplay assessment (Haldeman 1992:485).

### 3.3.2 Experimental Group – Group 1: Manipulation and Proprioceptive exercises

The patients in Group 1 received the same cervical spine manipulative therapy as those in Group 2.

However, prior to manipulation, they received the exercise protocol used by Fitz-Ritson (1995).

Each patient in Group 1 received an exercise sheet (Appendix H) depicting these proprioceptive exercises (Murphy 2000). They also each received a high density foam mat upon which to perform the exercises at home.

These exercises involved co-ordination of head, eye and body movements. In the study by Fitz-Ritson (1995), patients exercised for a minimum of four times weekly, for 8 weeks. Due to time restraints, the treatment period was condensed to 4 weeks. This was divided into two phases, each phase lasting 2 weeks. Each phase included 8 exercises which the patient had to perform daily. 5 – 10 repetitions of each exercise were recommended. Patients were instructed to begin slowly and focus on the components of the exercise. At the beginning of the 4$^{th}$ treatment i.e.: after the first 2 weeks of treatment, patients received phase 2 of their exercise protocol, which they performed for the remainder of the treatment period.

If any pain or discomfort was experienced whilst performing these exercises, patients were asked to reduce the number of repetitions of that exercise until they could achieve the exercise within a pain-free zone. They were then asked to slowly increase the number of repetitions of that exercise over the two-week period until a minimum of 5 repetitions could be performed. They were informed prior to acceptance onto the study of potential side-effects (Appendix D).

Patients performed the exercises before manipulation of their cervical spine and daily at home between treatment sessions. Those patients that admitted non-compliance were excluded from the study.

### 3.3.3 Flowchart (Critical Path)

Convenience sampling: The research was advertised on noticeboards at technikons, universities, panelbeaters, insurance brokers, sports clubs, gyms and in local newspapers prior to and during the research.

↓

Applicants were interviewed telephonically to determine whether they met the research inclusion and exclusion criteria as potential patients for the study.

↓ ↘

Applicant accepted as potential patient | Applicant rejected as potential patient

↓

An initial consultation was scheduled. During this, prospective patients underwent a case history, relevant physical examination and cervical spine regional examination.

↓ ↘

Patient accepted | Patient rejected

↓

Patients were given a patient information letter and signed an informed consent form prior to being randomly allocated into one of the two treatment groups, 15 patients in each group.

↓ ↓

**Group 1:** Manipulation and Proprioceptive exercises | **Group 2:** Manipulation alone

↓ ↓

Patients received a total of 6 treatments and 1 follow-up consultation, over a 4-week period. Subjective and objective data were collected before treatments 1, 4 and at the $7^{th}$ follow-up visit.

## 3.4 <u>Materials</u>

### 3.4.1 Objective Measurements

Two forms of objective measurements were utilized namely: pain tolerance of specific areas of the articular pillar (Pressure Algometer) and testing head repositioning accuracy (HRA). (Appendix G)

#### 3.4.1.1 Pressure Algometer

A Pressure Algometer was utilized to determine and quantify localized tenderness by measurement of the pressure threshold of each patient.

Pressure threshold is referred to as the minimum pressure (force) that induces pain or discomfort (Fisher 1987). The Pressure Algometer is a force gauge, which measures force in kilograms per square centimeter. Fisher (1987) concluded in his study, using 50 volunteers, that changes in pressure threshold, obtained under clinical conditions, can be regarded as reliable data and also correlates well with changes in clinical status. The higher the reading on the algometer, the less tender the underlying structure and thus the greater the patient's pain tolerance.

Patients were informed of what to expect in terms of sensation prior to measurements being taken using the algometer. The algometer was applied over the most tender area of the articular pillar on the left and right sides as predetermined at the first consultation by tenderness to palpation. The instrument was held perpendicular to the skin and slow steady pressure applied. When the patient felt the first sensation of pain or discomfort, he/she said "stop" and the algometer was removed. The reading was recorded and subsequent measurements on visits 4 and 7 were taken at the same level on the articular pillar, as determined by palpation on the initial visit.

#### 3.4.1.2 Head Repositioning Accuracy

This was measured using a method devised and piloted by Revel et al. (1991) and utilized again by Rogers (1997). The patient was seated with a backrest, facing a target 120 centimeters away. They were blindfolded, wearing a helmet on top of which a laser pointer was fixed. The helmet was light-weight, stable and adjustable to fit the patients' head. They were instructed to find a comfortable 'neutral' posture for their head. The projection of the light beam on the target represented the head-neck reference position and this was marked on the target. After several (approximately 8 – 10) seconds of concentration on this position, the patient performed a maximal rotation of the head to the left and then tried to relocate the reference position. The distance between the reference point and the point on which the light beam stopped indicated the error of repositioning (to the nearest 0.5 cm). This was then repeated for right rotation. Patients were not allowed to practice their repositioning skills, and only one reading per side was taken at visits 1, 4 and 7.

Revel et al. (1991) demonstrated that subjects with chronic neck pain performed this task significantly less accurately than healthy subjects, indicating an alteration in neck proprioception in the symptomatic group. A threshold value (4.5°) for accuracy was identified, with a discriminant value of 89% for symptomatic vs. asymptomatic subjects. They concluded that this test allows a discriminant classification of healthy and symptomatic subjects, justifies proprioceptive rehabilitation programs and allows a quantitative evaluation of their results.

HRA scores were used again in a study by Rogers (1997) to determine whether spinal manipulation or stretching exercises, as isolated interventions, had any effect on proprioception-dependent performance of subjects with chronic neck pain. The study was performed on 20 subjects with chronic neck pain whose pain levels (visual analogue scores) and HRA scores were assessed at baseline and at each of the 6 follow-up sessions. The results showed a correlation between pain levels and head repositioning ability, with the manipulation group demonstrating a mean reduction of 44% in visual analogue score and a 41%

improvement in HRA scores, while the stretching group only had a 9% mean reduction in visual analogue scores and a 12% improvement in HRA scores.

For the purposes of this study, only left and right rotation of the head was performed and the error of repositioning measured. The resulting two measurements were then averaged to produce a single number per subject for each session.

### 3.4.2 Subjective measurements

The CMCC Neck Disability Index was used to measure subjective pain intensity in this study.

#### 3.4.2.1 The CMCC Neck Disability Index

This questionnaire (Appendix F) was used to indicate the degree to which patients' neck pain interfered with their daily lives and activities, particularly those suffering from whiplash-type injuries. It consisted of 10 questions, including ratings of pain intensity, personal care, lifting, reading, headaches, concentration, work, driving, sleeping and recreation. Each question was scored at a maximum of 5 points and a minimum of 0 points. The patient answered these questions, receiving a total score out of 50 and this was calculated as a percentage.

The reliability and validity of the CMCC Neck Disability Index has been assessed in only 48 subjects, 70 % of whom had sustained whiplash injury within the past 4 to 6 weeks. However, it has been shown to demonstrate a high degree of test-retest reliability and internal consistency (Vernon and Mior 1991). It is applicable to a wide age range, is unaffected by gender, and has an acceptable level of validity.

Fitz-Ritson (1995) used the CMCC Neck Disability Index as his only outcome measure. The same questionnaire was used in this research to enable better comparison of the results.

## 3.5 Statistical Analysis

### 3.5.1 Introduction

A sample of 30 patients were utilized in this study, with $n_1$ = 15 and $n_2$ = 15. The Durban Institute of Technology research statistician was consulted with regards to the manner in which data was to be analyzed. The appropriate parametric and non-parametric tests were used to analyze the variables due to the small sample size of 15 patients per group. The SPSS statistical package was used for analysis of the data obtained from the CMCC Neck Disability Index, the Pressure Algometer and the HRA scores.

### 3.5.2 Inter-group comparison (manipulation and exercises versus manipulation alone)

Tests of Normality, namely the Kolmogorov-Smirnov test and Shapiro-Wilk test, were run to show whether the data did or did not exhibit trends of normality. Mann-Whitney U test, a non-parametric test and the Independent Samples T-test, a parametric test, was used to compare the manipulation and exercises group versus the manipulation alone group with regard to the CMCC Neck Disability Index, the Pressure Algometer and the HRA readings.

This test was used to determine whether any significant difference existed between the 2 groups for each of the variables, at the $\alpha = 0.05$ level of significance.

Hypothesis Testing

The null hypothesis ($H_0$) stated that there was no difference between the manipulation and proprioceptive exercise group, and the manipulation only group with respect to each of the variables.

The alternative hypothesis ($H_1$) stated that there was a difference.

$\alpha$ was set at a 0.05 level of significance.

- $H_0$: There was no mean difference between the groups.
- $H_1$: There was a mean difference between the groups.
- $\alpha = 0.05$ = level of significance of the test.

Decision rule

The null hypothesis ($H_0$) is rejected at the $\alpha$ level of significance if $p < 0.05$ where p was the observed level of significance or probability value. Failing this, the null hypothesis ($H_0$) was accepted at the same level of significance ($p \geq 0.05$).

### 3.5.3 Intra-group comparison (manipulation and exercises group and manipulation alone group)

Descriptive Statistics were generated to identify trends in the data. The Anova test, a parametric test and Friedman's T-test, a non-parametric test, compares three or more paired groups. These tests coupled with the Multiple Comparison Procedure (parametric) and the Wilcoxon test (non-parametric) were used to determine whether any significant improvement occurred within each group with regards to the CMCC Neck Disability Index, the Pressure Algometer and the HRA readings, between the 1$^{st}$, 4$^{th}$ and 7$^{th}$ consultations. The Multiple

Comparison Procedure and Wilcoxon test was used as a post-hoc test to determine which group differed from which other group, if the p value was small.

## Hypothesis Testing

The null hypothesis ($H_0$) stated that there was no improvement between consultations with regards to the CMCC Neck Disability Index, Pressure Algometer and HRA readings. The alternative hypothesis ($H_1$) stated that there was an improvement between consultations with regards to the variables of interest.

## Decision rule

The null hypothesis was rejected at the $\alpha = 0.05$ level of significance if $p < 0.05$ where p was the observed level or probability value. Otherwise, the null hypothesis was accepted at the $\alpha$ level of significance.

## Chapter Four

## 4.0 Results

### 4.1 Introduction

This chapter will represent the data and attempt to analyse the data in tabular form in order to accept or reject the hypotheses. The subjective and objective findings of both groups are discussed. Demographic data, accident related data and patient data were also highlighted.

### 4.2 Demographic Data

**Table 4.2.1 Age distribution**

| Age range | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| 18 – 29 yrs | 9 | 10 | 19 | 63.3 % |
| 30 – 44 yrs | 3 | 1 | 4 | 13.3 % |
| 45 – 60 yrs | 3 | 4 | 7 | 23.3 % |
| **Mean age** | 32.53 | 32.4 | 32.47 | |

**Table 4.2.2 Gender distribution**

| Gender | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **Female** | 9 | 10 | 19 | 63.3 % |
| **Male** | 6 | 5 | 11 | 36.7 % |

**Table 4.2.3 Race distribution**

| Race | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| **White** | 14 | 12 | 26 | 86.7 % |
| **Indian** | 1 | 2 | 3 | 10 % |
| **Coloured** | 0 | 1 | 1 | 3.3 % |

Table 4.2.4 Number of WAD incidents

| No. of WAD | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| 1 WAD | 10 | 9 | 19 | 63.3 % |
| 2 WAD | 5 ( 4 male ) | 6 ( 5 male ) | 11 | 36.7 % |

Table 4.2.5 Time elapsed since most recent WAD

| Time frame | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| < 8 weeks | 2 | 4 | 6 | 20 % |
| 8 wk – 6 mo | 0 | 1 | 1 | 3.3 % |
| 6 mo – 1 yr | 1 | 3 | 4 | 13.3 % |
| 1 yr – 2 yr | 7 | 0 | 7 | 23.3 % |
| 2 yr – 5 yr | 4 | 5 | 9 | 30 % |
| 5 yr – 15 yr | 1 | 2 | 3 | 10 % |

Table 4.2.6 Type of whiplash injury (most recent)

| Type | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| MVA | 13 | 12 | 25 | 83.3 % |
| Motorcycle | 0 | 1 | 1 | 3.3 % |
| Watersports | 1 | 1 | 2 | 6.7 % |
| Diving | 0 | 1 | 1 | 3.3 % |
| Rugby tackle | 0 | 0 | 0 | 0 % |
| Boat accident | 1 | 0 | 1 | 3.3 % |

