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The Effect of Cervical Spine Adjustment on Grip Strength and its Rate of Decline

A dissertation presented to the Faculty of Health Sciences, University of Johannesburg, as partial fulfilment for the Masters Degree in Technology: Chiropractic by

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DECLARATION

I, Luchelle Prinsloo, declare that this is my own, unaided work. It is being submitted as partial fulfilment of the Master's Degree in Technology, in the program Chiropractic at the University of Johannesburg. It has not been submitted before for any other degree or examination in any other Technikon or University.

__________________________________
Luchelle Prinsloo

On the ________ day of the month of _______________________ 2016.
ABSTRACT

Purpose: The aim of the study was to determine the immediate effect of chiropractic manipulation of the cervico-thoracic junction on grip strength and its rate of decline after manipulation.

Method: Fifty participants with asymptomatic cervico-thoracic dysfunction were selected. All participants were placed in a single group as they all received the same treatment. Participants had to meet the inclusion criteria to be part of the study and they had to be free of any contra-indications to chiropractic manipulation.

Procedure: Each participant was treated only once with a manipulation to the cervico-thoracic junction. Four measurements of grip strength were taken over a 24 hour period. Each participant’s grip strength was measured prior to manipulation with a Jamar handgrip dynamometer. Thereafter the restricted cervico-thoracic segmented was manipulated and grip strength was measured immediately thereafter. The participants were requested to return one hour after the initial treatment when another reading was taken. The last visit took place 24 hours after manipulation, where the final grip strength measurement was taken. All data was recorded by the researcher and analysed by Statkon.

Results: A significant increase in grip strength was noted immediately post treatment, with grip strength peaking one hour post treatment. Although a decline was noted twenty four hours post treatment, it did not return to the initial values.

Conclusion: The results indicated an increase in grip strength after manipulation of the cervico-thoracic junction. An increase was visible on all readings (immediately post treatment, one hour post treatment and twenty four hours post treatment), tested with the Jamar handgrip dynamometer. Most results were found to be statistically insignificant, with exclusion of measurement three (one hour post treatment) on the left hand side. In conclusion it was noted that manipulation directed to the cervico-thoracic junction increases muscle strength up to twenty four hours as measured by the Jamar Handgrip Dynamometer. Further readings are necessary in order to determine when the grip strength of participants would return to pre treatment values as the true rate of decline could not be determined in only a twenty four hour period.
In light of the above mentioned information it could be said that manipulation may have an excitatory effect on the nervous system and therefore also increase the grip strength of participants in this study.
DEDICATIONS

I dedicate this research to my loving family who supported me through every high and low for the past six years. Without your love, support and inspiration this would not have been possible and to Marni Kruger, the one person who understands without a single word to be uttered. It has been a privilege.

Thank you
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Lastly, to all of the participants that took part in this study. Thank you for having the patience to participate in this study. Without you it would not have been possible.
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CHAPTER 1

1.1 Background

Each vertebral segment contains neural receptors and each type of receptor has its own characteristics and differs in sensitivity. Reflexes in these neural pathways are activated when the receptors are stimulated. Research done by Haldeman (2000) has shown that these reflexes can be stimulated by spinal manipulative therapy to a specific segment, which in turn, has an effect on muscle strength related to that segment.

1.2 The Importance of Grip Strength

Grip strength is important in sport events such as power lifting, cross fit, athletics and cricket, as it can directly influence athletic performance. It is known that by applying spinal manipulative therapy to an asymptomatic segment of the cervico-thoracic junction there is an immediate increase in the grip strength of a participant (Naidoo & Myburgh, 2002). There is, however, no information on the rate of decline of improved grip strength after spinal manipulative therapy.

1.3 Neurophysiology

Neurophysiological models show that spinal manipulative therapy can stimulate the somatosensory system and evoke a neuromuscular reflex (Keller & Colloca, 2002). This finding is supported by a study done by Dunning and Rushton (2009) which indicated a significant increase in resting electromyographic activity of both the right biceps brachii and left biceps brachii muscles after a single high velocity, low amplitude manipulation had been delivered to the C5/C6 facet joint. In another study done by Keller and Colloca (2002), a significant increase in muscle activity following spinal manipulative therapy was found.

Various studies have also been done investigating the effect of manipulation on muscle strength. A study done by Swartz (2003) showed an immediate increase in triceps muscle strength after spinal manipulative therapy to the cervico-thoracic junction. This finding is supported by a study done by Pronto, Yelverton and Van Rensburg (2000), which showed an increase in grip strength after spinal manipulative treatment of the cervico-thoracic, junction after six treatments. Another study done by Sher, Grobler and Yelverton (2002) indicated a short term increase in quadriceps strength after chiropractic manipulation has
been delivered to a restricted sacroiliac joint. This finding correlates with a study done by Pretorius, Yelverton and Moodley (2008), which demonstrated a short term increase in gatrocnemius strength after chiropractic manipulation of the sacroiliac joint. Even though the above mentioned research is unpublished work, it serves as sufficient evidence of the effect of chiropractic manipulation on muscle strength.

1.4 Aim

The aim of this study was to determine the immediate effect of chiropractic manipulation on grip strength and its rate of decline after manipulation of the cervico-thoracic junction.

1.5 Outcomes

This study may indicate that participants treated with cervical manipulative therapy to the cervico-thoracic junction may have increased grip strength, with a rate of decline, for up to 24 hours.

1.6 Benefits of the Study

The possible benefits of this study are as follows:

- Giving chiropractors an adjunctive or alternative means of increasing grip strength. This technique could be an alternative to muscle strengthening.

- Demonstrating the immediate effect of chiropractic manipulation on grip strength and its rate of decline.

- Assisting in treatment protocols for competing athletes. The increase in muscle strength could provide increased power for physical activity and performance.

- Aiding in further research in this field in order to determine when maximum benefits occur.
CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

The focus of this study was primarily to determine the effect of cervical spine manipulation on grip strength and its rate of decline on patients with a cervico-thoracic dysfunction.

Relevant anatomy, biomechanics and neurology related to the lower cervical spine and upper thoracic spine will be discussed in this literature review. The role of chiropractic manipulation as related to this study was also addressed.

2.1 The Chiropractic Vertebral Subluxation Complex

As described by the World Health Organization, a fixation is an immobile articulation or motion segment that affects the physiology of the related joint. A subluxation may also be defined as a joint that is dysfunctional, where alignment, physiology and movement is altered, but the surfaces remain in contact with each other. A subluxation is usually a result of a fixation, and if left untreated it may have neurological and biomechanical repercussions (WHO, 2005). Even if a joint fixation is asymptomatic it may lead to altered biomechanics of the segment and other related segments (Vernon & Mrozek, 2005). It is thus important for practitioners to develop a full understanding regarding biomechanics in order to improve their treatment plan and diagnostic abilities (Gatterman, 2004).

In chiropractic terms, the vertebral subluxation complex (VSC) theoretically describes dysfunction of a specific motion segment in the spine, taking into account the complex pathological interactions of muscles, nerves, ligaments and vascular components. A VSC describes functional or structural alterations of a spinal motion segment, leading to subluxation and thus affecting the ability of the motion segment to maintain normal function (Leach, 2004). A chiropractic subluxation can be described as an alteration in the alignment, physiology and movement integrity of a specific motion segment (Peterson & Bergmann, 2011).

According to Gatterman (2005), the VSC is not a definite entity, it is only a conceptual model that only exists when all the components are present. It encompasses pathology related to anatomy, physiology, biochemistry and biomechanics, which in turn may lead to symptoms such as visceral dysfunction, autonomic dysfunction and pain. The VSC consists of five theoretical components. All of these components interact with each other,
but each represents a separate pathophysiological process that contributes to dysfunction (Gatterman, 2005).

- **Neuropathophysiology** which describe the neurological pathology associated with the VSC and in turn, leads to muscle hypertonia, dysasthesia, muscle atrophy, increased sympathetic response or sympathetic atonia (Gatterman, 2005).

- **Kinesiopathology** that describes the altered movement related to the VSC. This in turn may lead to hypermobility or hypomobility of a motion segment or decreased joint play (Gatterman, 2005). Altered motion may lead to altered distribution of mechanical stresses on articular surfaces, intervertebral discs, muscles and ligaments. As a result of altered motion neurological structures may become inflamed leading to dysfunction distal to the affected segment in the peripheral distribution of the affected neurological structure (Triano, 2001).

- **Myopathology** which describes the hypertonicity of a muscle that may occur as a secondary mechanism related to the neuropathology component or as a compensatory mechanism owing to the hypermobility or hypomobility related to spinal subluxation (Gatterman, 2005).

- **Histopathology** which describes the inflammatory process and the cellular response related to inflammation. Owing to the influx of fluids and inflammatory cells, oedema may compress neural structures in the intervertebral foramen contributing to the neurophysiological component of the VSC (Gatterman, 2005).

- **Biochemical/vascular pathology**, which describes the accumulation of chemicals and inflammatory mediators like prostaglandin, bradykinin, histamine and leukotriens that accumulates in stressed and damaged tissue (Gatterman, 2005).

These components are related, in that kinesiopathology is a result of joint subluxation, which in turn leads to hypomobility of a joint. Structural elements are compromised and irritated leading to neuropathology. The above mentioned changes will lead to physiological, anatomical and inflammatory changes, which in turn lead to vascular and histopathology (Esposito & Philipson, 2005).

The neurological component of the VSC is theorized to be the cornerstone of chiropractic. The nervous system is of great diagnostic value when assessing reflexes, motor function,
sensation and pain (Lantz, 1995).

2.2 The Chiropractic Manipulation

A joint restriction is defined as a dysfunction, locking or blockage of a joint (Gatterman, 2005). According to Esposito and Philipson (2005), chiropractic treatment aims to restore normal tone of the nervous system. Haldeman (2000) believes that neurological energy is then restored, relieving the pathophysiological process that develops as a result of restricted motion. This is done by using chiropractic manipulations that are very joint specific in order to correct the joint dysfunction and restore normal neurological function (Haldeman, 1992; Leach, 2004; Gatterman, 2004).

