THE EFFICACY OF MSM (methylsulfonylmethane) INCORPORATED INTO ULTRASOUND GEL USING PHONOPHORESIS IN THE TREATMENT OF AN ACUTE FACET SYNDROME IN THE CERVICAL SPINE

A dissertation submitted to the Faculty of Health Sciences, University of Johannesburg, as a partial fulfilment of the requirements for the Masters degree in Technology in Chiropractic by:

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DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Masters Degree in Technology in the program Chiropractic at the University of Johannesburg. It has not been submitted before for any degree of examination in any other Tertiary Institute.

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DEDICATION

To my father and mother, thank you for providing me with the opportunity to enrich my life with this degree, and for putting up with the frustrations that was needed to finish it. I cannot say thank you enough for your love and support.

To Lana Panagis, my best friend, who helped me through tough times and kept motivating me to finish this dissertation.
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ABSTRACT

Health professionals, while differentiated in their philosophies and choice of practice, still endeavour to expand the choice of effective and trustworthy techniques that can be applied to the individual needs of a patient. Therapeutic ultrasound is one such treatment that is used by many health practitioners.

Ultrasound is one of the complementary treatments used to treat an acute cervical facet syndrome. Thermal ultrasound has the ability to decrease pain, stiffness, muscle spasm and inflammation of the tissue surrounding an acute cervical facet (Wyatt, 2004 and Reid, 1992). The current ultrasound treatment regimens for acute cervical facet syndromes are time consuming, in that they require a series of ultrasound treatments (Wyatt, 2004). Methods that could improve ultrasound treatment regimens in the treatment of acute cervical facets, by decreasing the amount of ultrasound treatments required and by increasing the effectiveness of the treatment would be beneficial.

This research aims to test, in a clinical environment, the efficacy of MSM (methylsulfonylmethane) incorporated into ultrasound gel used with ultrasound in the treatment of an acute cervical facet syndrome.

Participants were recruited from the University of Johannesburg Chiropractic Day Clinic. They were eligible to participate in the study once they met the inclusion and exclusion criteria. Participants were recruited by means of word of mouth as well as with the use of advertisements that were placed around the respective campuses of the University of Johannesburg.

Thirty participants who presented with an acute cervical facet syndrome, volunteered for this comparative study. The study was double blinded, in which neither the researcher nor the participants knew which bottle contained the MSM incorporated into ultrasound gel or the standard ultrasound gel. It was only after the trials were completed that it was made know that group A received the MSM incorporated into ultrasound and group B the standard ultrasound. Group A received ultrasound treatment utilising MSM incorporated into ultrasound gel causing phonophoresis of the product’s ions, over the acute facets in the cervical spine. Group B received ultrasound treatment, using regular ultrasound gel, over the acute facets in the cervical spine.
Participants were treated for a total of 6 visits. Subjective and objective measurements were done at visits 1, 4 and a final visit 7 during which only measurements were taken.

Subjective measurements consisted of the Numerical Pain Rating Scale to assess the participants’ perception of pain. Objective measurements were done with the use of the pressure algometer to determine the participants’ pressure pain threshold of the acute cervical spine facet and with the Cervical Spine Range of Motion readings to determine the functional ability that the participants had in terms of cervical spine movement.

Based on the results of the study, it could be concluded that both the standard ultrasound protocol and the MSM incorporated into ultrasound gel protocol can be used effectively to treat acute cervical spine facets. It could not be statistically concluded whether one treatment is superior to the other, although clinically the MSM incorporated into ultrasound gel protocol seemed to be more effective and could thus be used in a clinical setting.
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CHAPTER ONE: INTRODUCTION

1.1 General Introduction

Health professionals, while differentiated in their philosophies and choice of practice, still endeavour to expand the choice of effective and trustworthy techniques that can be applied to the individual needs of a patient. Therapeutic ultrasound is one such treatment that is used by many health practitioners.

Ultrasound is one of the complementary treatments used to treat an acute cervical facet syndrome. The current ultrasound treatment regimens for acute cervical facet syndromes are time consuming, in that they require a series of ultrasound treatments (Wyatt, 2004). This decreases patient compliance. Methods that could improve ultrasound treatment regimens in the treatment of acute cervical facets, by decreasing the amount of ultrasound treatments required and by increasing the effectiveness of the treatment would be beneficial. Thermal ultrasound has the ability to decrease pain, stiffness, muscle spasm and inflammation of the tissue surrounding an acute cervical facet (Wyatt, 2004 and Reid, 1992).

Phonophoresis is defined as the migration of drug molecules, contained in a contact agent, through skin utilising ultrasound (Tyle and Agrawala, 1989). Ultrasound has been shown to, through phonophoresis; increase the permeability of the cells. This process allows the anti-inflammatory agents to enter the cells and therefore have an anti-inflammatory effect on the target cells (Reid, 1992).