Table 4.2.7 Direction of collision (MVA only)

| Direction | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| Rear | 7 | 4 | 11 | 44 % |
| Front | 3 | 3 | 6 | 24 % |
| Side | 1 | 4 | 5 | 20 % |
| Roll | 2 | 0 | 2 | 8 % |
| Spin | 0 | 1 | 1 | 4 % |

Table 4.2.8 Position in car (most recent MVA)

| Position | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| Driver | 10 | 9 | 19 | 76 % |
| Passenger front | 1 | 3 | 4 | 16 % |
| Passenger back | 2 | 0 | 2 | 8 % |

Table 4.2.9 Seatbelt use (most recent MVA)

| Seatbelt | Group 1 (n = 13) | Group 2 (n = 12) | Total (n = 25) | % |
|---|---|---|---|---|
| On | 4 | 8 | 12 | 48 % |
| Off | 9 | 4 | 13 | 52 % |

Table 4.2.10 Head Position (most recent MVA)

| Head position | Group 1 (n = 13) | Group 2 (n = 12) | Total | % |
|---|---|---|---|---|
| Forward | 12 | 9 | 21 | 84 % |
| Left | 1 | 0 | 1 | 4 % |
| Right | 0 | 3 | 3 | 12 % |

Table 4.2.11 Injuries other than WAD (most recent MVA)

| Injuries | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| None | 10 | 14 | 24 | 80 % |
| Bumped head only | 2 | 0 | 2 | 6.7 % |
| Bumped head – confusion | 1 | 0 | 2 | 6.7 % |
| Bumped head – concussion | 1 | 1 | 1 | 3.3 % |
| Dislocated AC joint | 1 | 0 | 1 | 3.3 % |

Table 4.2.12 Subjective location of cervical spine pain

| Location | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| Sub-occipital | 10 | 8 | 18 | 60 % |
| Mid-cervical | 3 | 4 | 7 | 23.3 % |
| Lower cervical | 1 | 1 | 2 | 6.7 % |
| Entire c-spine | 1 | 2 | 3 | 10 % |

Table 4.2.13 Distribution of signs and symptoms

| Signs and symptoms | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| Neck pain | 15 | 15 | 30 | 100 % |
| C-spine fixation | 15 | 15 | 30 | 100 % |
| Headaches | 13 | 15 | 28 | 93.3 % |
| Limited neck movement | 10 | 11 | 21 | 70 % |
| Upper thoracic pain | 10 | 11 | 21 | 70 % |
| Tenderness to palpation | 11 | 11 | 22 | 73.3 % |
| Low back pain | 8 | 2 | 10 | 33.3 % |
| Dizziness / vertigo | 3 | 1 | 4 | 13 % |
| Tinnitus | 0 | 0 | 0 | 0 % |
| Visual disturbances | 1 | 0 | 1 | 3.3 % |

Table 4.2.14 Radiographic findings

| Radiographic findings | Group 1 | Group 2 | Total | % |
|---|---|---|---|---|
| Normal | 2 | 4 | 6 | 20 % |
| Loss of lordosis | 11 | 10 | 21 | 70 % |
| Kyphosis | 2 | 0 | 2 | 6.7 % |
| Scoliosis | 0 | 1 | 1 | 3.3 % |

## 4.3 Results of Data Analysis

### 4.3.1 Subjective data (CMCC Neck Disability Index)

#### 4.3.1.1 Inter-group Comparison

4.3.1.1.1 Tests for normality

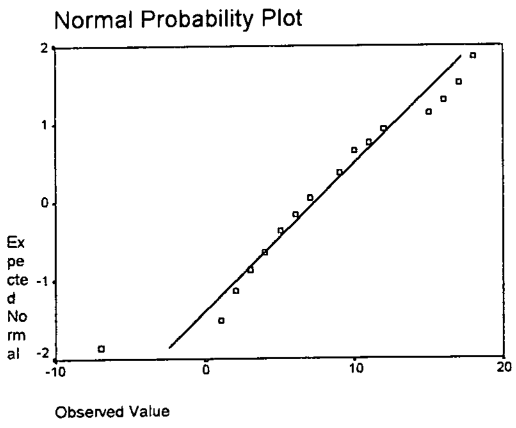
Before conducting the two independent sample T-Tests, we check if the assumption of normality and equal variances of both populations is false. Also note that this test is fairly robust to the assumption of normality. A test for non-normality in the table below suggests both sets of data are not significantly non-normal. (the p value, which equals 0.389, is not less than 0.05). Evidence of this is also portrayed in the normal probability plot below.

**Tests of Normality**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| NDI13 | .108 | 30 | .200* | .964 | 30 | .389 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction



### 4.3.1.1.2 Comparison of drop in CMCC NDI scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| NDI13 | 1 | 15 | 8.8667 | 5.16674 | 1.33405 |
| | 2 | 15 | 5.7333 | 5.17503 | 1.33619 |

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| NDI13 | Equal variances assumed | .096 | .759 | 1.659 | 28 | .108 | 3.1333 | 1.88814 | -.73435 | 7.00102 |
| | Equal variances not assumed | | | 1.659 | 28.000 | .108 | 3.1333 | 1.88814 | -.73435 | 7.00102 |

**Test Statistics[b]**

| | NDI13 |
|---|---|
| Mann-Whitney U | 80.000 |
| Wilcoxon W | 200.000 |
| Z | -1.354 |
| Asymp. Sig. (2-tailed) | .176 |
| Exact Sig. [2*(1-tailed Sig.)] | .187[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

The group statistics reflected above indicates that group 1 definitely has a bigger drop on average than group 2 with an average drop of 8.87 compared to group 2 with an average drop of 5.17. This drop is, however, **not significant**, as the p value in the table below is only 0.108 (for both equal and non-equal variances).

The independent sample T-tests results above are backed up when as a check we also conduct the equivalent non-parametric procedure (The Mann- Whitney U Test) and yield a p value equal to 0.187, also **not significant**.

Since the p-value is $\geq 0.05$, the null hypothesis is accepted. Therefore we conclude that there is not enough evidence to suggest that the CMCC Neck Disability Index scores have shown a significantly different drop between groups 1 and 2 at a $\alpha = 0.05$ level of significance.

From here on instead of going through the complete procedure above for all tests we have simply calculated both the parametric and equivalent non-parametric tests in all cases and if the results agree we concluded accordingly. However, if they disagreed then we ran the appropriate assumption diagnostics and applied the correct test.

4.3.1.1.3 Comparison of final treatment score means of group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| NDI3 | 1 | 15 | 6.53 | 5.514 | 1.424 |
| | 2 | 15 | 7.80 | 6.144 | 1.586 |

Parametric

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| NDI3 | Equal variances assumed | .584 | .451 | -.594 | 28 | .557 | -1.27 | 2.132 | -5.633 | 3.100 |
| | Equal variances not assumed | | | -.594 | 27.680 | .557 | -1.27 | 2.132 | -5.635 | 3.102 |

Non-parametric

**Test Statistics**[b]

| | NDI3 |
|---|---|
| Mann-Whitney U | 101.000 |
| Wilcoxon W | 221.000 |
| Z | -.480 |
| Asymp. Sig. (2-tailed) | .631 |
| Exact Sig. [2*(1-tailed Sig.)] | .653[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Although Group 1 has a mean, which is lower (6.53) compared to Group 2 (7.80), the difference is **not significant**:

Independent 2 sample parametric t- test at a 5% significance level yields a p value = 0.557

Independent 2 sample non-parametric Mann-Whitney test at a $\alpha = 0.05$ significance level yields a p value = 0.653

Therefore both population means from group 1 and 2 are **not significantly different**.

#### 4.3.1.2 Intra-group Comparison

##### 4.3.1.2.1 Group 1

**Descriptives[a]**

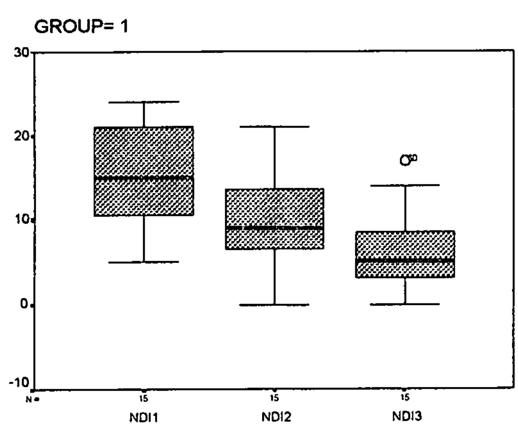
NDI

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean Lower Bound | 95% Confidence Interval for Mean Upper Bound | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| 1 | 15 | 15.4000 | 6.44537 | 1.66419 | 11.8307 | 18.9693 | 5.00 | 24.00 |
| 2 | 15 | 9.7333 | 5.73793 | 1.48153 | 6.5558 | 12.9109 | .00 | 21.00 |
| 3 | 15 | 6.5333 | 5.51448 | 1.42383 | 3.4795 | 9.5872 | .00 | 17.00 |
| Total | 45 | 10.5556 | 6.86412 | 1.02324 | 8.4933 | 12.6178 | .00 | 24.00 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for a reduction in mean values over time:
At stage 1 we have a mean = 15.40
At stage 2 we have a mean = 9.73
At stage 3 we have a mean = 6.53

This trend relationship is also highlighted in a box and whisker plot below.



4.3.1.2.1.1 Comparison of group 1's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric

**ANOVA[a]**

NDI

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 604.844 | 2 | 302.422 | 8.651 | .001 |
| Within Groups | 1468.267 | 42 | 34.959 | | |
| Total | 2073.111 | 44 | | | |

a. GROUP = 1

Non-parametric (Friedman's test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 25.481 |
| df | 2 |
| Asymp. Sig. | .000 |

a. Friedman Test

b. GROUP = 1

Anova p value: 0.001
Friedman p value: 0.000

Both the parametric Analysis of Variance Test and the equivalent non-parametric Friedman test yield the same conclusion, reject $H_0$ and conclude there is a **significant difference** between means.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the parametric test are utilised, as the data is not significantly non-normal.

## Parametric

**Multiple Comparisons[a]**

Dependent Variable: NDI
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | 95% Confidence Interval Upper Bound |
|---|---|---|---|---|---|---|
| 1 | 2 | 5.6667* | 2.15897 | .032 | .4215 | 10.9119 |
| | 3 | 8.8667* | 2.15897 | .001 | 3.6215 | 14.1119 |
| 2 | 1 | -5.6667* | 2.15897 | .032 | -10.9119 | -.4215 |
| | 3 | 3.2000 | 2.15897 | .310 | -2.0452 | 8.4452 |
| 3 | 1 | -8.8667* | 2.15897 | .001 | -14.1119 | -3.6215 |
| | 2 | -3.2000 | 2.15897 | .310 | -8.4452 | 2.0452 |

*. The mean difference is significant at the .05 level.

a. GROUP = 1

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

## Non-Parametric

## Wilcoxon Tests for Matched Pairs

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI2 - NDI1 | Negative Ranks | 13[a] | 7.00 | 91.00 |
| | Positive Ranks | 0[b] | .00 | .00 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. NDI2 < NDI1

b. NDI2 > NDI1

c. NDI1 = NDI2

d. GROUP = 1

**Test Statistics[b,c]**

| | NDI2 - NDI1 |
|---|---|
| Z | -3.186[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI1 | Negative Ranks | 15[a] | 8.00 | 120.00 |
| | Positive Ranks | 0[b] | .00 | .00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI1

b. NDI3 > NDI1

c. NDI1 = NDI3

d. GROUP = 1

**Test Statistics[b,c]**

| | NDI3 - NDI1 |
|---|---|
| Z | -3.414[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI2 | Negative Ranks | 10[a] | 6.20 | 62.00 |
| | Positive Ranks | 1[b] | 4.00 | 4.00 |
| | Ties | 4[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI2

b. NDI3 > NDI2

c. NDI2 = NDI3

d. GROUP = 1

**Test Statistics [b,c]**

| | NDI3 - NDI2 |
|---|---|
| Z | -2.584[a] |
| Asymp. Sig. (2-tailed) | .010 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

### 4.3.1.2.2 Group 2

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| NDI1 | .334 | 15 | .000 | .749 | 15 | .001 |
| NDI2 | .169 | 15 | .200* | .939 | 15 | .368 |
| NDI3 | .215 | 15 | .060 | .902 | 15 | .100 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

**Test of Homogeneity of Variances[a]**

NDI

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 1.257 | 2 | 42 | .295 |

a. GROUP = 2

The test for normality shows that stage 1 (visit 1) and stage 3 (visit 3) scores are significantly non-normal by their low p values as indicated above. The non-parametric test will tend to prove more accurate in this case but both analysis are reported on for comparative purposes. The test for homogeneity of variance does not however show significantly different variances (p value = 0.295).