A chiropractic manipulation can be defined as a high velocity low, amplitude thrust that is applied to a restricted segment in order to move the joint into the paraphysiological space by passing through its physiological limit, without exceeding anatomical integrity. Manipulation often results in an audible click. The aim of a chiropractic manipulation is to restore joint motion, by directly affecting the subluxation and indirectly affecting the related components of the VSC to ultimately promote and restore homeostasis (Eriksen, 2004; Gatterman, 2005; Haldeman, 1992). A chiropractic manipulation also aims to restore postural balance by correcting the motion restriction (Miners, 2010).

Joint range of motion, as alluded to above, was described by Sandoz (1970) as consisting of four zones and two barriers (Figure 2.1). Zone one represents the active range of motion, produced by active contraction of associated muscles. Zone two represents passive range of motion, extending to the elastic barrier and is where joint play is tested. Zone three is the paraphysiological space. The paraphysiological space extends from the elastic barrier of resistance and ends at the limit of anatomical integrity. When passing into this space a cavitations and audible click may occur. When passing through the paraphysiological space there is a separation of joint surfaces, an audible crack and the appearance of a radiolucent joint space. Zone four represents pathology in movement, where the joint moves past the anatomical limit (Esposito & Philipson, 2005). Joint injury will occur when a joint is moved to the limit of anatomical integrity, resulting in injury of the joint capsule and ligaments (Peterson & Bergmann, 2011).
2.3. The Effect of Chiropractic Manipulation on Athletic Performance

Haldeman (2005) states that the mechanical force of a manipulation will provide space and remove joint restrictions, which may change the effect on the nervous system, thus allowing ideal muscular control. The state of optimal muscle function provides the joint with stability leading to optimal joint function (Huiskes & Mow, 2005).

Chiropractic manipulation to the sacroiliac joint would provide increased muscle power input, especially to the quadriceps muscle group. A significant increase in gluteus maximus and quadratus muscle output can be achieved by manipulating the lumbar spine (Suter, McMorland, Herzog & Bray, 2000).

Manipulation may also affect the sympathetic hyper-sensitivity often associated with overstimulation of the neurons of hypertonic muscles (Haldeman, 2005). With the removal of the subluxation, muscular skeletal mechanoreceptors are normalized, allowing for favourable limb control and proprioception (Haldeman, 2005).

According to Herzog (2010), chiropractic manipulation should also lead to increased range of motion, increase muscle flexibility and decreased strain on the relative structures in turn resulting in improved performance.

---

**Figure 2.1: Sandoz’s model for joint range of motion (Esposito & Philipson, 2005)**

<table>
<thead>
<tr>
<th>Neutral joint play</th>
<th>Can occur through whole of active range.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active limit</td>
<td>End of active range.</td>
</tr>
<tr>
<td>Passive limit</td>
<td>End of passive range.</td>
</tr>
<tr>
<td>Elastic Barrier</td>
<td>Variable range at end of passive range.</td>
</tr>
<tr>
<td></td>
<td>Joint play occurs here.</td>
</tr>
<tr>
<td>Paraphysiological Space</td>
<td>Joint cavitation occurs here (&quot;Crack&quot;).</td>
</tr>
<tr>
<td>Anatomic limit</td>
<td>Limit of anatomical integrity.</td>
</tr>
<tr>
<td>Joint trauma</td>
<td>Ligamentous damage occurs.</td>
</tr>
</tbody>
</table>
2.3.1. The effect of chiropractic manipulation on asymptomatic athletes

Schwartzbauer, Kolber, Schwaetzbauer, Hart and Zhang (1997) and Ravell (2008) have evaluated athletic performance and physiological measurements following chiropractic treatment of 28 university baseball players. They came to a conclusion that there is a positive correlation between the athletes improved performance and chiropractic treatment. This finding is supported by another study done by Lauro and Mouch (1991), which tested a group of asymptomatic athletes on physical performance by utilising 11 different tests theorised to evaluate balance, agility, perception, power and reaction time of the athletes. This measurement was termed the "Index of Average Athletic Ability Improvement (IAAAI)". After six weeks of manipulation the athletes showed a 6.12% increase in their IAAAI score and therefore demonstrated an improvement in athletic performance.

These findings correlates with a statement made by Leonardi (1996) that manipulation has the ability to improve athletic performance by allowing optimal functioning of the nervous system, which in turn allows for optimal athletic performance.

2.3.2. The mechanical effect of chiropractic manipulation on athletes

According to Pickar and Wheeler (2001), the force of chiropractic manipulation affects the biomechanics of the altered segment. Herzog (2010) states that scar tissue and adhesions get broken within the joints by the application of manipulation which could account for the intersegmental motion changes. Manipulation, in braking down scar tissue and collagen adhesions, increases joint range of motion.

Although chiropractic manipulation cannot reverse damage to the joints and the surrounding tissue, it could have an effect on joint mobility and pain relief, and prevents the reoccurrence of the dysfunction. Chiropractic manipulation decreases surrounding inflammatory exudates and as well as mechanical stresses on the joint by correcting the altered biomechanics (Huisken & Mow, 2005).

Chiropractic manipulation also increases muscle strength and muscle tone, which then activates the spindle reflex as the muscles around the joint are stretched during manipulation (Gatterman, 2005). The chiropractic manipulation has a direct effect on the structures that surround the joints. The sensory receptors that are found in the muscles, ligaments and the related joint are activated by the manipulation. In turn, a central reflex
pathway is triggered, causing relaxation of the surrounding muscles as well as increased range of motion (Haldeman, 2000).

Furthermore, the mechanical force of the chiropractic manipulation that is applied to the fixated joint has a stimulatory effect on the somatosensory system and an inhibitory effect on the nociceptors. These effects allow for optimal functioning of the muscles, which in turn improves muscle contraction and improves range of motion (Colloca & Keller, 2002).

2.3.3 The effect of manipulation on muscle strength

Various studies have been done investigating the effect of manipulation on muscle strength. A study by Dunning and Rushton (2009) indicates a significant increase in resting electromyographic activity of the right biceps brachii muscle and left biceps brachii muscle after a single high velocity, low amplitude manipulation had been delivered to the C5/C6 facet joint. Muscle activity was measured with surface electromyography (EMG) in the paraspinal muscles to measure the effects of spinal manipulative therapy on muscle strength. This study done by Keller and Colloca (2002) concluded that there was a significant increase in muscle activity following spinal manipulative therapy. This finding is further supported by studies done by unpublished studies done by Pronto, Yelverton and Van Rensburg (2000), Sher, Grobler and Yelverton (2002) and Pretorius, Yelverton and Moodley (2008), which all demonstrate an increase in muscle strength after manipulation.

In addition numerous studies show that spinal manipulative therapy has an effect on muscle strength and it is known that there is an immediate increase in grip strength after cervico-thoracic manipulation as demonstrated in a study by Naidoo and Myburgh (2002). It is however unknown what the rate of decline of this effect is. This literature review will therefore aim to provide an outline of the mechanism and how it impacts the nervous system. It will also measure the duration of increased grip strength following spinal manipulative therapy.

2.4 Neurological Effects of Manipulation

A theory postulated by Keller & Colloca (2002) states that spinal manipulative therapy may stimulate the somatosensory system evoking a neuromuscular reflex. The hypothesized neurological effects of spinal manipulation are as follows:

- Increased mobility of the affected joints by increasing impulses in the afferent
neurons of muscle spindles and decreasing activity of y-motorneurons.

- Increased discharge of y-motorneurons in the muscles related to the vertebral segment that is subluxated.
- Reduces the gain of the y-loop, owing to impulses from the muscle spindle afferents.
- Production a high frequency discharge in golgi tendons and muscle spindles.
- Response by muscle spindles and golgi organs to spinal manipulative therapy. By stimulating muscle spindles of a specific limb, a monosynaptic excitatory potential is evoked in an alpha-motorneuron of the same muscle.

Altered sensory input can thus be removed by the biomechanical changes that occur as a result of manipulation (Leach, 2004). Primary efferent neurons in the paraspinal tissue are primarily affected, as well as the pain processing system and the motor system (Pickar, 2002). These changes may affect central integration within nociceptive, autonomic and motor neurological pools. As a result, changes will occur in afferent visceromotor and somatomotor neural activity (Pickar & Wheeler, 2001).

Also, abnormal biomechanics of vertebrae and their related facet joints can lead to compression of nerve roots. Neural tissue found in the intervertebral foramina were vulnerable to mechanical compression (Herzog, 2010). Slight compression of the dorsal root and dorsal root ganglia could thus produce prolonged and increased neurological discharge of groups I, II, III and IV afferents (Haldeman, 2005).

In addition, stimulation and biomechanical alteration caused by spinal manipulative therapy could activate reflex centres in the spinal cord and higher centres leading to a sympathetic and parasympathetic response (Haldeman, 2005). The central facilitation theory describes the excitability of the dorsal horn neurons to afferent inputs. Increased stimulation of related paraspinal segments may assist alpha motor neurons in being held in a facilitated state. Some pathways in the abnormal segment were also stimulated, which was suggested by the motor reflexes corresponding with the pain threshold. Therefore, it is suggested that stimuli produced as an effect thereof may decrease the painful stimuli by replacement with mechanical stimuli (Pickar, 2002).
2.5 Theories of the Chiropractic Manipulation

2.5.1 The reflex theory of chiropractic manipulation

The reflex theory states that the chiropractic subluxation is a biomechanical alteration. A biomechanical alteration is theorized to stimulate sensory receptors that are found in the spinal muscles and paraspinal muscles, joint capsules and ligaments and facets of the related vertebrae. There are numerous sensory receptors located in muscles, facet joints, ligaments, paraspinal skin, the peripheral intervertebral disc fibres and the meninges. These sensory receptors respond to mechanical changes, temperature changes and inflammatory changes (Haldeman, 2000).

It is believed that impulses generated by spinal structures activate neural reflex centres located in the spinal cord or in higher brain centres. These impulses then lead to somatovisceral responses in sympathetic or parasympathetic nerves, which can also lead to somatic-somatic responses that will lead to muscle spasm (Haldeman, 2000).

Chiropractors tend to palpate for a restricted motion segment with a related tight muscle bundle or secondary muscle spasm in the area. When applying a high velocity chiropractic manipulation to a restricted motion segment there is found to be muscle relaxation if the impulse removes the stimulus for the reflex muscle (Schafer & Faye, 1990). It is believed that chiropractic manipulation can normalize the abnormal muscle tone, which is attributed to stimulation of inhibitory afferent neurons in the dorsal horn (Evans, 2002).

In a study done by Lehman and McGill (2001) it is shown that there is reflexive muscle activity in muscles distant to the site of chiropractic manipulation. This finding supports the study done by Davis (2001), which shows a reflex response after spinal manipulative therapy that leads to benefits, including the reduction of pain and muscle relaxation.

In a study done by Dunning and Rushton (2008), it is shown that there is an increase in motor activity of the biceps brachii muscle, following spinal manipulative therapy of the C5/C6 spinal level. The C5/C6 level corresponds to the innervation of the biceps brachii muscle. Increased electromyography (EMG) readings were found bilaterally after chiropractic manipulative therapy, although EMG activity was higher on the ipsilateral side (Dunning & Rushton, 2008).

Anatomy and biomechanics relative to this study will now be discussed.
2.6 Anatomy of the Cervical Spine

The most mobile spinal segment is the cervical spine. It contains seven vertebrae, of which the last five are typical vertebrae. The atlas, axis and C7 vertebrae are seen as atypical vertebrae. The cervical spine has sacrificed stability in order to be more mobile, therefore it is more prone to injury (Magee, 2014).

2.6.1 Typical vertebrae

The typical cervical vertebra has a small body and is triangular in shape, with a concave superior surface and a convex inferior surface. Compared to rest of the spine the vertebral bodies are small, with a large intervertebral foramen (Middelditch & Oliver, 2005). The superior articular facets are directed superiorly and posteriorly and the inferior articulating facets are directed inferiorly and posteriorly. The spinous processes are bifid and short in comparison to those of rest of the spine (Moore, Dalley & Agur, 2009).

2.6.2 Atypical vertebrae

Cervical vertebra one (Atlas), two (Axis) and seven (C7) are atypical vertebrae when describing their morphology.

The atlas has no spinous process or vertebral body; it's anterior and posterior arches connects the two lateral masses. The function of the lateral masses is to bear the weight of the skull, as it forms the atlanto-axial joint. The vertebra is also shaped like a kidney and has a large, round vertebral foramen. The axis has a normal spinous process, but it has a cylinder like process, called the dens (Moore, Dalley, Agur, 2009 & Martini & Nath, 2004).

The C7 is seen as an area of transition between the cervical spine and the thoracic spine. Owing to the transition there is a lot of strain on this area and it is therefore prone to subluxation, which in turn has an effect on the musculature supplied by the nerves originating from this area (Martini & Nath, 2004 ; Gray’s Anatomy, 2008).
2.6.3. Zygapophysial Joints

Zygapophysial joints are also known facet joints and are formed between the superior articular process of the inferior vertebra and the inferior articular process of the superior vertebra. They are synovial joints and surrounded by a joint capsule that is thin and loose, allowing for a wide range of motion (Moore, Dalley & Agur, 2009). The zygapophysial joints serve to resist shear compression and torsional and tensile forces and transmit forces to the lamina. In flexion and extension they allow gliding movements and translation to a lesser extent (Levangie & Norkin, 2011). These joints also have a weight bearing function, especially during lateral flexion.
2.6.4 Unco-vertebral Joints

These joints, also known as interbody joints, occur in the lower cervical and upper thoracic spine (C3 – T2). Because of the uncinate processes the inferior surface of the vertebrae is concave and the superior surfaces are convex in the frontal plane. Rocking and translator motions occur in the vertebrae owing to the structure of these joints (Levangie & Norkin, 2011).

![Unco-vertebral Joints Image](image)

2.7 Biomechanics of the Lower Cervical Spine

The shape of the articular facets determines the movements in the cervical spine (Levangie & Norkin, 2011). In flexion, the articulating surfaces of the facet joints slide in opposite directions. There is stretching of the posterior aspect of the disc and compression of the anterior aspect of the disc. In extension, the opposite will occur; the posterior aspect of the disc will be compressed, and the anterior aspect will be stretched. The lower aspect of the cervical spine allows more flexion and extension compared to other movements (Bergmann & Peterson, 2011).
Lateral flexion and rotation is a coupled movement, therefore rotation is coupled with lateral flexion and rotation decreases in the lower cervical spine. The orientation of the facet joints of the lower cervical spine prevents pure lateral flexion and pure rotation. The inferior facet moves posteriorly and inferiorly on the side of rotation; on the contralateral side, the opposite occurs as the inferior facet moves anteriorly and superiorly (Bergmann & Peterson, 2011). On the side of lateral flexion, the facets will slide towards each other; the inferior facet slides inferior and medially as a result of the coupled motion.

2.8 Anatomy of the Thoracic Spine

The thoracic spine consists of 12 vertebrae. They increase in size from T1 to T12 in order to be able to carry the increased load of the head and the trunk. The T5 to T8 vertebrae are considered to be typical thoracic vertebrae and demonstrate all features of a typical vertebra. The T1 to T4 vertebrae have features that correspond to the cervical spine and the T9 to T12 vertebrae have features corresponding to the lumbar vertebrae.

2.8.1 Typical thoracic vertebra

The body of a typical thoracic vertebra is heart shape and it is larger than a cervical vertebral body. The spinous process is slender and it projects posteriorly and inferiorly. From T10 onwards the spinous processes resemble the lumbar spine spinous processes (Martini & Nath, 2004). The articular processes extend vertically with paired, coronally orientated articular facets (Moore, Dalley & Agur, 2009).

2.8.2 The First Thoracic Vertebra

This vertebra is atypical, with a horizontal spinous process that may be as prominent as the vertebral prominence of C7. On the superior border of the T1 vertebra there is a complete costal facet for the articulation of the first rib, and on the inferior edge there is a demifacet to contribute to the articular surface of the second rib (Martini, 2004).

2.9 Biomechanics of the Upper Thoracic Spine

During flexion of the thoracic spine the anterior aspects of the vertebral bodies move closer together and the posterior aspects separate. The nucleus polposus moves posteriorly. The articular facets of the associated vertebra slides superiorly and the inferior facet of the superior vertebra overhangs the superior facet of the vertebra below. During extension the opposite occurs to flexion. During lateral flexion the articular facets of the two adjacent
vertebrae moves relative to each other. The facet on the contralateral side moves as in flexion, sliding superiorly. The facet on the ipsilateral side moves as in extension, sliding inferiorly (Kapanji, 1974).

2.10 Neuroanatomy

2.10.1 Spinal Nerves

The 32 pairs of spinal nerves that are attached to the vertebral column are found in the intervertebral foramina. Each nerve contains an anterior division and a posterior division. They have connections to the spinal cord through dorsal and ventral nerve roots. These roots give rise to smaller rootlets, which connect with the spinal cord to form a pathway that links the central and peripheral nervous system. Most motor fibres are carried by the ventral roots, and most sensory fibres are carried by the dorsal roots. The cell bodies of all sensory fibres related to a spinal nerve are found in the dorsal root ganglion, located near the junction of the ventral and dorsal roots. Most ganglia are found within the intervertebral foramen, with exception of the ganglia of the first and second cervical nerves, which are found on the vertebral arches of the atlas and the axis; the sacral ganglia, which are found within the vertebral canal; and the coccygeal ganglia found within the dura. Each spinal nerve is covered by pia mater; they are loosely invested in the arachnoid mater until they pierce the dura, marking the point of transition to a peripheral nerve (Middleditch & Oliver, 2005).

Typical spinal nerves consist of somatic and visceral fibres. The somatic component of the spinal nerve contains both efferent and afferent fibres. Skeletal muscles are innervated by somatic efferent fibres, while impulses from receptors in joints, muscles, tendons, ligaments, the skin and subcutaneous tissue are carried via somatic afferent fibres towards the spinal cord. A combination of efferent autonomic and afferent autonomic fibres, which include parasympathetic and sympathetic fibres form the visceral components of the spinal nerves (Middleditch & Oliver, 2005).

2.10.2 Anatomy of the nerves of the hand and forearm

The median, radial and ulnar nerves are considered to be the main nerves of the forearm. These nerves supply the forearm of motor innervation and sensory innervation.
2.10.2.1 The Median nerve

The median nerve is formed where the lateral and medial roots of the brachial plexus unites. The C6, C7, C8 and T1 nerve roots contributes to the formation of the median nerve.

The median nerve serves as the main innervation of the anterior compartment of the forearm. It has muscular braches that directly supply the superficial layers and intermediate layers of the flexors of the forearm (excluding flexor carpi ulnaris) and the deep muscles (excluding the medial half of flexor digitorum profundus) via the anterior interosseus nerve (Moore, Dalley, Agur, 2009).

2.10.2.2 The Ulnar nerve

The terminal branch that originates from the medial cord of the brachial plexus forms the ulnar nerve. The C7, C8 and T1 nerve roots contribute to the formation of the ulnar nerve.

In the forearm the ulnar nerve supplies one and a half muscles, the flexor carpi ulnaris and the flexor digitorum profundus (ulnar half), which is responsible for flexion of the fourth and fifth digits (Moore, Dalley, Agur, 2009).