**Descriptives[a]**

NDI

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 | 15 | 13.5333 | 5.78010 | 1.49241 | 10.3324 | 16.7342 | 8.00 | 30.00 |
| 2 | 15 | 9.8000 | 6.51591 | 1.68240 | 6.1916 | 13.4084 | 1.00 | 22.00 |
| 3 | 15 | 7.8000 | 6.14352 | 1.58625 | 4.3978 | 11.2022 | .00 | 21.00 |
| Total | 45 | 10.3778 | 6.47474 | .96520 | 8.4326 | 12.3230 | .00 | 30.00 |

a. GROUP = 2

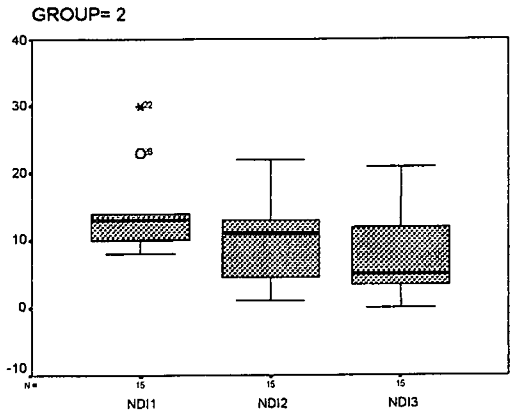
The Mean values above indicate there is a definite trend for a reduction in mean values over time:

At stage 1 we have a mean = 13.53

At stage 2 we have a mean = 9.8

At stage 3 we have a mean = 7.8

This trend relationship is also highlighted in a box and whisker plot below.



4.3.1.2.2.1 Comparison of group 2's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric

**ANOVA[a]**

NDI

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 254.044 | 2 | 127.022 | 3.354 | .045 |
| Within Groups | 1590.533 | 42 | 37.870 | | |
| Total | 1844.578 | 44 | | | |

a. GROUP = 2

Non-parametric (Friedman's test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.552 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 2

Anova p value: 0.045
Friedman p value: 0.002

Both the parametric Analysis of Variance Test and the equivalent non-parametric Friedman test yield the same conclusion, reject $H_0$ and conclude we have a **significant difference** between means.

As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. If the results differ, the non-parametric test results will be utilised as the data is considered non-normal.

Parametric

**Multiple Comparisons[a]**

Dependent Variable: NDI
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | 3.7333 | 2.24707 | .232 | -1.7259 | 9.1926 |
| | 3 | 5.7333* | 2.24707 | .038 | .2741 | 11.1926 |
| 2 | 1 | -3.7333 | 2.24707 | .232 | -9.1926 | 1.7259 |
| | 3 | 2.0000 | 2.24707 | .650 | -3.4592 | 7.4592 |
| 3 | 1 | -5.7333* | 2.24707 | .038 | -11.1926 | -.2741 |
| | 2 | -2.0000 | 2.24707 | .650 | -7.4592 | 3.4592 |

*. The mean difference is significant at the .05 level.

a. GROUP = 2

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI2 - NDI1 | Negative Ranks | 9[a] | 7.72 | 69.50 |
| | Positive Ranks | 4[b] | 5.38 | 21.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. NDI2 < NDI1

b. NDI2 > NDI1

c. NDI1 = NDI2

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI2 - NDI1 |
|---|---|
| Z | -1.682[a] |
| Asymp. Sig. (2-tailed) | .093 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI1 | Negative Ranks | 14[a] | 7.93 | 111.00 |
| | Positive Ranks | 1[b] | 9.00 | 9.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI1

b. NDI3 > NDI1

c. NDI1 = NDI3

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI3 - NDI1 |
|---|---|
| Z | -2.901[a] |
| Asymp. Sig. (2-tailed) | .004 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| NDI3 - NDI2 | Negative Ranks | 11[a] | 8.00 | 88.00 |
| | Positive Ranks | 4[b] | 8.00 | 32.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. NDI3 < NDI2

b. NDI3 > NDI2

c. NDI2 = NDI3

d. GROUP = 2

**Test Statistics[b,c]**

| | NDI3 - NDI2 |
|---|---|
| Z | -1.595[a] |
| Asymp. Sig. (2-tailed) | .111 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

### 4.3.1 Objective data ( Algometer readings )

Three paired t-tests were run for each group to see if the left and the right hand side results were significantly different at a 5 % significance level.

## Group 1 – Algometer reading 1

**Paired Samples Test[a]**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | | | |
| Pair 1 AR1L - AR1R | -.0800 | .28335 | .07316 | -.2369 | .0769 | -1.093 | 14 | .293 |

a. GROUP = 1

## Group 2 – Algometer reading 1

**Paired Samples Test[a]**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | | | |
| Pair 1 AR1L - AR1R | .0467 | .23258 | .06005 | -.0821 | .1755 | .777 | 14 | .450 |

a. GROUP = 2

## Group 1 – Algometer reading 2

**Paired Samples Test[a]**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | | | |
| Pair 1 AR2L - AR2R | -.0733 | .28149 | .07268 | -.2292 | .0826 | -1.009 | 14 | .330 |

a. GROUP = 1

## Group 2 – Algometer reading 2

**Paired Samples Test[a]**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | | | |
| Pair 1 AR2L - AR2R | .0067 | .21536 | .05561 | -.1126 | .1259 | .120 | 14 | .906 |

a. GROUP = 2

## Group 1 – Algometer reading 3

**Paired Samples Test[a]**

| | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|
| | Mean | Std. Deviation | Std. Error Mean | 95% Confidence Interval of the Difference Lower | 95% Confidence Interval of the Difference Upper | | | |
| Pair 1 AR3L - AR3R | -.1133 | .49261 | .12719 | -.3861 | .1595 | -.891 | 14 | .388 |

a. GROUP = 1

Group 2 – Algometer reading 3

**Paired Samples Test**[a]

| | | Paired Differences | | | | | t | df | Sig. (2-tailed) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 95% Confidence Interval of the Difference | | | | |
| | | Mean | Std. Deviation | Std. Error Mean | Lower | Upper | | | |
| Pair 1 | AR3L - AR3R | .0133 | .20307 | .05243 | -.0991 | .1258 | .254 | 14 | .803 |

a. GROUP = 2

The above tables all show p values not less than 0.05 which suggests that all measures from the left and the right are not significantly different. Therefore for the purpose of all further analysis both left and right readings were averaged out and analysis run on this new data.

### 4.3.1.2 Inter-group Comparison

4.3.1.2.2 Comparison of increase in Algometer scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| AR31 | 1 | 15 | .5900 | .22850 | .05900 |
| | 2 | 15 | .3033 | .33936 | .08762 |

<u>Parametric</u>

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| AR31 | Equal variances assumed | .411 | .527 | 2.714 | 28 | .011 | .2867 | .10563 | .07028 | .50305 |
| | Equal variances not assumed | | | 2.714 | 24.530 | .012 | .2867 | .10563 | .06890 | .50444 |

## Non-Parametric

**Test Statistics[b]**

| | AR31 |
|---|---|
| Mann-Whitney U | 42.500 |
| Wilcoxon W | 162.500 |
| Z | -2.914 |
| Asymp. Sig. (2-tailed) | .004 |
| Exact Sig. [2*(1-tailed Sig.)] | .003[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

The increase in Group1's algometer reading is significantly higher than in Group 2.
Both parametric and non-parametric tests yield **significant** p values 0.011 and 0.003 in both cases respectively.

### 4.3.1.2.3 Comparison of final treatment algometer score means of group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| AR3 | 1 | 15 | 1.8567 | .42840 | .11061 |
| | 2 | 15 | 1.5267 | .39860 | .10292 |

## Parametric

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| AR3 | Equal variances assumed | .099 | .755 | 2.184 | 28 | .037 | .3300 | .15109 | .02051 | .63949 |
| | Equal variances not assumed | | | 2.184 | 27.856 | .038 | .3300 | .15109 | .02044 | .63956 |

Non – Parametric

**Test Statistics[b]**

| | AR3 |
|---|---|
| Mann-Whitney U | 59.000 |
| Wilcoxon W | 179.000 |
| Z | -2.222 |
| Asymp. Sig. (2-tailed) | .026 |
| Exact Sig. [2*(1-tailed Sig.)] | .026[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Both the unpaired t-test and the Mann Whitney U test yield the same results namely that the algometer reading at final stage for group1 is significantly higher than group 2 at a 5% level of significance.

Since the p-value is < 0.05, the null hypothesis is rejected. Therefore we conclude that there is enough evidence to suggest that the Algometer scores have shown a **significantly different** increase between groups 1 and 2 at a $\alpha$ = 0.05 level of significance.

### 4.3.2.2 Intra-group Comparison

4.3.2.2.1 Group 1

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| AR1 | .133 | 15 | .200* | .963 | 15 | .739 |
| AR2 | .160 | 15 | .200* | .961 | 15 | .716 |
| AR3 | .131 | 15 | .200* | .966 | 15 | .799 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 1

**Test of Homogeneity of Variances[a]**

ALG

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| .131 | 2 | 42 | .877 |

a. GROUP = 1

All stages do not show significant departures from normality and significantly different variances and hence Anova may be the appropriate test here but we still do the equivalent non-parametric test namely the Friedman test.

**Descriptives[a]**

ALG

| | | | | | 95% Confidence Interval for Mean | | | |
|---|---|---|---|---|---|---|---|---|
| | N | Mean | Std. Deviation | Std. Error | Lower Bound | Upper Bound | Minimum | Maximum |
| 1 | 15 | 1.2667 | .39446 | .10185 | 1.0482 | 1.4851 | .70 | 2.05 |
| 2 | 15 | 1.5433 | .39725 | .10257 | 1.3233 | 1.7633 | .95 | 2.35 |
| 3 | 15 | 1.8567 | .42840 | .11061 | 1.6194 | 2.0939 | 1.20 | 2.75 |
| Total | 45 | 1.5556 | .46640 | .06953 | 1.4154 | 1.6957 | .70 | 2.75 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for an increase in mean values over time:
At stage 1 we have a mean = 1.27
At stage 2 we have a mean = 1.54
At stage 3 we have a mean = 1.86

4.3.2.2.1.1 Comparison of group 1's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric (Anova test)

**ANOVA[a]**

ALG

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | 2.614 | 2 | 1.307 | 7.891 | .001 |
| Within Groups | 6.957 | 42 | .166 | | |
| Total | 9.571 | 44 | | | |

a. GROUP = 1

Non-Parametric (Friedman Test)

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 24.667 |
| df | 2 |
| Asymp. Sig. | .000 |

a. Friedman Test

b. GROUP = 1

Both Anova and Friedman yield the same results namely that all three means are **significantly different** at a 5% level of significance.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the parametric test are utilised, as the data is not significantly non-normal.

Parametric

**Multiple Comparisons[a]**

Dependent Variable: ALG

Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | -.2767 | .14861 | .163 | -.6377 | .0844 |
| | 3 | -.5900* | .14861 | .001 | -.9511 | -.2289 |
| 2 | 1 | .2767 | .14861 | .163 | -.0844 | .6377 |
| | 3 | -.3133 | .14861 | .100 | -.6744 | .0477 |
| 3 | 1 | .5900* | .14861 | .001 | .2289 | .9511 |
| | 2 | .3133 | .14861 | .100 | -.0477 | .6744 |

*. The mean difference is significant at the .05 level.

a. GROUP = 1

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

## Non-Parametric

## Wilcoxon test for matched pairs procedure

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR2 - AR1 | Negative Ranks | 1[a] | 5.50 | 5.50 |
| | Positive Ranks | 13[b] | 7.65 | 99.50 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. AR2 < AR1
b. AR2 > AR1
c. AR1 = AR2
d. GROUP = 1

**Test Statistics[b,c]**

| | AR2 - AR1 |
|---|---|
| Z | -2.956[a] |
| Asymp. Sig. (2-tailed) | .003 |

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR | Negative Rank | 0[a] | .00 | .00 |
| | Positive Ranks | 15[b] | 8.00 | 120.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. AR3 < AR1
b. AR3 > AR1
c. AR1 = AR3
d. GROUP = 1

**Test Statistics[b,c]**

| | AR3 - AR1 |
|---|---|
| Z | -3.413[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR2 | Negative Ranks | 1[a] | 5.50 | 5.50 |
| | Positive Ranks | 12[b] | 7.13 | 85.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR2
b. AR3 > AR2
c. AR2 = AR3
d. GROUP = 1

**Test Statistics[b,c]**

| | AR3 - AR2 |
|---|---|
| Z | -2.798[a] |
| Asymp. Sig. (2-tailed) | .005 |

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test
c. GROUP = 1

The follow up pairwise comparison of means using non-parametric procedures results in:
The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

4.3.2.2.2 Group 2

**Tests of Normality[b]**

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| AR1 | .260 | 15 | .007 | .760 | 15 | .001 |
| AR2 | .199 | 15 | .114 | .912 | 15 | .144 |
| AR3 | .127 | 15 | .200* | .934 | 15 | .308 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

**Test of Homogeneity of Variances[a]**

ALG

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 1.519 | 2 | 42 | .231 |

a. GROUP = 2

Stage 1 shows significant departures from normality and stage 2 comes very close to being significantly non-normal. Both tests are applied but Friedman's test is more appropriate here.