2.10.2.3 The Radial nerve

The largest terminal branch of the brachial plexus that originates from the posterior cord forms the radial nerve. The C5, C6, C7, C8 and T1 nerve roots contributes to the radial nerve.

The radial nerve has both sensory and motor functions in the hand and the forearm, although it splits into two separate branches, namely the superficial radial interosseus nerve for cutaneous or sensory supply and the deep radial interosseus nerve for motor supply.

In the posterior compartment, the radial nerve gives rise to the posterior cutaneous nerve of the forearm, independently supplying cutaneous innervation of the posterior aspect of the forearm. Another cutaneous nerve, the superficial branch of the radial nerve supplies the skin of the dorsum of the hand, and gives off articular branches that supply several joints in the hand. It crosses the anatomical snuff box after emerging from the brachioradialis muscle. Finally, the deep branch of the radial nerve supply muscles in the
posterior compartment, distal to the lateral epicondyle of motor innervation. The superficial and deep branches are the terminal branches of the radial nerve (Moore, Dalley & Agur, 2009).

2.11 Muscles of the Hand, Wrist and Forearm

Wrist movements are mainly generated by muscles originating in the forearm. Tendons originating from these muscles extend across the wrist and attach to the carpal bones in order to produce movement (Moore, Dalley & Agur, 2009). The main function of the muscles surrounding the wrist is support, in order to allow optimal range of motion in the hand. There are six muscles that are responsible for flexion at the wrist; they have tendons that cross the volar area of the wrist that insert distal to the wrist complex. These muscles include the flexor digitorum profundus (FDP), flexor carpi ulnaris (FCU), flexor carpi radialis (FCR), flexor digitorum superficialis (FDS), palmaris longus (PL) and flexor pollicis longus (FPL). Extension of the wrist relies on nine different muscles with tendons crossing the dorsal aspect of the wrist to produce the motion. These muscles include the extensor digiti minimi (EDM), extensor indicis proprius (EIP), extensor digitorum communis (EDC), extensor pollicis brevis (EPB), abductor pollicis brevis (APB) and extensor pollicis longus (EPL) (Levangie & Norkin, 2011).

2.11.1 Muscles of the volar aspect of the wrist

The primary wrist flexors are the flexor carpi ulnaris and the flexor carpi radialis muscles. The secondary flexors include the flexor digitorum profundus, flexor digitorum superficialis and flexor pollicis longus. These muscles act as secondary flexors at the wrist joint and flexors of the digits. All muscles on the volar aspect run beneath the flexor retinaculum, except the flexor carpi ulnaris and palmaris longus muscles (Figure 2.4).
2.11.2 Muscles of the dorsal aspect of the wrist

The primary wrist extensors include the extensor carpi ulnaris and extensor carpi radialis brevis and longus. The secondary wrist extensors include the extensor pollicis longus and brevis, extensor digitorum communis, extensor digiti minimi and extensor indicis proprius and abductor pollicis longus. All of these muscles act as secondary extensors of the wrist and extensors of the digits. All the muscles of the dorsal aspect of the wrist pass under the extensor retinaculum. Each individual tendon is covered with a tendon sheath in order to prevent excessive friction (Levangie & Norkin, 2011).

2.11.3 Thenar muscles of the hand

The thenar muscles of the hand form the thenar eminence of the palm and are mainly responsible for thumb opposition. Several muscles control the movement of the 5th digit:

- Extension: Extensor pollicis brevis and longus and abductor pollicis longus.
- Flexion: Flexor pollicis longus and brevis.
- Abduction: Abductor pollicis longus and brevis.
- Adduction: First dorsal interossei and adductor pollicis.
- Opposition: Opponens pollicis.
2.11.4 Hypothenar muscles of the hand

The hypothenar muscles form the hypothenar eminence of the palm and they provide movement of the little finger. These muscles include the adductor digiti minimi, flexor digiti minimi brevis, opponens digiti minimi and palmaris brevis.

2.11.5 The short muscles of the hand

The short muscles of the hand include the lumbricals, extend the interphalangeal joints and flex the metacarpophalangeal joint, and the interossei, which are divided into the dorsal and the palmar interossei. The dorsal interossei abducts the digits and the palmar interossei adducts the digits (Moore, Dalley & Agur, 2009).

2.12. Myotomes

According to McGee (2014) it is possible to test neurological weakness that has its origin at the nerve root by testing the related muscle tone. This is done by testing the resisted isometric movement at a joint. This type of movement has to be a strong isometric movement in order to test if the contractile tissue is intact.

2.12.1. Cervical Myotomes

Table 2.1: Cervical myotomes (McGee, 2014)

<table>
<thead>
<tr>
<th>C1/C2</th>
<th>Neck flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3</td>
<td>Neck lateral flexion</td>
</tr>
<tr>
<td>C4</td>
<td>Shoulder elevation</td>
</tr>
<tr>
<td>C5</td>
<td>Shoulder abduction</td>
</tr>
<tr>
<td>C6</td>
<td>Elbow flexion and/or extension</td>
</tr>
<tr>
<td>C7</td>
<td>Elbow extension and/or wrist flexion</td>
</tr>
<tr>
<td>C8</td>
<td>Thumb extension and/or ulnar deviation of the wrist</td>
</tr>
</tbody>
</table>
2.13 The power grip

Power grip is used when force and power is required to hold an object tight against the palm. The requirements for power grip are ulnar deviation and slight flexion at the wrist and digit flexion.

There are four different types of power grip, namely hook grasp, controlled by the forearm flexors and extensors; cylinder grasp where the thumb is also recruited; spherical grasp, where opposition is more prominent; and fist grasp, where flexion is more prominent. The cylinder grip will be discussed in more detail, as this will be used to hold the Jamar Dynamometer in the measurement of grip strength (Magee, 2014).

2.13.1 Cylinder Grip

In the cylinder grip (Figure 2.5.), the flexor muscle group is used to position the fingers around the related object. This movement is mainly maintained by an active flexor digitorum profundus in the dynamic phase, when the digits are closed around an object, and by the flexor digitorum superficialis in the static phase. In the static phase a larger force is required (Levangie & Norkin, 2011).

![Cylinder grip](image)

Figure 2.5: Cylinder grip (Magee, 2008)
CHAPTER 3 - METHODOLOGY

3.1 Introduction

This chapter serves as a discussion of the procedure used to select participants, the treatment approach, data collection, data analysis and ethical considerations applicable to this study.

3.2 Study Design

The study was a descriptive quantitative study utilizing a single group with one intervention. The aim of the study was to measure the rate of decline of increased grip strength after spinal manipulative therapy of the cervico-thoracic junction up to 24 hours. The grip strength of the participants was before spinal manipulative therapy, immediately after spinal manipulative therapy, then at one hour and again at 24 hours after spinal manipulative therapy. The Jamar handgrip dynamometer was used to measure the grip strength of the participants.

3.2.1 Participant recruitment

Participants were recruited by handing out advertisements (Appendix A) at the University of Johannesburg Chiropractic Clinic. Permission was asked to advertise on campus (Appendix D). Participants were also recruited by word of mouth.

3.2.2 Selection criteria and sample size

Fifty participants with asymptomatic cervico-thoracic dysfunction were selected. All participants were placed in a single group as they all received the same treatment.

Participants had to meet the inclusion criteria to be part of the study and they had to be free of any contra-indications to chiropractic manipulation (Appendix B).

3.2.2.1 Inclusion criteria

Participants could be male or female, between the ages of 18 and 40 years. Participants had to be asymptomatic, but have cervico-thoracic junction motion restrictions, as determined by motion palpation.
3.2.2.2 Exclusion criteria

Participants were excluded from this study if they exhibited any contra-indications to chiropractic manipulation (Appendix B). Signs or symptoms of contraindications were screened for during the initial physical exam, regional examination and history taking. Participants were also excluded if they presented with any wrist or hand pathology, as patients had to use their hands to utilize the handgrip dynamometer.

3.3 Methodology

3.3.1 Consultation procedure

Each participant was treated only once with spinal manipulative therapy to the cervico-thoracic junction. Four measurements of grip strength were taken over a 24 hour period.

The first consultation included:

- Explanation of the study to the participants;
- Signing of the participant consent form and reading of the information form (Appendices C and D);
- Completion of a case history and a physical examination (Appendices E and F); and
- Completion of a cervical spine regional examination (Appendix G).

Each participant’s grip strength was measured prior to spinal manipulative therapy with a Jamar handgrip dynamometer. Thereafter, the restricted cervico-thoracic segment was adjusted and grip strength was measured immediately thereafter. The participants were requested to return one hour after initial treatment, where another reading was taken with a handgrip dynamometer. The last visit took place 24 hours after spinal manipulative therapy, where grip strength was measured for the last time with a Jamar handgrip dynamometer.

3.4 Objective Data

The objective data for this study was the grip strength measurement done with a Jamar handgrip dynamometer. Grip strength was tested by holding the dynamometer in a vertical position, arm perpendicular to the body and fingers on the pad that needed to be pressed. Strength is measured by applying pressure for a sustained duration. The hand grip dynamometer reports values in newtons, pounds or kilograms. The Jamar handgrip
dynamometer has been tested and proven to be a reliable method of grip strength testing, (Bellace, Healy, Besser, Byron & Hohman, 2002).

3.4.1 The Jamar Dynamometer

When focusing on hand dynamometers, the Jamar dynamometer seems to be the most often cited dynamometer in literature. The Jamar dynamometer seems to be the benchmark to which all other dynamometers are compared (Roberts, Denison, Martin, Patel, Syddall, Cooper and Sayer, 2011). The Jamar dynamometer has an adjustable handle that can be changed to fit five different grip or hand sizes in order to ensure accuracy of the test (Magee, 2014).

![Figure 3.1: Jamar Handgrip Dynamometer (Photograph by researcher)](image)

3.5 Ethical Considerations

All participants who wished to participate in this study were requested to read an information form (Appendix C) and sign a consent form (Appendix D). These forms outlined the name of the researcher, purpose of the study, participant assessment and experiment procedure. The information form explained that the privacy of the participant will be protected, as only the participant, researcher and occasionally the supervising clinician will
be in the treatment room. The information form explained that there may be slight discomfort and stiffness after receiving spinal manipulative therapy. Any risks, benefits and discomforts pertaining to the experiment were explained and the participants’ safety was ensured. The participants stayed anonymous, as the information was converted into data, which could not be traced back to the participant. Any further questions from the participants were explained by the researcher and all results were available on request.

This study was approved by the Ethics Committee of the University of Johannesburg; with the ethics clearance number REC – 01-219-2015 (Appendix J).

To ensure that this study was done as original work and plagiarism was prevented by the researcher, it was submitted to and reported on by Turnitin (Appendix L).
CHAPTER 4 – STATISTICAL ANALYSIS

4.1 Introduction

This chapter provides the empirical findings and analysis based on the data collected by the researcher, in order to measure the rate of decline of increased grip strength after spinal manipulative therapy of the cervico-thoracic junction. The data was compiled by the researcher and analysed by STATKON. SPSS version 23 was used to analyse the data.

Table 4.1: Key for abbreviations used in the tables

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM_1</td>
<td>Left measurement one</td>
<td>Highest dynamometer reading pre-treatment on the left</td>
</tr>
<tr>
<td>RM_1</td>
<td>Right measurement one</td>
<td>Highest dynamometer reading pre-treatment on the right</td>
</tr>
<tr>
<td>LM_2</td>
<td>Left measurement two</td>
<td>Immediate post treatment dynamometer reading on the left</td>
</tr>
<tr>
<td>RM_2</td>
<td>Right measurement two</td>
<td>Immediate post treatment dynamometer reading on the right</td>
</tr>
<tr>
<td>LM_3</td>
<td>Left measurement three</td>
<td>One hour post treatment dynamometer reading on the left</td>
</tr>
<tr>
<td>RM_3</td>
<td>Right measurement three</td>
<td>One hour post treatment dynamometer reading on the right</td>
</tr>
<tr>
<td>LM_4</td>
<td>Left measurement four</td>
<td>24 hour post treatment dynamometer reading on the left</td>
</tr>
<tr>
<td>RM_4</td>
<td>Right measurement four</td>
<td>24 hour post treatment dynamometer reading on the right</td>
</tr>
</tbody>
</table>
4.2 Demographic Information

4.2.1: Gender distribution

**Table 4.2.1: Gender Distribution**

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>17</td>
<td>34</td>
</tr>
<tr>
<td>Female</td>
<td>33</td>
<td>66</td>
</tr>
<tr>
<td>Total</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 4.2.1 above shows the distribution of the participants according to gender in percentage. The female population was 66% and the male population was 34%.

When looking at the above data, it is evident that the sample size was 50.

**Table 4.2.2: Age**

<table>
<thead>
<tr>
<th></th>
<th>Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>23.08</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>2.257</td>
</tr>
<tr>
<td>Maximum</td>
<td>32</td>
</tr>
<tr>
<td>Minimum</td>
<td>19</td>
</tr>
<tr>
<td>Range</td>
<td>13</td>
</tr>
</tbody>
</table>

From Table 4.2.2 it can be deduced that the mean age of the participants was 23.08 years, the maximum age was 32 years and the minimum age was 19 years.
4.3 Normality Test

Before any tests could be done the distribution of each continuous variable in the data was tested. This testing included all four left dynamometer readings and all four right dynamometer readings. The distribution (normal or not normal) determined whether the researcher could use parametric or non-parametric tests. The Kolmogorov-Smirnov Test was used since the sample size was equal to 50.

**Table 4.3.1: Normality Tests of Left Dynamometer Readings**

<table>
<thead>
<tr>
<th>Tests of Normality</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td>LM_1</td>
<td>0.016</td>
<td>0.004</td>
</tr>
<tr>
<td>LM_2</td>
<td>0.046</td>
<td>0.027</td>
</tr>
<tr>
<td>LM_3</td>
<td>0.200</td>
<td>0.027</td>
</tr>
<tr>
<td>LM_4</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

From the SPSS results shown in Table 4.3.1, it is evident that LM_1, LM_2 and LM_4 are not normally distributed since the p-values are below the 0.05 level of significance. LM_3 is normally distributed, since its p-value is greater than the 0.05 level of significance. Therefore normality is found one hour after manipulation was delivered.

**Table 4.3.2: Normality Tests of Right Dynamometer Readings**

<table>
<thead>
<tr>
<th>Tests of Normality</th>
<th>Kolmogorov-Smirnov</th>
<th>Shapiro-Wilk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
From the SPSS results shown in Table 4.3.2, it is evident that RM_1, RM_2, RM_3 and RM_4 are not normally distributed since the p-values are below the 0.05 level of significance.

### 4.4 Within (Intra)-Group Analysis

#### 4.4.1 Clinical significance

**Table 4.4.1: Average Grip Strength of Measurements 1, 2, 3 and 4**
The results in Table 4.4.1 indicate a mean percentage increase in grip strength on the left of 1.66% between measurements one and two (immediately post treatment), a 3.48% increase between measurements one and three (one hour post treatment) and a 0.96% between measurements one and four (24 hours post treatment). A mean percentage increase on the right of 0.91% between measurements one and two (immediately post treatment), a 3.47% increase between measurements one and three (one hour post treatment) and a 1.19% increase between measurements one and four (24 hours post treatment) is indicated.

As depicted in section 4.3 above, most variables were not normally distributed and as a result, non-parametric tests (Friedman Test and Wilcoxon Signed Rank Test) were used in this section to perform intra-group analysis.

4.4.2 Statistical significance

In this section the statistical significance of this study are discussed. The dynamometer readings on the left hand side and the dynamometer readings on the right hand side are be discussed separately.

4.4.2.1. Left dynamometer results

The results of the dynamometer readings on the left hand side of the participants will be discussed below. In order to determine statistical significance over all four readings the Friedman Test was performed.

Table 4.4.2: Friedman Test of Left Dynamometer Readings

<table>
<thead>
<tr>
<th>Friedman test</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
<td>50</td>
</tr>
<tr>
<td>p-value</td>
<td>0.039</td>
</tr>
</tbody>
</table>

The results of the Friedman Test in Table 4.4.1.1 above indicate that there was a statistically significant difference in left dynamometer readings across the four time periods.
(LM_1, LM_2, LM_3 and LM_4) as shown by the p-value of 0.039 being less than the 0.05 level of significance.

Having established that there is a statistically significant difference somewhere among the four time periods, it was ideal to use the Wilcoxon Signed Rank Test as a post-hoc test in order to test which time period significantly differ from each other. To control for type one error, Bonferroni adjustment to the alpha value was necessary. In this case, Bonferroni adjustment involved dividing the alpha level of 0.05 by 6 (the number of tests to be done using Wilcoxon Signed Rank Test), meaning a stricter alpha level of \( \frac{0.05}{6} = 0.0083 \) to be used on every possible comparison.

**Table 4.4.3: Wilcoxon Signed Rank Tests of Left Dynamometer Readings**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.126</td>
<td>0.007</td>
<td>0.255</td>
<td>0.274</td>
<td>0.466</td>
<td>0.039</td>
</tr>
</tbody>
</table>

The results of the Wilcoxon Signed rank Tests in Table 4.4.1.2 reveal that there was a statistically significant difference between LM_1 and LM_3, as indicated by the p-value = 0.007 less than the alpha value of 0.0083. This result indicates that the statistical significance was found on the left hand side of the participants one hour after manipulation was applied. There was not any statistically significant difference in any other comparisons, as indicated by the p-values greater than 0.0083 level of significance. The second and fourth reading on the left hand side of the participants was found to be statistically insignificant which indicates the dynamometer readings immediately after manipulation and twenty four hours thereafter.
4.4.2.2 Right dynamometer results

Table 4.4.4: Friedman Test of Right Dynamometer Readings

<table>
<thead>
<tr>
<th>Friedman test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size</td>
</tr>
<tr>
<td>50</td>
</tr>
<tr>
<td>p-value</td>
</tr>
<tr>
<td>0.059</td>
</tr>
</tbody>
</table>

The results of the Friedman Test in Table 4.4.4 above indicates that there was no statistically significant difference in right dynamometer readings across the four time periods (RM_1, RM_2, RM_3 and RM_4) as shown by the p-value of 0.059 being greater than the 0.05 level of significance. Owing to the lack of statistical significance there was no need to perform the Wilcoxon Signed Rank test for the right dynamometer readings. This result indicates that there were no statistical significant readings at any time post treatment on the right hand side of the participants.

4.5 Male and Female Analysis

Even though a discussion regarding the gender of the participants was not part of the aim of this study, it was evident during the course of this study that male and female participants responded differently. Male and female results will thus be discussed separately in order to assess the results independently.
4.5.1 Male analysis

4.5.1.1 Clinical significance

Table 4.5.1: Average Grip Strength of Measurements 1, 2, 3 and 4 of the Male Participants

The results in Table 4.5.1 indicate a mean percentage increase in grip strength of male participants on the left of 2.36% between measurements one and two (immediately post treatment), a 3.01% increase between measurements one and three (one hour post treatment) and a 2.4% between measurements one and four (24 hours post treatment). A mean percentage decrease on the right of 1.35% between measurement one and two (immediately post treatment), a 0.34% increase between measurements one and three (one hour post treatment) and a 1.5% decrease between measurements one and four (24 hours post treatment) is indicated.