**Descriptives[a]**

ALG

| | N | Mean | Std. Deviation | Std. Error | 95% Confidence Interval for Mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound | | |
| 1 | 15 | 1.2233 | .28402 | .07333 | 1.0660 | 1.3806 | .95 | 2.10 |
| 2 | 15 | 1.4233 | .29330 | .07573 | 1.2609 | 1.5858 | 1.00 | 2.10 |
| 3 | 15 | 1.5267 | .39860 | .10292 | 1.3059 | 1.7474 | 1.00 | 2.50 |
| Total | 45 | 1.3911 | .34613 | .05160 | 1.2871 | 1.4951 | .95 | 2.50 |

a. GROUP = 2

The Mean values above indicate there is a definite trend for an increase in mean values over time:
At stage 1 we have a mean = 1.22
At stage 2 we have a mean = 1.42
At stage 3 we have a mean = 1.53

#### 4.3.2.2.2.1 Comparison of group 2's means at visits 1, 4 and 7 using parametric and non-parametric testing

Parametric (Anova test)

**ANOVA**[a]

ALG

| | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Between Groups | .713 | 2 | .357 | 3.287 | .047 |
| Within Groups | 4.558 | 42 | .109 | | |
| Total | 5.271 | 44 | | | |

a. GROUP = 2

Non-Parametric (Friedman Test)

**Test Statistics**[a,b]

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.473 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 2

Both Anova and Friedman yield the same results with p Values less than 0.05, therefore all three means are significantly different.

As the null hypothesis (H0) is rejected for Friedman's T-test, multiple comparison tests are applied to determine which of the treatments are significantly different. If results differ, the results of the non-parametric test are utilised, as the data is significantly non-normal.

## Parametric

**Multiple Comparisons [a]**

Dependent Variable: ALG
Tukey HSD

| (I) STAGE | (J) STAGE | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| 1 | 2 | -.2000 | .12029 | .231 | -.4922 | .0922 |
| | 3 | -.3033* | .12029 | .040 | -.5956 | -.0111 |
| 2 | 1 | .2000 | .12029 | .231 | -.0922 | .4922 |
| | 3 | -.1033 | .12029 | .669 | -.3956 | .1889 |
| 3 | 1 | .3033* | .12029 | .040 | .0111 | .5956 |
| | 2 | .1033 | .12029 | .669 | -.1889 | .3956 |

*. The mean difference is significant at the .05 level.

a. GROUP = 2

The follow up pairwise comparison of means using parametric procedures results in:
The means from Stages 1 and 2 are **not significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

## Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR2 - AR | Negative Rank | 2[a] | 3.50 | 7.00 |
| | Positive Ranks | 12[b] | 8.17 | 98.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. AR2 < AR1

b. AR2 > AR1

c. AR1 = AR2

d. GROUP = 2

**Test Statistics[b,c]**

| | AR2 - AR1 |
|---|---|
| Z | -2.867[a] |
| Asymp. Sig. (2-tailed) | .004 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR | Negative Rank | 1[a] | 1.50 | 1.50 |
| | Positive Ranks | 12[b] | 7.46 | 89.50 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR1

b. AR3 > AR1

c. AR1 = AR3

d. GROUP = 2

**Test Statistics[b,c]**

| | AR3 - AR1 |
|---|---|
| Z | -3.082[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| AR3 - AR | Negative Rank | 5[a] | 5.40 | 27.00 |
| | Positive Ranks | 8[b] | 8.00 | 64.00 |
| | Ties | 2[c] | | |
| | Total | 15 | | |

a. AR3 < AR2

b. AR3 > AR2

c. AR2 = AR3

d. GROUP = 2

**Test Statistics[b,c]**

| | AR3 - AR2 |
|---|---|
| Z | -1.295[a] |
| Asymp. Sig. (2-tailed) | .195 |

a. Based on negative ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **not significantly** different.

### 4.3.3 Objective data (Head Repositioning Accuracy)

#### 4.3.3.1 Inter-group Comparison

The HRA left and right readings were averaged to produce a single score per patient at visits 1, 4 and 7.

**Tests of Normality**[b]

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| HRA13 | .152 | 15 | .200* | .933 | 15 | .302 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 1

**Tests of Normality**[b]

| | Kolmogorov-Smirnov[a] | | | Shapiro-Wilk | | |
|---|---|---|---|---|---|---|
| | Statistic | df | Sig. | Statistic | df | Sig. |
| HRA13 | .174 | 15 | .200* | .942 | 15 | .403 |

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

b. GROUP = 2

The tests for normality show that both data sets are not significantly non-normal (both p values are large).

### 4.3.3.1.1 Comparison of drop in HRA scores in group 1 and group 2 using parametric and non-parametric tests

**Group Statistics**

| | GROUP | N | Mean | Std. Deviation | Std. Error Mean |
|---|---|---|---|---|---|
| HRA13 | 1 | 15 | 5.1167 | 4.56781 | 1.17940 |
| | 2 | 15 | 4.4667 | 3.57804 | .92385 |

<u>Parametric</u>

**Independent Samples Test**

| | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | 95% Confidence Interval of the Difference | |
| | | F | Sig. | t | df | Sig. (2-tailed) | Mean Difference | Std. Error Difference | Lower | Upper |
| HRA13 | Equal variances assumed | 1.647 | .210 | .434 | 28 | .668 | .6500 | 1.49816 | -2.41884 | 3.71884 |
| | Equal variances not assumed | | | .434 | 26.481 | .668 | .6500 | 1.49816 | -2.42679 | 3.72679 |

Non-parametric

**Test Statistics[b]**

| | HRA13 |
|---|---|
| Mann-Whitney U | 104.000 |
| Wilcoxon W | 224.000 |
| Z | -.353 |
| Asymp. Sig. (2-tailed) | .724 |
| Exact Sig. [2*(1-tailed Sig.)] | .744[a] |

a. Not corrected for ties.

b. Grouping Variable: GROUP

Group statistics shows that the mean drop in HRA score in group 1 is 5.11 where in group 2 it is 4.67. This difference is however, **not significant** according to the results of both parametric and non-parametric tests, the p values in each case respectively of 0.668 and 0.744.

Since the p-value is $\geq 0.05$, the null hypothesis is accepted. Therefore we conclude that there is not enough evidence to suggest that the HRA scores have shown a significantly different drop between groups 1 and 2 at a $\alpha = 0.05$ level of significance.

### 4.3.3.2 Intra-group Comparison

#### 4.3.3.2.1 Group 1

**Test of Homogeneity of Variances[a]**

HRA

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 3.264 | 2 | 42 | .048 |

a. GROUP = 1

The test for equality of variances yield significantly different variances (p value = 0.048), therefore the Anova test would not be appropriate here and the non-parametric Friedman's Test is used.

**Descriptive Statistics[a]**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| HRA1 | 15 | 10.7167 | 4.38429 | 4.50 | 20.00 |
| HRA2 | 15 | 8.4167 | 3.55777 | 4.00 | 15.50 |
| HRA3 | 15 | 5.6000 | 2.21359 | 2.00 | 11.00 |

a. GROUP = 1

The Mean values above indicate there is a definite trend for a decrease in mean values over time:
At stage 1 we have a mean = 10.72
At stage 2 we have a mean = 8.42
At stage 3 we have a mean = 5.60

4.3.3.2.1.1 Comparison of group 1's HRA means at visits 1, 4 and 7 using non-parametric testing

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 12.644 |
| df | 2 |
| Asymp. Sig. | .002 |

a. Friedman Test

b. GROUP = 1

The Friedman test is outlined above yielding a p value =0.002, therefore we have **significantly different** means at a 5% level of significance

As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. A non-parametric test is utilised, as the data is significantly non-normal.

Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA2 - HRA | Negative Rank | 10[a] | 9.70 | 97.00 |
| | Positive Ranks | 5[b] | 4.60 | 23.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA2 < HRA1

b. HRA2 > HRA1

c. HRA1 = HRA2

d. GROUP = 1

**Test Statistics[b,c]**

| | HRA2 - HRA1 |
|---|---|
| Z | -2.104[a] |
| Asymp. Sig. (2-tailed) | .035 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA | Negative Rank | 13[a] | 7.77 | 101.00 |
| | Positive Ranks | 1[b] | 4.00 | 4.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA1

b. HRA3 > HRA1

c. HRA1 = HRA3

d. GROUP = 1

**Test Statistics[b,c]**

| | HRA3 - HRA1 |
|---|---|
| Z | -3.047[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA | Negative Ranks | 12[a] | 9.50 | 114.00 |
| | Positive Ranks | 3[b] | 2.00 | 6.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA2

b. HRA3 > HRA2

c. HRA2 = HRA3

d. GROUP = 1

**Test Statistics[b,c]**

| | HRA3 - HRA2 |
|---|---|
| Z | -3.068[a] |
| Asymp. Sig. (2-tailed) | .002 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 1

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

4.3.3.2.1 Group 2

**Test of Homogeneity of Variances[a]**

HRA

| Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|
| 3.051 | 2 | 42 | .058 |

a. GROUP = 2

The test for equality of variances yield significantly different variances (p value = 0.058), therefore the Anova test would not be appropriate here and the non-parametric Friedman's Test is used.

**Descriptive Statistics[a]**

| | N | Mean | Std. Deviation | Minimum | Maximum |
|---|---|---|---|---|---|
| HRA1 | 15 | 10.7000 | 4.00803 | 4.00 | 18.00 |
| HRA2 | 15 | 8.1333 | 2.55976 | 4.00 | 13.50 |
| HRA3 | 15 | 6.2333 | 2.45580 | 4.00 | 13.00 |

a. GROUP = 2

The Mean values above indicate there is a definite trend for a decrease in mean values over time:
At stage 1 we have a mean = 10.70
At stage 2 we have a mean = 8.13
At stage 3 we have a mean = 6.23

4.3.3.2.2.1 Comparison of group 2's HRA means at visits 1, 4 and 7 using non-parametric testing

**Test Statistics[a,b]**

| | |
|---|---|
| N | 15 |
| Chi-Square | 14.724 |
| df | 2 |
| Asymp. Sig. | .001 |

a. Friedman Test

b. GROUP = 2

The Friedman test is outlined below yielding a p value =0.001, therefore we have **significantly different** means at a 5% level of significance. As the null hypothesis (H0) is rejected for Friedman's T-test, a multiple comparison test is applied to determine which of the treatments are significantly different. A non-parametric test is utilised, as the data is significantly non-normal.

Non-Parametric

Wilcoxon test for matched pairs procedure.

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA2 - HRA | Negative Rank | 12[a] | 7.54 | 90.50 |
| | Positive Ranks | 2[b] | 7.25 | 14.50 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA2 < HRA1

b. HRA2 > HRA1

c. HRA1 = HRA2

d. GROUP = 2

**Test Statistics[b,c]**

| | HRA2 - HRA1 |
|---|---|
| Z | -2.391[a] |
| Asymp. Sig. (2-tailed) | .017 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA | Negative Ranks | 13[a] | 8.00 | 104.00 |
| | Positive Ranks | 1[b] | 1.00 | 1.00 |
| | Ties | 1[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA1

b. HRA3 > HRA1

c. HRA1 = HRA3

d. GROUP = 2

**Test Statistics[b,c]**

| | HRA3 - HRA1 |
|---|---|
| Z | -3.237[a] |
| Asymp. Sig. (2-tailed) | .001 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

**Ranks[d]**

| | | N | Mean Rank | Sum of Ranks |
|---|---|---|---|---|
| HRA3 - HRA | Negative Rank | 11[a] | 8.91 | 98.00 |
| | Positive Ranks | 4[b] | 5.50 | 22.00 |
| | Ties | 0[c] | | |
| | Total | 15 | | |

a. HRA3 < HRA2

b. HRA3 > HRA2

c. HRA2 = HRA3

d. GROUP = 2

**Test Statistics[b,c]**

| | HRA3 - HRA2 |
|---|---|
| Z | -2.161[a] |
| Asymp. Sig. (2-tailed) | .031 |

a. Based on positive ranks.

b. Wilcoxon Signed Ranks Test

c. GROUP = 2

The follow up comparison of means using non-parametric procedures results in:

The means from Stages 1 and 2 are **significantly** different.
The means from Stages 1 and 3 are **significantly** different.
The means from Stages 2 and 3 are **significantly** different.