The decrease in grip strength on the right hand side of participants may have been due to the fact that most participants were right hand dominant, therefore participants may have used their right hand more during the course of their daily lives.
4.5.2 Female analysis

4.5.2.1 Clinical significance

Table 4.5.2: Average Grip Strength of Measurements 1, 2, 3 and 4 of the Female Participants

The results in Table 4.5.2 indicate a mean percentage increase in grip strength of female participants on the left of 0.24% between measurements one and two (immediately post treatment), a 0.27 % increase between measurements one and three (one hour post treatment) and a 0.0 % change between measurements one and four (24 hours post treatment). A mean percentage increase on the right of 0.037 % between measurements one and two (immediately post treatment), a 0.7 % increase between measurements one and three (one hour post treatment) and a 0.0 % change between measurements one and four (24 hours post treatment) is indicated.

4.5.3 Male and Female Statistical Significance

Even though an inter group analysis was not stated in the aim of the study it was evident that there was a significant difference in response between male and female participants.
during the conduction of this trial. As a result an inter group analysis was performed in order to compare the difference in response between the male and female participants.

As depicted in section 4.3 above, most variables were not normally distributed and, as a result, non-parametric tests (Mann-Whitney U Test) were used in this section to perform inter-group analysis.

**Table 4.5.3: Mann-Whitney U Test of Left Dynamometer Readings**

<table>
<thead>
<tr>
<th>Mann-Whitney U Test</th>
<th>LM_1</th>
<th>LM_2</th>
<th>LM_3</th>
<th>LM_4</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

A Mann-Whitney U Test was conducted to compare the left dynamometer readings for males and females. Table 4.5.3 suggests that there was a statistically significant difference in left dynamometer readings between males and females as indicated by the p-values of 0.000 across all the four readings (LM_1, LM_2, LM_3 and LM_4).

**Table 4.5.4: Mann-Whitney U Test of Right Dynamometer Readings**

<table>
<thead>
<tr>
<th>Mann-Whitney U Test</th>
<th>LM_1</th>
<th>LM_2</th>
<th>LM_3</th>
<th>LM_4</th>
</tr>
</thead>
<tbody>
<tr>
<td>p-value</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

A Mann-Whitney U Test was also conducted to compare the right dynamometer readings for males and females. Table 4.5.4 shows that there was a statistically significant difference in right dynamometer readings between males and females as indicated by the p-values of 0.000 across all the four readings (RM_1, RM_2, RM_3 and RM_4).
4.6 Conclusion

When looking at the results above, although not statistically significant, it is evident that the average grip strength of participants increased after chiropractic manipulative therapy. The biggest increase was seen at measurement three, which was one hour post treatment. Thereafter, there was an evident decline towards the 24 hour mark. The fourth measurement still read higher than the initial measurement which proves that there is still an effect 24 hours post manipulation.
CHAPTER 5 - DISCUSSION

5.1 Introduction

The results obtained in this study are discussed in terms of the statistical analysis of chapter 4 and the aim of the study that was presented in chapter 1.

5.2 Demographic Data

The population of the study consisted of 50 participants, of which 17 were male and 33 female. Therefore, the female participants made up 66 percent and the male participants made up 34 percent of the study. The age range of the population that participated in this study were between the ages of 19 and 33, with the mean age being 23.08 years.

5.3 Objective Data

5.3.1 Grip Strength

It is known that normal muscle functioning is reliant on neural integrity (Pollard & Ward, 1996). As reviewed in chapter 2, there are many claims that manipulation increases muscle strength when treating a restricted spinal segment.

5.3.1.1 General discussion

The grip strength of each participant was measured before receiving chiropractic manipulative therapy, immediately post treatment, at one hour post treatment and finally at 24 hours post treatment. Grip strength measurements were collected by using the Jamar handgrip dynamometer in order to assess the change in grip strength.

The overall results indicated a maximum mean percentage increase in grip strength on the left of 3.48% between measurements one and three. A maximum mean percentage increase of 3.47% was recorded on the right between measurements one and three. The average grip strength of participants had not yet returned to initial measurements 24 hours post treatment as is evident by a mean increase of 0.38% on the left and 0.55% on the right at the 24 hour mark. It is therefore evident that there is a decline in grip strength in most participants starting one hour post manipulation, continuing up to twenty four hours post manipulation. Some participants however still presented with grip strength higher than the initial readings twenty four hours post manipulation, therefore it would be more
appropriate to state that the change in grip strength was observed and measured, instead of the rate of decline.

These results support a study by Herzog (2010), which theorized that manipulation could add positive neurological input or remove aberrant neurological input. There is substantial evidence to show that manipulation can evoke a paraspinal reflex in the related muscles that is able to change the excitability of motor neurons in participants that are asymptomatic. Herzog's research indicates that manipulation to any spinal region increased electromyography activity in the paraspinal muscles, which was directly related to the area that was treated.

The evidence above also supports various studies that have been done in order to prove that manipulation has a stimulatory effect and in turn increases muscle strength. Two separate studies done by Dunning and Rushton (2009) and Keller and Colloca (2002) respectively show increased electromyography readings following chiropractic manipulative therapy. The above mentioned studies serve as a plausible explanation of the immediate effect of manipulation on grip strength.

These results are also supported by a study done by Pronto, Yelverton and Van Rensburg (2002), which show an increase in grip strength following six chiropractic treatments; a study done by Sher, Grobler and Yelverton (2002), which indicate a short term increase in quadriceps strength after chiropractic manipulation has been delivered to a restricted sacroiliac joint and a study done by Pretorius, Yelverton and Moodley (2008), which show a short term increase in gastrocnemius strength after chiropractic manipulation of the sacroiliac joint. Even though the above mentioned studies are unpublished studies they serve as sufficient proof of the effect of manipulation on muscle strength.

Therefore it is evident that manipulation alters the excitability of motoneurones and evokes muscle reflexes. There is however limited research showing the duration of increased muscle strength post manipulation. This study aimed to measure the rate of decline after the excitatory effect of a chiropractic manipulation.

The results show that there was an increase in grip strength of participants in this study, but it is necessary to statistically assess the data retrieved during the study.
The only statistical significant measurement was found at measurement three, one hour post treatment, on the left hand side of participants. This was determined by the Wilcoxon Signed Rank Test, performed as a post-hoc test in order to establish which time period specifically was significant and differed from the others.

Other previous studies that are relevant to the current study include, firstly, those done by El-Bohy, Goldberg and King (1999), and Cramer, Tuck and Knudsen (2000), where it was evident that the joint space of the facet joints widened after manipulation, as visible on magnetic resonance imaging. This study showed that the joint space widened up to 0.7 mm post treatment and imaging done showed that the joint space did not return to its pre-treatment state up to ten minutes post treatment. However limited information exists with regards to the time period required for these joints to return to the pre manipulation state. Even though this time period is unknown there is sufficient evidence to show that the facet joints and surrounding tissue may be stretched for a longer period than the duration of the chiropractic manipulation.

Secondly Keller & Colloca (2002) theorised that spinal manipulative therapy may stimulate the somatosensory system evoking a neuromuscular reflex. Altered sensory input could be removed by the biomechanical changes that occur as a result of manipulation (Leach, 2004). By removing altered sensory input there should be a lasting neurological effect.

Thirdly, Herzog (2010) has found abnormal biomechanics of vertebrae and their related facet joints can lead to compression of nerve roots. Neural tissue found in the intervertebral foramen is vulnerable to mechanical compression (Herzog, 2010). Thus, Haldeman believes that slight compression of the dorsal root and dorsal root ganglia could produce prolonged and increased neurological discharge of groups I, II, III and IV afferents (Haldeman, 2005).

In addition, stimulation and biomechanical alteration caused by spinal manipulative therapy could activate reflex centre in the spinal cord and higher centres leading to a sympathetic and parasympathetic response (Haldeman 2005). The central facilitation theory describes the excitability of the dorsal horn neurons to afferent inputs. Increased stimulation of related paraspinal segments may also assist alpha motor neurons to be held in a facilitated state. Furthermore some pathways in the abnormal segment were stimulated, which was suggested by the motor reflexes corresponding with the pain threshold. This finding
therefore suggests it that stimuli produced as an effect of manipulation may decrease the painful stimuli by replacing it with mechanical stimuli (Pickar, 2002), thus contributing to the lasting effects of manipulation leading to an increase on muscles strength several hours post treatment.

Finally, a study done by Zhu, Haldeman, Wu and Starr (2002) showed decreased muscle spasm and increased cerebral responses several minutes post treatment. This finding is supported by a study done by Korr (1976), which states that manipulation increases the mobility of the affected joint, producing an increased amount of neurological impulses in the muscles spindles. Chiropractic manipulative therapy aims to normalize muscular and articular biomechanics, in turn leading to increased muscle strength. Better biomechanical function will decrease the pressure on the nervous tissue and allow for optimal functioning. This theory could explain the delayed response of increased muscle strength and the continued increased muscle strength up to twenty four hours post manipulation.

5.3.1.2 Male versus female discussion

Even though an inter group analysis was not indicated in the aim of the study it became evident that there was a difference in response between the male and female population. A Mann-Whitney U Test was performed in order to determine the difference in response between male and female participants. The results in Table 4.5.1 and 4.5.2 suggest that there was a statistically significant difference in dynamometer readings between males and females as indicated by the p-values of 0.000 across all readings.

The results in Table 5.1 show that the maximum increase in grip strength for male participants were seen at measurement three (one hour post treatment) with a 6.4kg increase on the left and a 0.34kg increase on the right. The grip strength of male participants on the left did not return to normal 24 hours post treatment (at the final measurement), as is evident by a 5.1kg increase on the left and a 3kg decrease on the right. The maximum increase in grip strength of the female participants were also found at measurement three (24 hours post treatment), which is evidenced by the 0.8kg increase on the left and a 1.9kg increase on the right. The grip strength of female participants returned to normal 24 hours post treatment, unlike that of the male participants.
There are limited resources regarding the difference in response between male and female participants on chiropractic manipulative therapy. Further research is required in order to explain these results thoroughly.