# Chapter Five

## 5 Discussion

### 5.1 Introduction

This chapter includes an interpretation of the results seen in Chapter Four. The demographic data is compared to that of previous research, and the analysis of the subjective and objective data is discussed.

The sample utilized for this study consisted of 30 subjects. Statistical analysis therefore was at risk of accepting the incorrect hypotheses (Type II error) due to the relatively small sample size. To decrease the chance of this happening, all data was subjected to tests of normality, which showed whether the data was representative of a normal distribution.

Two important results are taken from this study. Firstly, statistically significant differences were seen between the two groups on inter-group analysis with the objective algometer readings. Secondly, statistically significant changes were seen on intra-group analysis for both subjective and objective readings between visits for both groups.

## 5.2 Demographic Data

The average age of the patients that participated in this study was 32.47 years (Table 4.2.1). The average age of group 1 was 32.53 years and group 2 was 32.4 years. However, 63.3 percent of the subjects fell between the ages of 18 to 29 years and only 13.3 percent fell between the ages of 30 to 44 years. The remaining 23.3 percent fell between the ages of 45 to 60 years. This corresponds with the findings of Spitzer et al. (1995), where the highest incidence of whiplash injury for both genders occurred in the 20 – 24 age group. The ages between the groups were closely matched, as intended by the researcher, by selecting every even numbered subject in a particular age group into group 2.

The gender distribution of the 30 patients in the study was 63.3 percent female and 36.6 percent male (Table 4.2.2). Group 1 and 2 were similarly matched for gender ratios. Females are 1.5 times more likely to experience whiplash injuries than are men (Spitzer et al. 1995). Women have slimmer, less muscular necks, which may be less able to resist damaging acceleration forces. They also may be more likely to seek medical attention than their male counterparts (Teasell and Shapiro 1998).

The race distribution of this study was not representative of South Africa, but perhaps more representative of the patient population attending the clinic. 86.7 percent were white, 10 percent Indian and 3.3 percent coloured (Table 4.2.3).

On the recommendations of Kruger (2000) and Spitzer et al. (1995), certain accident-related data was recorded. The number of WAD incidents was limited to a maximum of two, to create a more uniform sample. The majority of patients (63.3%) had had only one WAD incident (Table 4.2.4) while 36.7 percent had sustained two WAD injuries. This is important to consider, as the prognosis of WAD is poorer following previous whiplash injury (Tollison and Satterthwaite 1992:306, Foreman and Croft 1995:85).

Table 4.2.5 outlines the time frames in which the patients presented to the research following their most recent WAD incident. Twenty percent presented in the early chronic stage, namely between 6 – 8 weeks, where inflammation could be a major source of their pain. Surprisingly, few (16.7 %) presented between 8 weeks and 1 year of the WAD incident, and the majority occurred between 1-2 years (23.3%) and 2-5 years (30%). It is possible that degenerative changes could have occurred in the cervical spine that had begun to be symptomatic only years later.

The majority of whiplash injuries occur in MVA's but a small percentage occur from other types of acceleration / deceleration forces found in contact sports or high-velocity sports (Hertling and Kessler 1990:516). In this study, MVA-related WAD accounted for 83.3% of patients (Table 4.2.6); watersports, such as water-skiing and wakeboarding, was 6.7%; and boating accidents, diving injuries and motorcycle accidents accounting each for 3.3% of the WAD cases. Rugby tackle injuries are also a common source of WAD, however these injuries were not seen in this patient population, possibly due to the small sample size.

Typically, a whiplash injury occurs when a vehicle is struck from the rear or side (Spitzer et al.1995). Of the 25 patients in this study involved in MVA's, 44% had had a rear impact, 20% a side impact, 24% a front impact, 8% rolled and 4% had their vehicle spin out of control (Table 4.2.7). Spitzer et al. 1995 found that of the 3014 study cohort members, 30.7% had had a rear collision, 19.1% a side collision, 14.5% a head-on collision and the remaining 35.8% was classified as missing data or other. There appears to a higher percentage of residual symptoms in WAD patients involved in rear-impact collisions than those in front and side collisions (Foreman and Croft 1995:325). One possible reason for this is that drivers who are struck from the front or side are usually alerted to the impending collision in sufficient time to brace for the impact (Foreman and Croft 1995:74).

Of the 25 WAD patients involved in MVA's in this study, 76% were driving the vehicle at the time of the collision (Table 4.2.8), which corresponds with the findings of Spitzer et al. (1995). Only 48% of the patients in this study were wearing a seatbelt at the time of the accident (Table 4.2.9). This percentage is lower than the 87.6% recorded by Spitzer et al. 1995 but their information was obtained from police reports, where patients may have over-reported as a result of medicolegal claims. Neck injuries are three times more likely to occur in belted drivers than in unbelted drivers. The primary reason for this being that the shoulder harness abruptly restrains the decelerating trunk of the occupant while the heads inertia carries it forward unrestrained, resulting in a tremendous bending moment at the cervicothoracic region (Foreman and Croft 1995:85).

The likelihood of injury is greater when non-symmetrical loads are applied to the spine such as in oblique collisions e.g. vehicle struck in right rear corner or when the occupant's head is turned during a rear-end collision (Foreman and Croft 1995:85). The three-point or diagonal seatbelt may also add a rotational component to the force during flexion of the head and trunk (Foreman and Croft 1995:85). Table 4.2.10 shows that of the 25 patients involved in MVA's in this research, 3 had their head turned to the right and 1 had their head turned to the left. The remainder were reported as looking forward, however, a few appeared uncertain when recalling the accident. Only the one patient looking left, however, had a rear collision and he also had the highest initial subjective pain reading on the CMCC Neck Disability Index in Group 1.

Patients often report being temporarily dazed, shaken, confused or disoriented following an MVA. These alterations in consciousness are a component of concussion (Foreman and Croft 1995:120). A patient who strikes his or head during the accident may lose consciousness for a brief period of time. The impact to the head is, essentially, a second, separate accident. Therefore, the structures of the cervical spine are subjected to a second trauma and have almost twice the amount of post-traumatic degeneration (Foreman and Croft 1995:446). Hohl (1974) studied as a subgroup, those patients who had lost consciousness during accidents, 64% experienced degenerative changes within the five year study period, as opposed to 36% of those patients who did not lose consciousness. Table 4.2.11 shows that 80% of the subjects in this study reported no injuries other than WAD at the time of the accident. Of the 5 patients that bumped their heads, 2 were confused and 1 was concussed. All 5 patients showed loss of cervical lordosis on radiographic examination. Another patient dislocated his acromio-clavicular joint after rolling his vehicle.

All the patients entering this study had cervical spine pain. In general, it can be said that in WAD trauma, the lower segments of the cervical spine (C4 – C7) receive the brunt of the damage most of the time (Foreman and Croft 1995:73). However, the subjective location of this pain varied considerably (Table 4.2.12). In fact 60% of the patients had sub-occipital pain, 23.3% had mid-cervical pain and only 6.7% had lower cervical spine pain. The remaining 10% could not pinpoint their pain and stated the pain was along the entire cervical spine. These findings are interesting when one looks at the radiographic findings in these patients (Table 4.2.14). Loss of lordosis and cervical spine kyphosis between segments C4 to C6 was seen in 70% and 6.7% of these patients respectively. The remaining 20% had normal radiographs and 1 patient had a cervical spine scoliosis. It appears that the objective site of the lesion is not necessarily the site at which the patient feels the pain.

Neck pain is the most commonly reported symptom after WAD trauma (88 – 100% of the time). It may be immediate, but it is generally delayed in onset and usually occurs within 72 hours (Foreman and Croft 1995:311). For the purposes of this study, all patients had to present with neck pain and cervical spine fixations. Headache is the second most frequently reported symptom in WAD injury. The studies utilized by Spitzer et al. 1995 show an incidence between 54 – 66% but this study shows an incidence of 93.3% (Table 4.2.13). However, it is possible that those with more severe symptoms are more likely to seek medical attention.

Limited neck movement and upper thoracic pain occurred in 70% of the subjects in this research. Similarly, Hildingsson and Toolanen (1990) found neck stiffness in 69% of their 93 subjects. Low back pain is a common symptom in WAD and according to Foreman and Croft (1995:299) is more likely to occur in side impact accidents, where the seat offers little protection to lateral bending forces. In this study 33.3% suffered low back pain, however no correlation was seen between vector of impact and incidence of low back pain. Hohl (1974) and Gargan and Bannister (1990) showed an incidence of LBP of 35% and 42% respectively.

Point tenderness is considered a musculoskeletal sign in a Grade II WAD injury (Spitzer et al. 1995). However, Foreman and Croft (1995:328) state tenderness to palpation may be present in all cases and is not particularly specific from a diagnostic standpoint. 73.3% of the subjects had point tenderness in their cervical spine. According to Travell and Simons (1999:451), experiencing forceful head movement in an automobile accident can produce extreme neck flexion and muscle strain. This strain activates trigger points in head and neck muscles, especially the posterior cervical muscles. Automobile impact from any direction is likely to activate semispinalis capitis trigger points (Travell and Simons 1999:452).

Other symptoms included dizziness and vertigo, seen in 13% of the research patients and 3.3% had visual disturbances (Table 4.2.13). Gargan and Bannister (1990) showed similar findings with 19% of their patients presenting with vertigo and 2% with visual disturbances. Auditory disturbances such as tinnitus are often seen in WAD, however no such cases were seen in this research.

## 5.3 Discussion of Data Analysis

### 5.3.1 The first objective

The first objective was to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of subjective measures, for pain and disability.

5.3.1.1 Inter-group analysis (CMCC Neck Disability Index)

Subjectively no statistically significant differences were seen between Group 1 and Group 2 for the CMCC Neck Disability Index. The group statistics indicate that group 1 definitely has a bigger average drop in score for the CMCC Neck Disability Index than group 2. This drop is, however, not statistically significant. Both groups are considered to have improved equally in terms of subjective measurements. Proprioceptive exercises as an adjunct to manipulation do not significantly alter the patients perception of his or her pain or disability as compared to manipulation alone.

5.3.1.2 Intra-group analysis

Statistically significant changes were seen between visits for subjective measurements in both groups.

For the proprioceptive exercises and manipulation group, the mean scores between visits 1 and 4 and between visits 1 and 7 show a significant improvement. No significant change was seen between visits 4 and 7. Therefore the patients improvement was more marked in the first 2 weeks of the treatment program.

For the manipulation only group, the mean scores between visits 1 and 7 show a significant improvement. No significant changes were seen between visits 1 and 4 or visits 4 and 7. The patients therefore improved gradually over the treatment program.

Proprioceptive exercises, as an adjunct to manipulation did not appear to play a more important role in the patients subjective perception of their pain and disability as compared to manipulation alone. However, they may have served to provide the patient with more rapid pain relief.

### 5.3.2 The second objective

The second objective was to evaluate the relative effectiveness of proprioceptive exercises and cervical spine manipulation compared to manipulation alone, in terms of objective measures, for pain and proprioceptive function

5.3.2.1.1 Inter-group Analysis (Algometer Readings)

Statistically significant differences were seen between the two groups for objective algometer readings.

The increase in group1's algometer reading is significantly higher than in group 2 and the algometer reading at final stage for group 1 is significantly higher than that of group 2 at a 5% level of significance.

The null hypothesis is rejected and we conclude that there is enough evidence to suggest that there is a significant objective improvement in pain and tenderness in the proprioceptive exercise and manipulation group as compared to manipulation alone.

A possible explanation for this may be the fact that semispinalis capitis muscle overlies the articular pillars of the cervical spine. The trigger points in this muscle, according to Travell and Simons (1999:452), are almost always activated in a whiplash injury. As the algometer reading was taken on the most tender cervical articular pillar of the patient, it is likely that these active trigger points as well as a fixation were present at that level. To treat these trigger points, Travell and Simons (1999:469) suggest a combination of stretches and exercise therapy, which includes posture training.