5.3.2 Conclusion

The results discussed above indicate a significant increase in grip strength between the first and final reading for male participants on the left hand side. Additionally the left hand side measurements for male participants showed an average increase of 6.4kg one hour post treatment and the right hand side showed an increase of 0.6kg one hour post treatment. The left hand side measurements for female participants also showed an average increase in grip strength of 0.8kg one hour post treatment and the right hand side showed an increase of 1.9kg one hour post treatment. This result would still be beneficial to any athlete who relies on grip strength for performance.

According to the above results it would be most beneficial for athletes to receive manipulation one hour prior to competing as the greatest percentage increase were observed at that time in both male and female participants.

5.4 Observation

Statistically, the only significant measurement was found one hour post treatment on the left hand side of participants.

The data collected for this study included 33 participants with left posterior restrictions of the C7 vertebra and 17 participants with right posterior restrictions of the C7 vertebra. This situation may account for the statistical significant results recorded on the left hand side.

It was observed that the greatest percentage of increase in grip strength occurred one hour post treatment on both the left hand side and right hand side of participants. Therefore it would be most beneficial for athletes to receive treatment one hour prior to competing.
CHAPTER 6 - CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this study was to determine if cervical manipulative therapy of the cervico-thoracic junction would have a stimulatory effect on the nervous system by increasing the grip strength of the participants and to assess its rate of decline.

The assumption that there would be a decline in grip strength post treatment may have been incorrect as some participants still showed increased grip strength at the 24 hour mark, therefore it would be more appropriate to state that the change in grip strength was assessed, instead of the rate of decline.

The results indicated an increase in grip strength after manipulation of the cervico-thoracic junction. An increase was visible on all readings (immediately post treatment, one hour post treatment and 24 hours post treatment), tested with the Jamar handgrip dynamometer. Most results were found to be statistically insignificant, with the exclusion of measurement three (one hour post treatment) on the left hand side.

In conclusion it was noted that manipulation directed to the cervico-thoracic junction increases muscle strength up to 24 hours post manipulation as measured by the Jamar handgrip dynamometer. A gradual decline in grip strength was evident for most participants starting at one hour post manipulation. The grip strength of most participants had not yet returned to pre treatment values twenty four hours post manipulation. Further studies are necessary in order to determine when the grip strength of participants would return to pre treatment values.

In light of the above mentioned information, it could be said that manipulation may have an excitatory effect on the nervous system and therefore also increase the grip strength of participants in this study with a peak in grip strength at the one hour mark. It was also evident that not all participants showed a decline in grip strength up to the twenty four hour mark; therefore it would be more appropriate to state that the rate of change was assessed.

6.2 Recommendations

The following recommendations could be considered in order to improve the validation and statistical significance of the study:
• Utilization of a more comfortable dynamometer. This was a common complaint among participants. The Pneumatic hand dynamometer utilizes a rubber ball on a tube, which is squeezed to measure grip strength. The Martin vigorimeter is the most commonly used Pneumatic dynamometer and could be considered as an alternative.

• The inclusion of a symptomatic group. The symptomatic group should include participants that experience neck pain or discomfort. This inclusion will serve to show if participants who experience neck pain will have a greater improvement in grip strength with longer lasting effects than participants that are asymptomatic, and thus serve as a comparison between the effects of chiropractic on a purely biomechanical level versus the removal of a painful stimulus in combination with biomechanical effects. This may show that participants are stronger when they do not experience any pain.

• Utilization of a larger sample group in order to find a generalized trend in the results of the participants. A small sample group prevents the researcher from establishing variations in the results.

• Inclusion of a control group in order to rule out a learned response.

• Addition of more measurements between the one hour and 24 hour marks in order to assess when the decline starts and to assess when further changes occur.

• Addition of more measurements post 24 hours in order to measure when grip strength returns to pre intervention levels.

• Taking three measurements at every appointment, not only at the initial appointment, and using the highest of the measurements. The first measurement tends to be lower as participants are not yet comfortable with the dynamometer.

• Assessing male versus female participants in order to understand why they respond differently by measuring hormone levels pre and post manipulation.
REFERENCES


Get your grip tested

Take part in a chiropractic research study that will test your grip strength after chiropractic manipulation as well as assess the rate of decline.

To qualify for this research you must be:

- Between 18-40 years of age.
- Injury free
- Willing to take part in a research study.

If you meet the above requirements please contact Luchelle Prinsloo on 0721417421.

Treatment is conducted in the Supervised University of Johannesburg clinic, Sherwell road, Doornfontein.
APPENDIX B: Contra-indications to Chiropractic Manipulation (Gatterman, 2004).

Vascular complications
Vertebral artery syndrome
Aneurysms

Tumors
Primary to the bone
Secondary (Metastasized to the bone)

Bone infection
Tuberculosis of the spine
Osteomyelitis of the spine

Traumatic injuries
Fractures
Joint instability
Severe sprains or strains
Unstable spondylolysis

Arthritis
Ankylosing spondylitis
Rheumatoid arthritis
Psoriatic arthritis
Uncoarthritis
Osteoarthritis

Psychological considerations
Malingering
Hysteria
Hypochondriasis
Pain intolerance

Neurological complications
Sacral nerve root involvement from medial or massive disc protrusion
Disc lesions (advanced neurological deficits)
Space occupying lesions
Metabolic disorders
Clotting disorders
Osteopenia (osteoporosis, osteomalacia)
Good day, my name is Luchelle Prinsloo, and I am doing my Master’s Degree at the University of Johannesburg. I would like to invite you to consider participating in my research study. The purpose of this study is to determine the rate of decline of increased grip strength as a result of manipulation of the cervico-thoracic junction.

Before agreeing to participate, there are a few points that I would like to bring to your attention:

This study is entirely voluntary and you are free to withdraw at any point without reason and without any consequences.

- Your anonymity will be ensured as your information will be kept confidential at all times and no data will be able to be traced back to you as your name will be converted to a file number on all documentation. The data from this study may however be used for publication purposes.

- During treatment only me, the researcher, and possibly the supervising clinician will be present. Both I, and the supervising clinician, are legally obliged to keep your information confidential and protect your privacy all times.

- Some important details directly related to this study that I would like you to be aware of should you decide to participate:

- You need to be between the ages of 18-40, be free of any wrist and hand pathology, have cervico-thoracic junction motion restriction and not have any contraindications to chiropractic. These criteria will be determined by the researcher and discussed in more detail with you at your first consultation.
• You will have the motion restriction of the neck manipulated by the researcher. Spinal manipulation is a standard procedure performed by Chiropractors on a regular basis. There are limited side effects, with a small chance of feeling some stiffness and mild discomfort after the treatment. You will need to notify me of any side effects that you do notice. Be aware that you may hear an audible clicking sound during treatment, this is completely normal.

• You will have your grip strength measure by a grip dynamometer before treatment, immediately after treatment, one hour post treatment and 24 hours post treatment. A dynamometer is a hand held device that you will clench in your hand to measure the force exerted by your hand.

• The duration of the study will be 24 hours during which time you will receive one chiropractic manipulation. Your grip strength will be measured before treatment and immediately after treatment. You will be asked to return within one hour and 24 hours after treatment to take grip strength measurements. All treatments will take place at the University of Johannesburg’s Chiropractic Day Clinic and be performed by the researcher.

If you have any questions at any time please contact me on 072 141 7421, or alternatively contact my supervisor, Dr C. Bester on 011 559 6936

Thank you for taking the time to read this form and consider participation in this study.
APPENDIX D: Consent Form

DEPARTMENT OF CHIROPRACTIC

Date: _________________

CONSENT FORM

Dear participant

Before signing this consent form please take your time and read the information form.

Please indicate below whether you would like me to notify your personal doctor or your specialist of your participation in this study.

☐ YES, I want you to inform my personal doctor or your specialist of your participation in this study.

☐ NO, I don’t want you to inform my personal doctor or your specialist of your participation in this study.

☐ I don’t have a personal doctor or specialist.

INFORMED CONSENT

• I hereby confirm that I have been informed by the researcher Luchelle Prinsloo about the nature, conduct, benefits and risks of this study that will determine the effect of cervical spine adjustment on improved grip strength and its rate of decline.

• I have received, read and understood the written information form regarding this study.

• I am aware that the results of this study, including personal details regarding my sex, age, date of birth and diagnosis will be anonymously processed into a study report.

• In view of the requirements of research, I agree that data collected during this study can be processed.

• I may, at any stage, without prejudice, withdraw my consent and participation in this study.

• I have had sufficient opportunity to ask questions and, of my own free will, I declare
myself prepared to participate in this study.