It is then possible that the proprioceptive exercises utilised in this research caused inactivation of these trigger points, resulting in reduced tenderness over the articular pillar and therefore an improved algometer reading.

#### 5.3.2.1.2 Intra-group Analysis (Algometer Readings)

Statistically significant differences were seen for both treatment groups between visits 1 and 7. No significant differences were seen for either group between visits 1 and 4 or visits 4 and 7 using parametric testing. However, non-parametric testing showed significant changes between both these visits for group 1 and between visits 1 and 4 for group 2.

Therefore both groups improved significantly over the whole treatment program in terms of objective pain and tenderness. However, group 1's overall improvement was significantly higher than that of group 2 as is seen on inter-group testing.

#### 5.3.2.2.1 Inter-group Analysis (HRA readings)

The HRA left and right readings were averaged to produce a single score per patient at visits 1, 4 and 7 as per Rogers (1997).

No significant differences were seen between the two groups for objective HRA readings. Group statistics shows that the mean drop in HRA score in group 1 is greater than in group 2. This difference is however, not significant and the null hypothesis is accepted.

Therefore we conclude that there is not enough evidence to suggest that the proprioceptive exercises as an adjunct to manipulation have an active role in improving objective proprioceptive function as compared to manipulation alone.

5.3.2.2.2 Intra-group Analysis

Both groups show statistically significant differences between visits. Non-parametric testing was used only, as the data was non-normal. All visits for both groups showed statistically significant improvement. Interestingly, group 1 showed its greatest improvement between visits 4 and 7. This could imply the exercises are more effective over a prolonged use.

There is therefore an improvement in proprioceptive function for both manipulation and proprioceptive exercises and for manipulation alone. This could possibly be attributed to the positive effects of manipulation on proprioceptive function as described by Rogers (1997) as both groups received manipulative therapy.

## 5.4 Limitations

In this study, although an original sample size of 60 was intended, sufficient patients were not seen within the time frame. A sample size of 30 was utilised which resulted in mainly non-parametric testing being used. Tests of normality were conducted on the data, which limited the possibility of accepting the incorrect hypothesis or a Type II error. A larger sample size however would have allowed the correct use of parametric testing and been more representative of a population of WAD sufferers.

In terms of data collection, bias may have occurred either on the part of the patient or the researcher.
Patients may have answered questionnaires so as to please the researcher. However, the reverse is possibly also true, where the patient pays closer attention to his / her pain levels due being more informed than prior on the research, and in doing so, is more aware of pain or disability.

Algometer readings, although considered an objective reading, are subject to the speed and release of the pressure by the researcher. Faster application of the algometer could result in an overshoot and therefore a higher reading after the patients' signal.

A few problems were seen with the HRA readings. Firstly, only left and right readings were taken for standardisation purposes. However, flexion and extension data and perhaps even lateral flexion data would have been valuable for comparison with previous research. Most patients had some form of extension or flexion displacement on rotation seen the chart. Secondly, additional readings on either side would have also led to a more accurate average score, but only one reading was taken each side per data collection session. And thirdly, lining up the laser on the patients' head to be perpendicular to the chart was open to error from the researcher. This could have caused angular displacement of the beam on the target and possibly a slightly inaccurate reading.

Another major limitation of this study was the assumption that patients in Group 1 were performing their exercises in an unsupervised setting. Patients were told to perform exercises daily, however, they needed only do them at least four times weekly, thus allowing some degree of non-compliance. Exercises were repeated in front of the researcher during treatments; however, these exercises may have been performed incorrectly, if at all, in the home environment.

## 5.5 Discussion of Statistical Analysis

The results of this study differ slightly from those found by Fitz-Ritson (1995) who also compared manipulation and phasic exercises to manipulation alone. He found a significant difference between the two groups for the CMCC Neck Disability Index, whereas in this research, there was a difference but it was not considered statistically significant at the 5% level of significance. The algometer readings in this research however, show a statistically significant difference between groups, but this reading was not used in the research by Fitz-Ritson (1995).

Correlations between the two researches were seen on intra-group testing. His manipulation alone group improved by 7.4% which was statistically significant at the $p > 0.05$ level. His exercise and manipulation group improved by 48.3%, which was highly significant at the $p > 0.001$ level. However, he stated that his samples were non-uniform in terms of gender, age and number of WAD incidents and may have been responsible for the minimal improvement of the manipulation only group and the remarkable improvement of the exercise and manipulation group. However in this research, where these confounders were eliminated, similar findings were seen on intra-group testing. Between visits 1 and 7, the manipulation only group improved at a $p < 0.05$ level of significance, which was statically significant, whereas the exercise and manipulation group improved at a $p = 0.001$ level of significance which was highly significant.

Rogers et al. (1997) compared whether cervical spine manipulation as an isolated intervention had any effect on proprioception-dependent performance of subjects with chronic neck pain, compared with effects achieved through stretching exercises. He utilised the same methods of head repositioning accuracy (HRA) as in this research. However, he repeated this for flexion and extension in addition to rotation.

His manipulation group (group 1) showed a significant improvement with a mean baseline score of 35.5 to an ending score of 21 (Table 5.5.1). In this research, the mean baseline of group 1 was 10.72 and for group 2 it was 10.70, and an ending score of 5.60 and 6.23 respectively (Table 5.5.2).

Table 5.5.1

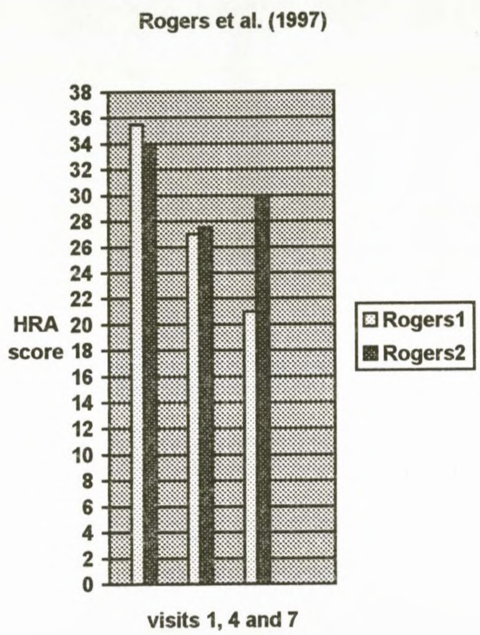
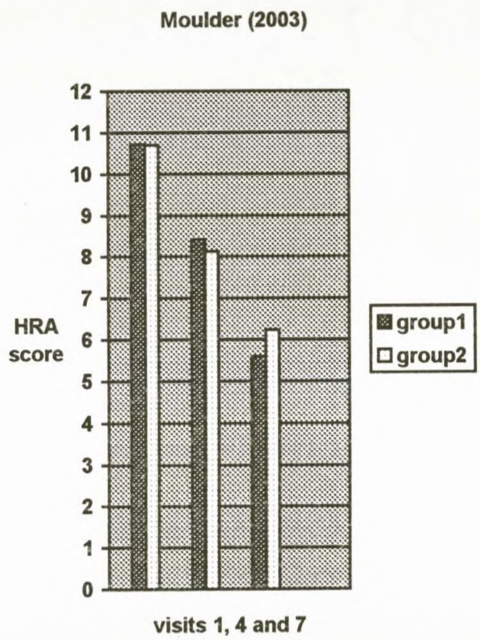



Table 5.5.2




There was a significant improvement between visits for both groups but no significant inter-group difference. The results of both these studies suggest that spinal manipulation may impact the complex process of proprioceptive sensibility.

# Chapter Six

## 6.0 Conclusions and Recommendations

### 6.1 Conclusions

The results of this study suggest that the use of manipulation and proprioceptive exercises can have beneficial effects on pain, tenderness and proprioceptive function in patients suffering with WAD.

Both groups improved significantly over the whole treatment period for all measurements. The use of proprioceptive exercises as an adjunct to spinal manipulation appears to play an important role in reducing the patients' tenderness over the articular pillar of their cervical spine. The exercises combined with manipulation also appeared to have had a more rapid positive effect on the patients pain perception as compared to manipulation alone, with most patients benefiting within the first two weeks of treatment.

The proprioceptive function of patients in this study was vastly improved, however, there was no significant difference between the two groups which could imply that manipulation had the greatest effect on proprioceptive abilities in these WAD patients. This may be due to stimulation of the articular mechanoreceptors as described by Wyke (1980). The exercises appeared to further improve the proprioceptive abilities of the WAD patient, but not at a significant level.

## 6.2 Recommendations

One of the weaknesses of this study is its relatively small sample size. This increases the risk of accepting the incorrect hypothesis (Type II error). A sample size of at least thirty should be utilized to allow more accurate parametric testing. Future attempts should also be made to create a sample group that is more representative of the general population.

Unfortunately, the long-term benefits of this treatment protocol could not be established in this study. The long-term benefit of manipulation in WAD is one of the areas that has been identified as lacking in sufficient randomised controlled trials. This study is weakened by the fact there was no placebo control group. A blinded study would help eliminate researcher bias. The lack of experience of the researcher and the adjusting techniques utilised may also have played a role in the outcome of this study. Further studies need to address these issues.

There is no certainty that the exercises utilised in this research actually stimulate the phasic component of the cervical musculature. Different exercises that require rapid eye, head and trunk co-ordination may have more positive results in improving WAD patients' pain and proprioceptive function.

Patients with a previous history of neck pain and those involved in head-on collisions were not excluded from this study. However, the diagnosis of WAD is a controversial issue in itself. Future studies should attempt to lay out more defined criteria to create a more uniform sample.

Based on the results of this study, it is the author's hope that larger, more comprehensive investigations be done to validate these findings.

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## Appendix A

**TECHNIKON NATAL CHIROPRACTIC DAY CLINIC**
**CASE HISTORY**

Patient:......................................... Date: ................

File # :.......................... Age : ................

Sex :............... Occupation:.................................................

Intern :.........................................Signature:...............................

**FOR CLINICIANS USE ONLY:**

Initial visit

Clinician:...................................... Signature:...............................

| **Case History:** |
|---|
| |

Examination:

Previous: Current:

X-Ray Studies:

Previous: Current:

Clinical Path. lab:

Previous: Current:

**Case Status:**

**PTT:**...........................................................................................

**Signature:**.................................................... **Date:**...........................

**Conditional:**

**Reason for Conditional:**............................................................

**Signature:**.................................................... **Date:**...........................

**All Conditions met in Visit No:**..............................................

**To be signed into PTT:**.......................................................

**Signature:**.......................................... **Date:**...............................

**Signed off:**...................................................................

**Intern's Case History:**

1. **Source of History:**

2. **Chief Complaint : (patient's own words):**

3. **Present Illness:**

| | Complaint 1 | Complaint 2 |
|---|---|---|
| Location | | |
| Onset : Initial: | | |
| ▸ Recent: | | |
| Cause: | | |
| Duration | | |
| Frequency | | |
| Pain (Character) | | |
| Progression | | |
| Aggravating Factors | | |
| ▸ Relieving Factors | | |
| Associated S & S | | |
| Previous Occurrences | | |
| Past Treatment | | |
| **Outcome:** | | |

4. **Other Complaints:**

5. **Past Medical History:**

▸ General Health Status

Childhood Illnesses

Adult Illnesses

- Psychiatric Illnesses
- Accidents/Injuries
- Surgery
- Hospitalizations

**6. Current health status and life-style:**

- Allergies
- Immunizations
- Screening Tests incl. xrays

- Environmental Hazards (Home, School, Work)
- Exercise and Leisure
- Sleep Patterns
- Diet
- Current Medication
  Analgesics/week:

- Tobacco
- Alcohol
- Social Drugs

**7. Immediate Family Medical History:**

- Age
- Health
- Cause of Death
- DM
- Heart Disease
- TB
- Stroke
- Kidney Disease
- CA
- Arthritis
- Anaemia
- Headaches
- Thyroid Disease
- Epilepsy
- Mental Illness
- Alcoholism
- Drug Addiction
- Other

## 8. Psychosocial history:

- Home Situation and daily life
- Important experiences
- Religious Beliefs

## 9. Review of Systems:

- General
- Skin
- Head
- Eyes
- Ears
- Nose/Sinuses
- Mouth/Throat
- Neck
- Breasts
- Respiratory
- Cardiac
- Gastro-intestinal
- Urinary
- Genital
- Vascular
- Musculoskeletal
- Neurologic
- Haematologic
- Endocrine
- Psychiatric

**Appendix B**

TECHNIKON NATAL

## TECHNIKON NATAL CHIROPRACTIC DAY CLINIC

## PHYSICAL EXAMINATION

Patient:______________________File#: ________________________Date:__________
Clinician:______________________Signature:______________________
Intern:________________________Signature:______________________

### 1. VITALS

Pulse rate:
Respiratory rate:
Blood pressure: R L
Temperature:
Height:
Weight:

### 2. GENERAL EXAMINATION

General Impression:
Skin:
Jaundice:
Pallor:
Clubbing:
Cyanosis (Central/Peripheral):
Oedema:
Lymph nodes
- Head and neck:
- Axillary:
- Epitrochlear:
- Inguinal:

Urinalysis:

### 3. CARDIOVASCULAR EXAMINATION

1) Is this patient in **Cardiac Failure** ?
2) Does this patient have signs of **Infective Endocarditis** ?
3) Does this patient have **Rheumatic Heart Disease ?**

**Inspection**
- Scars
- Chest deformity:
- Precordial bulge:
- Neck -JVP:

**Palpation:**
- Apex Beat (character + location):
- Right or left ventricular heave:
- Epigastric Pulsations:
- Palpable P2:
- Palpable A2:

Pulses:
- General Impression:
- Radio-femoral delay:
- Carotid:
- Radial:
- Dorsalis pedis:
- Posterior tibial:
- Popliteal:
- Femoral:

**Percussion:** - borders of heart

**Auscultation:** - heart valves (mitral, aortic, tricuspid, pulmonary)
- Murmurs (timing,systolic/diastolic, site, radiation, grade).

## 4. RESPIRATORY EXAMINATION

1) Is this patient in **Respiratory Distress** ?

**Inspection**
- Barrel chest:
- Pectus carinatum/cavinatum:
- Left precordial bulge:
- Symmetry of movement:
- Scars:

**Palpation**
- Tracheal symmetry:
- Tracheal tug:
- Thyroid Gland:
- Symmetry of movement (ant + post)
- Tactile fremitus:

**Percussion**
- Percussion note:
- Cardiac dullness:
- Liver dullness:

**Auscultation**
- Normal breath sounds bilat.:
- Adventitious sounds (crackles, wheezes, crepitations)
- Pleural frictional rub:
- Vocal resonance
  - Whispering pectoriloquy:
  - Bronchophony:
  - Egophony:

## 5. ABDOMINAL EXAMINATION

1) Is this patient in **Liver Failure** ?

**Inspection**
- Shape:
- Scars:
- Hernias:

**Palpation**
- Superficial:
- Deep = Organomegally:

- Masses (intra- or extramural)
- Aorta:

**Percussion** - Rebound tenderness:
- Ascites:
- Masses:

**Auscultation** - Bowel sounds:
- Arteries (aortic, renal, iliac, femoral; hepatic)

**Rectal Examination**
- Perianal skin:
- Sphincter tone & S4 Dermatome:
- Obvious masses:
- Prostate:
- Appendix:

## 6. G.U.T EXAMINATION

External genitalia:
Hernias:
Masses:
Discharges:

## 7. NEUROLOGICAL EXAMINATION

**Gait and Posture**
- Abnormalities in gait:
- Walking on heels (L4-L5):
- Walking on toes (S1-S2):
- Rombergs test (Pronator Drift):

**Higher Mental Function**
- Information and Vocabulary:
- Calculating ability:
- Abstract Thinking:

**G.C.S.**:
- Eyes:
- Motor:
- Verbal:

**Evidence of head trauma:**

**Evidence of Meningism:**
- Neck mobility and Brudzinski's sign:
- Kernigs sign:

**Cranial Nerves:**

I Any loss of smell/taste:
Nose examination:

II External examination of eye:
- Visual Acuity:
- Visual fields by confrontation:

- Pupillary light reflexes = Direct:
  = Consensual:
- Fundoscopy findings:

III Ocular Muscles:
Eye opening strength:

IV Inferior and Medial movement of eye:

V a. Sensory - Ophthalmic:
- Maxillary:
- Mandibular:
b. Motor - Masseter:
- Jaw lateral movement:
c. Reflexes - Corneal reflex
- Jaw jerk

VI Lateral movement of eyes

VII a. Motor - Raise eyebrows:
- Frown:
- Close eyes against resistance:
- Show teeth:
- Blow out cheeks:
b. Taste - Anterior two-thirds of tongue:

VIII General Hearing:
Rinnes = L: R:
Webers lateralisation:
Vestibular function - Nystagmus:
- Rombergs:
- Wallenbergs:
Otoscope examination:

IX & X Gag reflex:
Uvula deviation:
Speech quality:

XI Shoulder lift:
S.C.M. strength:

XII Inspection of tongue (deviation):

**Motor System:**

a. Power
- Shoulder = Abduction & Adduction:
  = Flexion & Extension:
- Elbow = Flexion & Extension:
- Wrist = Flexion & Extension:

| | |
|---|---|
| - Forearm | = Supination & Pronation: |
| - Fingers | = Extension (Interphalangeals & M.C.P's): |
| - Thumb | = Opposition: |
| - Hip | = Flexion & Extension: |
| | = Adduction & Abduction: |
| - Knee | = Flexion & Extension: |
| - Foot | = Dorsiflexion & Plantar flexion: |
| | = Inversion & Eversion: |
| | = Toe (Plantarflexion & Dorsiflexion): |

b. Tone
- Shoulder:
- Elbow:
- Wrist:
- Lower limb - Int. & Ext. rotation:
- Knee clonus:
- ankle clonus:

c. Reflexes
- Biceps:
- Triceps:
- Supinator:
- Knee:
- Ankle:
- Abdominal:
- Plantar:

**Sensory System:**

a. Dermatomes
- Light touch:
- Crude touch:
- Pain:
- Temperature:
- Two point discrimination:

b. Joint position sense
- Finger:
- Toe:

c. Vibration:
- Big toe:
- Tibial tuberosity:
- ASIS:
- Interphalangeal Joint:
- Sternum:

**Cerebellar function:**

Obvious signs of cerebellar dysfunction:

= Intention Tremor:
= Nystagmus:
= Truncal Ataxia:

Finger-nose test (Dysmetria):
Rapid alternating movements (Dysdiadochokinesia):
Heel-shin test:
Heel-toe gait:
Reflexes:
Signs of Parkinsons:

**8. SPINAL EXAMINATION:**(See Regional examination)

Obvious Abnormalities:
Spinous Percussion:
R.O.M:
Other:

**9. BREAST EXAMINATION:**

Summon female chaperon.

**Inspection**
- Hands rested in lap:
- Hands pressed on hips:
- Arms above head:
- Leaning forward:

**Palpation**
- masses:
- tenderness:
- axillary tail:
- nipple:
- regional lymph nodes:

Appendix C

## TECHNIKON NATAL CHIROPRACTIC DAY CLINIC
## REGIONAL EXAMINATION - *CERVICAL SPINE*

Patient: ______________________________ File: ______________

Date: ________________ Intern/Resident: ______________________________

Clinician: ______________________________ Sign: ______________________

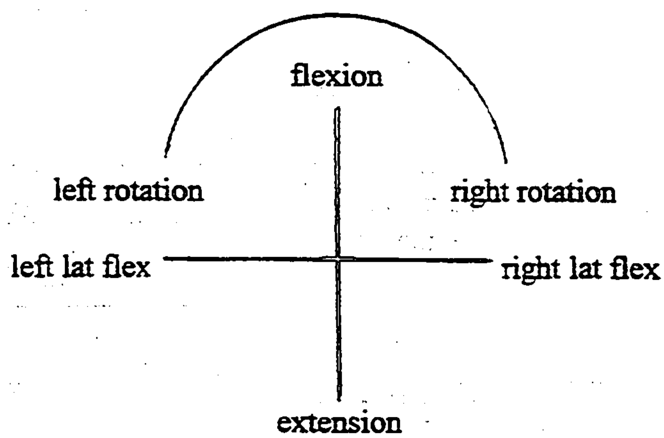
**OBSERVATION:**

Posture
Swellings
Scars
Discolouration
Hair Line
Bony & Soft Tissue Contours

Shoulder position:
Left:
Right:
Muscle spasm
Facial expression

**RANGE OF MOTION:**

Flexion (45'):
L/R Rotation (70'):
Extension (70'):
L/R Lat Flex (45'):




**PALPATION:**

Lymph Nodes
Thyroid Gland
Trachea

**ORTHOPAEDIC EXAMINATION:**

Tenderness

Trigger Points: SCM, Scalenii, Post Cervicals, Trapezius, Lev Scap

Doorbell sign
Kemp's test
Cervical distraction
Halstead's test
Hyperabduction test
Shoulder abduction test
Cervical compression
Lateral compression
Adson's test
Costoclavicular test
Eden's test
Shoulder depression test

Dizziness rotation test
Brachial plexus tension

Lhermitte's sign

NEUROLOGICAL EXAMINATION:

| Dermatomes | Left | Right | Myotomes | Left | Right | Reflexes | Left | Right |
|---|---|---|---|---|---|---|---|---|
| C2 | | | C1 | | | C5 | | |
| C3 | | | C2 | | | C6 | | |
| C4 | | | C3 | | | C7 | | |
| C5 | | | C4 | | | | | |
| C6 | | | C5 | | | | | |
| C7 | | | C6 | | | | | |
| C8 | | | C7 | | | | | |
| T1 | | | C8 | | | | | |
| | | | T1 | | | | | |

VASCULAR:

| | Left | Right |
|---|---|---|
| Blood Pressure | | |
| Carotid arts. | | |
| Subclavian arts. | | |
| Wallenberg's test | | |

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:

Right: Motion palpation:
Joint Play:

Basic Exam: Shoulder:
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

Upper T horacics:
Motion Palpation:
Joint Play:

Basic Exam: Thoracic Spine:
Case History:

ROM: Motion Palp:
Active:
Passive:
Orthopaedic/Neuro/
Vascular:
Observ/Palpation:

**Appendix D**

# LETTER OF INFORMATION

Dear Patient

Welcome to this research study on whiplash injuries. I am comparing the effect of chiropractic manipulation and proprioceptive exercises to manipulation alone. Both are widely recognised treatments for neck pain in whiplash injuries. Manipulation is commonly used by chiropractors and is a safe and relatively risk-free rehabilitation and is taught at the Technikon Natal. Possible complications to manipulation include vertigo and vascular complications. Proprioceptive exercises, involving head, eye and body coordinated movements, may have side effects such as post-exercise tenderness and stiffness.

All treatment is free of charge and on a voluntary basis. There is no compensation for being on this research; however, possible benefits to you include relief from pain and disability. It will be conducted at the Technikon Natal Chiropractic Day Clinic. Be assured that all information will be regarded as strictly confidential, as data will be placed on anonymous spreadsheets, and you have the right to reject the use of anything with which you do not feel comfortable. The study will consist of two groups of 30, equally and randomly divided. To participate in this study the following criteria will be required:

a. You must be between the age of 20 – 35 years of age.
b. Your whiplash injury must have occurred at least 6 weeks ago.
c. You must be experiencing some degree of neck pain, stiffness or tenderness.
d. If any contraindications to cervical spine manipulation or exercises are suspected on examination, you may not be included in this study.
e. You may not take any NSAID (eg. aspirin, ibuprofen), anti-spasmodic or analgesic drug therapy, neither allopathic nor homoeopathic, for three days before and during the treatment period, as this may influence the results.
f. No other manual therapy may be undertaken during the research period.
g. You are required not to change your lifestyle or level of activity during the research to avoid bias results.

You will receive 6 chiropractic treatments and one follow-up treatment over a 4 week period. Your initial treatment will take approximately two hours, and thereafter one hour each. All treatments will be performed under the supervision of a qualified chiropractor and the researcher has been trained in the last 2 years in spinal manipulative therapy. You will remain in the study as long as you commit to the appointment schedule and there will be no adverse consequences if you decide to stop participating in the research. If for any reason the researcher thinks it is in your best interests to terminate your participation in the research, she has the authority to do so. If there are any unusual findings by the researcher you will be informed of these. At this point I also remind you that there are no right or wrong answers and I appeal to you to be as accurate and honest as possible in your responses to all questions.

Yours sincerely

Nicole Moulder (Researcher to be contacted at 2042205)
Dr B. Kruger (Supervisor to be contacted at 2042205)

## Appendix E

# LETTER OF INFORMED CONSENT

Technikon Natal
Date:__________________________

**Title of research project:** The purpose of this investigation is to evaluate the relative effectiveness of proprioceptive exercises as an adjunct to cervical spine manipulation in the treatment of whiplash-associated disorders.