Signed Participant

________________________________________
Printed name    Signature    Date and time

Signed Researcher

________________________________________
Printed name    Signature    Date and time
APPENDIX E: Participant Case History

UNIVERSITY OF JOHANNESBURG CHIROPRACTIC DAY CLINIC

CASE HISTORY

Date: _________________

Patient: ___________________________ File No: ___________

Age: ______  Sex: _________  Occupation: ______________

Student: ___________________________ Signature: __________

Complies with Inclusion criteria of the research:

Clinician:

_____________________________

Signature: ____________________

Examination:

Previous: UJ  Current: UJ
X-ray Studies:

Previous: UJ  Current: UJ
Other       Other

Clinical Path Lab:

Previous: UJ  Current: UJ
Other       Other

Case status:

PTT: Conditional: Signed off: Final sign out:

Recommendations
Students case history

1. Source of history:

2. Chief complaint:(patient's own words)

3. Present illness:

Location
Onset
Duration
Frequency
Pain (character)
Progression
Aggravating factors
Relieving factors
Associated Sx's and Sg's
Previous occurrences
Past treatment and outcome
4. *Other complaints:*

5. *Past history*

General health status
Childhood illnesses Adult illnesses
Psychiatric illnesses
Accidents/injuries
Surgery Hospitalisation

6. *Current health status and lifestyle*

Allergies Immunizations
Screening tests
Environmental hazards
Safety measures Exercise and leisure Sleep patterns
Diet

Current medication
Tobacco
Alcohol Social drugs
7. Family history:
   Immediate family:

Cause of death
DM
Heart disease TB
HBP

Stroke

Kidney disease
CA
Arthritis
Anaemia
Headaches
Thyroid disease
Epilepsy
Mental illness
Alcoholism
Drug addiction
Other

8. Psychosocial history:

Home situation 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 F: Physical Examination

UNIVERSITY OF JOHANNESBURG CHIROPRACTIC DAY CLINIC

PHYSICAL EXAMINATION

(NOTE: only if Cervical Spine Regional is complete)

Underline abnormal findings in RED. Date: ________________

Patient: ________________ File No: ________________
Clinician: ___________________ Signature: ________________
Student: ___________________ Signature: ________________

Height: _______ Weight: _______ Temp: _______
Rates: Heart:_______ Pulse: _______ Respiration:_______

Blood pressure: | Arms: | L | R |
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General Appearance:
STANDING EXAMINATION

1. Minor’s sign
2. Skin changes
3. Posture: Erect
   Adam’s
4. Ranges of motion (Thoracolumbar Spine)
   T/L spine: Flexion: 90° (fingers to floor)
   Extension: 50°
   R. lat. flex: 30° (fingers down leg)
   L. lat. flex: 30° (fingers down leg)
   Rot. To R: 35°
   Rot. To L: 35°

5. Romberg’s sign
6. Pronator drift

/ = pain-free limitation  // = painful limitation
7. Trendelenburg’s sign
8. Gait: - rhythm
   - balance
   - pendulousness
   - on toes
   - on heels
   - tandem
9. Half squat
10. Scapular winging
11. Muscle tone
12. Spasticity/Rigidity
13. Shoulder: skin
   symmetry
   ROM - glenohumeral
   - scapulo-thoracic
   - acromioclavicular
   - elbow
   - wrist
14. Chest measurement:
   - Inspiration
     | L | R |
     | cm | cm |
   - expiration
15. Visual acuity
16. Breast examination:

Inspection:
- skin
- size
- contour
- nipples
- arms overhead
- hands against hips
- leaning forward

Palpation
- axillary lymph nodes
- breast incl. tail

SEATED EXAMINATION

1. Spinal posture
2. Head
   - hair
   - scalp
   - skull
   - face
   - skin
3. Eyes:
   Observation
   - conjunctiva
   - sclera
   - eyebrows
   - eyelids
   - lacrimal glands
   - nasolacrimal duct
   - position and alignment
- corneas and lenses

- corneal reflex
- ocular movement

L     R
III    IV    VI    III    IV    VI

- visual fields
- accommodation
- Ophthalmoscopic
- Examination
  - iris
  - pupils
  - red reflex
  - optic disc
  - vessels
  - general background
    - macula
    - vitreous
    - lens

4. Ears:
- auricle

- Inspection
  - ear canal
  - drum
• auditory acuity
• Weber test
• Rinne test

5. Nose:

• External
• Internal
  - septum
  - turbinates
  - olfaction

6. Sinuses (frontal & maxillary):
  - tenderness
  - transillumination

7. Mouth and pharynx:

• lips
• buccal mucosa
• gums and teeth
• roof
• tongue
  - inspection
  - movement
  - taste
- palpation

- pharynx - CNX

- inspection

- carotid arteries (thrills, bruit)

- Cranial Nerves - CNV
  - CNVII
  - CNVIII (nystagmus)
  - CNIX
  - CNXI
  - CNXI

8. Peripheral vasculature:

- Inspection - skin
  - Nail beds
  - pigmentation
  - hair loss

- Palpation - pulses: - femoral - dorsalis pedis
  - popliteal - radial
  - post. Tibial-brachial

- lymph nodes - epitrochlear
  - femoral (horizontal & vertical)
- temperature (feet and legs)

- Manual compression test
- Retrograde filling (Tredelenburg) test
- Arterial insufficiency test

10. Musculoskeletal:

(i) ROM

- hip

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knee
ankle
leg length

-dysdiachokinesia

9. TMJ
deviation

Palpation crepitus

10. Thorax

- Inspection
  - skin
  - shape
  - respiratory distress
  - rhythm (respiratory)
  - depth (respiratory)
  - effort (respiratory)
  - intercostals/supraclavicular retraction

- Percussion
  - lungs (posterior)
  - Diaphragmatic excursion
• Auscultation
  (i) breath sounds
  - vesicular
  - bronchial

(ii) adventitious sounds
  - crackles (rales)
  - wheezes (rhonchi)
  - rubs

(iii) voice sounds
  - broncophony
  - whispered pectoriloquy
  - egophony

• Cardiovascular
  - auscultation (aortic murmurs)
  - Allen’s test

SUPINE EXAMINATION

1. JVP
2. PMI
3. Auscultation heart
   (L. lat. Recumbent)
4. Respiratory excursion
5. Percussion chest
   (anterior)
6. Breast palpation
7. Abdominal Examination
   □ Inspection
     - skin
     - umbilicus
     - contour
     - peristalsis
- pulsations
- hernias (umbilical/incisional)

- Auscultation
  bowel sound
  bruit

- general
  liver

- Palpation
  superficial reflexes
  cough
  light
  rebound tenderness
  deep
  liver
  spleen

- Acute abdomen
  where pain began and now
  cough
  tenderness
  guarding/rigidity
  rebound tenderness
  rovsing’s sign

MENTAL STATUS

(i) Appearance and behaviour
- level of consciousness
- Posture and motor behaviour
- dress, grooming, personal hygiene
- facial expression
(ii) Speed and language
- quantity
- rate
- volume
- fluency
- aphasia (pm)

(iii) Mood

(iii) Memory and attention

- orientation (time, place, person)
- remote memory
  - recent memory
  - new learning ability

(vi) Higher cognitive functions

- Information and vocabulary
- (general and specialised knowledge)
- Abstract thinking
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APPENDIX G: Cervical Regional Examination

UNIVERSITY OF JOHANNESBURG
CHIROPRACTIC DAY CLINIC

REGIONAL EXAMINATION CERVICAL SPINE

Date: ______________________

Patient: ______________________ File No: ______________________

Clinician: ______________________ Signature: ________________

Student: ______________________ Signature: ________________

OBSERVATION

• Posture
• Size
• Swellings
• Scars
• Discolouration
• Hairline
• Bony and soft tissue contours
• Shoulder level
• Muscle spasm
• Facial expression

5. RANGE OF MOTION

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<td>L/R Lat Flexion</td>
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PALPATION

- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points

ORTHOPAEDIC EXAMINATION

1. Doorbell Sign
2. Max. Cervical Compression

3. Spurling’s manoeuvre

4. Lateral Compression (Jackson’s test)

5. Kemp’s Test

6. Cervical Distraction

7. Shoulder abduction Test

8. Shoulder depression Test

9. Dizziness rotation Test

10. Lhermitte’s Sign

11. O’ Donoghue Manoeuvre

12. Brachial Plexus Tension

13. Carpal tunnel syndrome:
   - Tinel’s sign
   - Phalen’s Test
14. TOS:

- Halstead’s test
- Adson’s test
- Eden’s (traction) test
- Hyperabduction (Wright’s) test–Pec minor
- Costoclavicular test

Remarks:

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COMMENTS:

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APPENDIX H: Soap Note

CHIROPRACTIC DAY

CLINIC SOAP

NOTE:

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Comments:
APPENDIX I: Higher Degrees Committee Approval

FACULTY OF HEALTH SCIENCES
HIGHER DEGREES COMMITTEE

HDC-01-147-2015
21 August 2015

TO WHOM IT MAY CONCERN:

STUDENT: PRINSLOO, L
STUDENT NUMBER: 201176080

TITLE OF RESEARCH PROJECT: “The Effect of Cervical Spine Adjustment on Grip Strength and its Rate of Decline”

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr C Bester
CO-SUPERVISOR:

The Faculty Higher Degrees Committee has scrutinised your research proposal and concluded that it complies with the approved research standards of the Faculty of Health Sciences, University of Johannesburg.

The HDC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

Prof J Coopoo
Chair: Faculty of Health Sciences HDC
Tel: 011 559 6944
Email: yogac@uj.ac.za
APPENDIX J: Research Ethics Committee Approval

TO WHOM IT MAY CONCERN:

STUDENT: PRINSLOO, L
STUDENT NUMBER: 201176080

TITLE OF RESEARCH PROJECT: "The Effect of Cervical Spine Adjustment on Grip Strength and its Rate of Decline"

DEPARTMENT OR PROGRAMME: CHIROPRACTIC

SUPERVISOR: Dr C Bester

The Faculty Research Ethics Committee has scrutinised your research proposal and confirm that it complies with the approved ethical standards of the Faculty of Health Sciences, University of Johannesburg.

The REC would like to extend their best wishes to you with your postgraduate studies.

Yours sincerely,

Prof M Poggenpoel
Chair: Faculty of Health Sciences REC
Tel: 011 559 6686
Email: mariep@uj.ac.za
APPENDIX K: Turnitin Digital Receipt

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author: L PRINSLOO
Assignment title: Submit proposals, theses, disserta...
Submission title: The effect of cervical spine adjust...
File name: Turnitin.docx
File size: 3.55M
Page count: 45
Word count: 10,466
Character count: 58,435
Submission date: 14-Apr-2016 10:28PM
Submission ID: 655271985

The effect of cervical spine adjustment on grip strength with the use of decline
APPENDIX L: Turnitin Submissions Information and Overall Similarity Score

The effect of cervical spine adjustment on gr...
By L PRINSLOO