**Name of supervisor:** Dr B. Kruger
**Name of research student:** Nicole Moulder

**Please tick correct box**

Group 1 will receive manipulation and proprioceptive exercises ☐

Group 2 will receive manipulation only ☐

| **Please circle the appropriate answer** | **Yes** | **No** |
|---|---|---|
| 1. Have you read the research information sheet? | **Yes** | **No** |
| 2. Have you had time to ask questions regarding this study? | **Yes** | **No** |
| 3. Have you received satisfactory answers to your questions? | **Yes** | **No** |
| 4. Have you had an opportunity to discuss this study? | **Yes** | **No** |
| 5. Have you received enough information about this study? | **Yes** | **No** |
| 6. Who have you spoken to? ____________________ | | |
| 7. Do you understand the implications of your involvement in this study? | **Yes** | **No** |
| 8. Do you understand that you are free to withdraw from this study? a) at any time b) without having to give any reason for withdrawing, and c) without affecting your future health care. | **Yes** | **No** |
| 9. Do you agree to voluntarily participate in this study? | **Yes** | **No** |

**If you have signed no to any of the above, please obtain the information before signing.**

**Please print in block letters:**

Patient name:______________________________Sign:________________

Research Student name:______________________Sign:________________

Witness:______________________________

# Appendix F

## CMCC NECK DISABILITY INDEX

Patient Name:________________________________ File no.:______________ Date:______________

This questionnaire has been designed to give the doctor information as to how your back pain has affected your ability to manage everyday life. Please answer every section and mark in each section only ONE box as it applies to you. We realize you may consider that two of the statements in any one section could relate to you, but please just mark the box which most closely describes your problem.

**Section 1 - Pain Intensity**

- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

**Section 2 - Personal Care (Washing, Dressing ...)**

- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain..
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but manage most of my personal care.
- ☐ I need help every day in most aspects of self care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

**Section 3 - Lifting**

- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights but it gives extra pain.
- ☐ Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned .
- ☐ I can lift only very light weights.
- ☐ I cannot lift or carry anything at all.

**Section 4 - Reading**

- ☐ I can read as much as I want to without pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I cannot read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

**Section 5 - Headaches**

- ☐ I have no headaches at all.
- ☐ I have slight headaches which come infrequently.
- ☐ I have moderate headaches which come infrequently.
- ☐ I have moderate headaches which come frequently.
- ☐ I have severe headaches which come frequently.
- ☐ I have headaches almost all the time.

**Section 6 - Concentration**

- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have fair degree of difficulty in concentrating when I want to.
- ☐ I have a lot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

**Section 7 - Work**

- ☐ I can do as much work as I want to .
- ☐ I can do only my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I cannot do any work at all.

**Section 8 - Driving**

- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I like with moderate pain in my neck.
- ☐ I cannot drive my car as long as I want because of moderate pain in my neck.
- ☐ I can hardly drive at all because of severe pain in my neck..
- ☐ I cannot drive at all.

**Section 9 - Sleeping**

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (<1 hour sleep loss).
- ☐ My sleep is mildly disturbed (1-2 hours sleep loss).
- ☐ My sleep is moderately disturbed (2-3 hours sleep loss).
- ☐ My sleep is greatly disturbed (3-5 hours sleep loss).
- ☐ My sleep is completely disturbed (5-7 hours sleep loss).

**Section 10 - Recreation**

- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities, with some pain in my neck.
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck.
- ☐ I am able to engage in a few of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I cannot do any recreation activities at all.

Vernon/Hagino, modified from Foubister et al.,Physiotherapy, 1980

**Appendix G**

Name:_______________________________ File no: _________________

Group:_________________________

## ALGOMETER READINGS

| Visit | One | Four | Seven |
|---|---|---|---|
| Left | | | |
| Right | | | |

## HEAD REPOSITIONING ACCURACY (HRA) READINGS

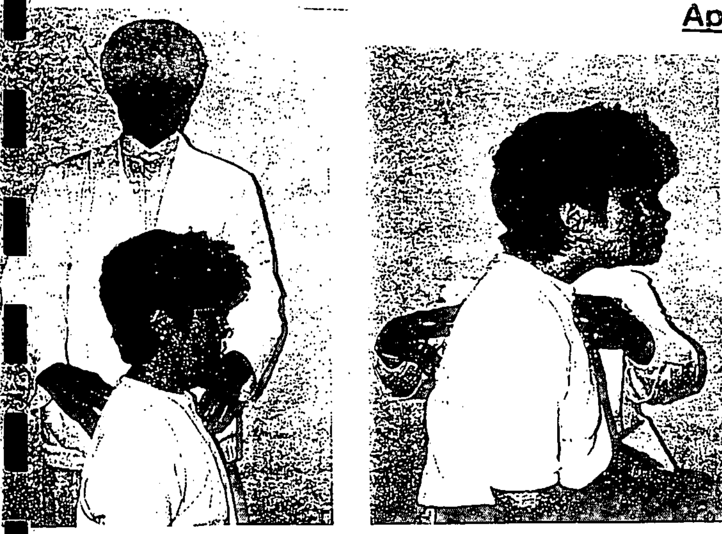
| Visit | One | Four | Seven |
|---|---|---|---|
| Left rotation | | | |
| Right rotation | | | |

Appendix H

# Level 1 exercises

Before you start the exercises, practice gliding your head forwards and backwards on your neck ('Funky Chicken').

Each exercise is done daily.
5 – 10 reps of each exercise is recommended
Begin exercises slowly and focus on the components of each exercise.

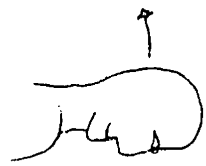


B

...-4. Occiput-atlas-axis flexion and extension. The physician stabilizes the upper body while the patient moves the ...d and neck forward.

...e 10–8. Prone extension with chin in.

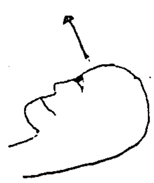
1.



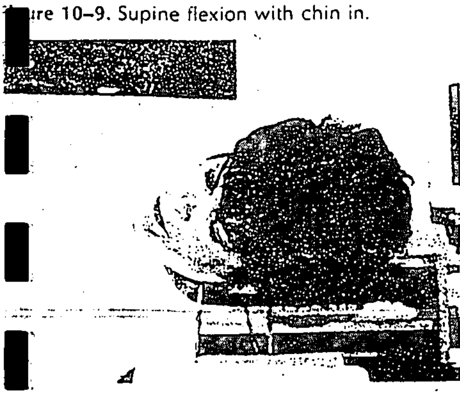
Lying face down
Move head backwards,
Keeping chin in

...ure 10–9. Supine flexion with chin in.

2.



Lying face up
Move head forwards,
Keeping chin in



...ure 10–10. Side posture, chin in, lateral flexion.

3.

Lying on side
Bend head to shoulder,
Keeping chin in
Repeat on other side

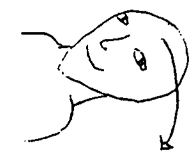
...0–11. Prone, extension, chin in, rotation with eyes ...head.

4.

Lying face down,
Keeping chin in,
Rotate head to one side,
lead by the eyes.
Repeat on other side.

Figure 10–12. Supine, flexion, chin in, rotation with eyes leading head.

5.



Lying face up,
Keeping chin in and head flexed, rotate head from side to sid lead by eyes.

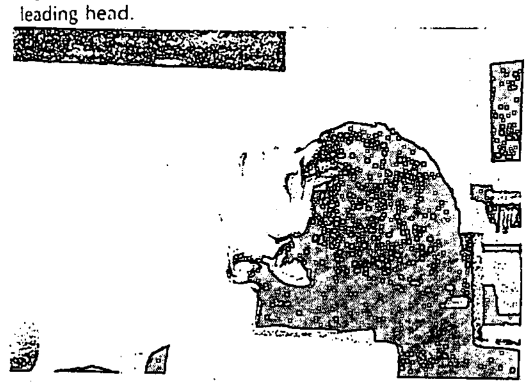
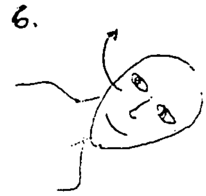


Figure 10–13. Side posture, lateral flexion, chin in, rotation with eyes leading.

6.



Lying on side,
Keeping chin in,
Bend head towards shoulder, while rotating head to that side, lead by eyes

7.

Standing upright,
Focus your eyes on your hand as you move it forward,
repeat with other hand

Figure 10–14. Eyes and head focused on hands, with slow left-to-right movements.

# Level 2 exercises

Each exercise is done daily.
5 – 10 reps of each exercise is recommended.

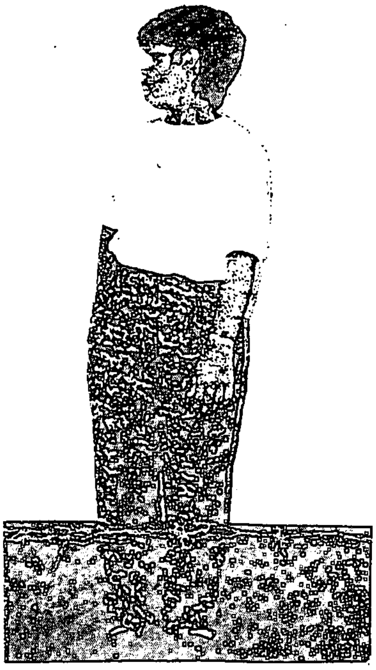
1

Figure 10-15. Patient balancing on foam and slowly moving from side to side.

2.

Repeat no's 1, 2, 4 and 5 of level 1 exercises

3.



igure 10-20. Full body rotation with eyes leading the ead.

4.

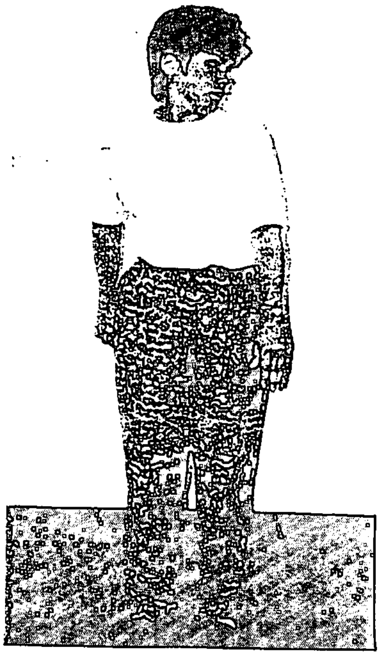
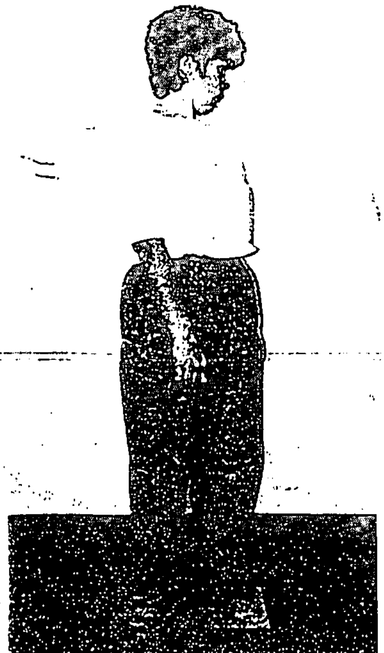


Figure 10-21. Body rotation right, eyes leading head left.

5.

Figure 10-22. Eyes and head focused on hands, with left-to-right movements.

6.



ure 10-23. Patient standing on foam, full body rotation h eyes leading the head.

7.

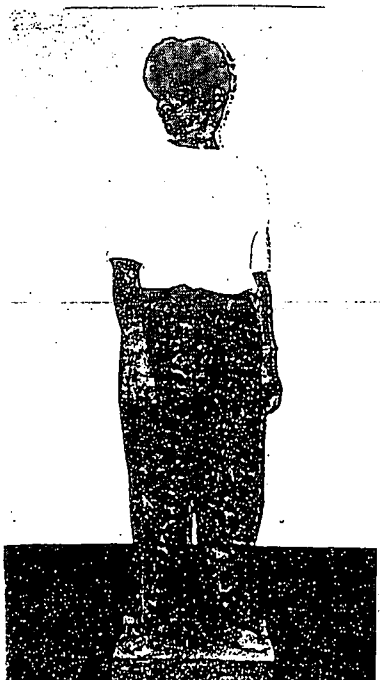


Figure 10-24. Patient standing on foam, body rotation left, eyes leading head right.

8.

Figure 10-25. Patient standing on foam, eyes and head cused on hand with fast left-right movement.