MSM (Methylsulfonylmethane) is a naturally occurring nutrient found in normal human diets (Total Health, 1998; Williams, 1997; Jacob and Appleton, 2002). MSM reduces inflammation and swelling, consequently allowing for increased range of motion and decreased pain (Lovelock, 1972). According to Jacob et al. (1999) “MSM is the first safe, natural, side effect-free remedy for many types of pain and inflammatory conditions”.
1.2 The Aim of this Study

This research aims to test, in a clinical environment, the efficacy of MSM (methylsulfonylmethane) incorporated into ultrasound gel with ultrasound in the treatment of an acute facet syndrome in the cervical spine by comparing it to standard ultrasound regimes.

1.3 Benefits of the Study

This study will be beneficial in determining whether ultrasound is an appropriate treatment modality, when treating an acute cervical facet. It will determine whether MSM incorporated into ultrasound gel is more effective than using standard ultrasound gel. It will also provide insight into the mechanism of phonophoresis and determine if it does have a therapeutic effect on the involved cells, therefore allowing for more effective treatment of an acute cervical facet.

With respect to the above introduction, Chapter Two will review the literature done on the anatomy and biomechanics of the cervical vertebral column, acute facet syndrome, therapeutic ultrasound and MSM.; followed by Chapter Three which will focus on the methodology relevant to this study. Chapter Four reports the findings with Chapter Five discussing these results. Chapter Six will provide possible conclusions and recommendations for the future studies on this topic.
CHAPTER TWO- LITERATURE REVIEW

2.1 Cervical Spine Anatomy

2.1.1 Physiology of the Joints

The cervical spine is made up of two functionally distinct segments, the upper and lower cervical spine. The upper cervical spine, or suboccipital segments, contains the atlas (first cervical vertebrae) and axis (second cervical vertebrae), while the lower cervical spine starts at the lower surface of the axis and the upper surface of the first thoracic vertebrae (Middleditch and Olivier, 2005).

2.1.2 The Structure of Typical Cervical Vertebrae

The third to the seventh cervical vertebrae are considered to be typical cervical vertebrae (Moore, 2006).

Figure 2.1: An Illustration of a Typical vertebra (Netter, 2006)
A typical vertebra consists of a vertebral body, a vertebral arch and seven vertebral processes. The vertebral body is the roughly cylindrical anterior part of the vertebra. It provides strength to the vertebral column and supports the weight of the head. The vertebral body consists of vascular and trabecular bone enclosed by a thin external layer of compact bone (Moore, 2006).

The superior and inferior surfaces of the vertebral body are covered with hyaline cartilage (vertebral end-plates). The epiphyseal rim is found at the periphery of the vertebral body and serves as growth zones, protection to the vertebral body and allows diffusion of fluid between the intervertebral (IV) discs and capillaries in the vertebral body (Moore, 2006).

The superior borders of the transversely elongated cervical vertebral bodies are elevated posteriorly and especially laterally but are depressed anteriorly. The inferior border of the body of the superiorly placed vertebra is reciprocally shaped. The elevated superolateral margin is the uncus of the body (uncinate process) (Moore, 2006).

The vertebral arch is posterior to the vertebral body and consists of two pedicles and laminae. The pedicles are short processes that project posteriorly from the vertebral body to meet the laminae. The laminae are flat bones which connect in the midline. The anterior surface of the vertebral arch and the posterior surface of the vertebral body form a wall around the vertebral foramen. The succession of vertebral foramina in the vertebral column forms the vertebral canal, which contains the spinal column (Moore, 2006).

The vertebral notches are indentations observed in lateral views on the superior and inferior surfaces of the pedicles. The superior and inferior vertebral notches of adjacent vertebrae and the IV discs connecting them form the intervertebral foramina. The intervertebral foramina house the spinal (posterior root) ganglia and the cervical spinal nerves emerge through it with accompanying vessels (Moore, 2006).

Seven processes arise from the vertebral arch of a typical vertebra. One bifid spinous process projects posteriorly from the junction of the laminae. Two transverse processes (TVP) project posterolaterally from the junctions of the pedicles and laminae. The medial portions of the TVP’s are perforated by the foramen transversarium, which houses the vertebral artery. Four articular processes (zygapophyses), two superior and two inferior, also arise from the junction of the pedicles and laminae, each bearing an articular surface (facet). The four articular processes are in
position with corresponding processes of vertebra superior and inferior to them, forming zygapophysial (facet) joints. Through their participation in these joints, these processes determine the types and ranges of motion permitted and restricted between adjacent vertebrae of each region (Moore, 2006).

The facet joints are true synovial joints in that they have a thin ligamentous capsules, that seals the joint and hyaline cartilage that covers their articular surfaces. The facet joints capsules are innervated by the medial branches of the adjacent posterior rami of the segmental levels above and below (Murphy, 2000). The synovium as well as the capsule have substance P-sensitive nerves in addition to nociceptors (Souza, 1998).

2.1.3 The Structure of the First Two Cervical Vertebrae

The first cervical vertebra (atlas) is ring shaped with the anteroposterior diameter smaller than the transverse diameter. It doesn’t have a central vertebral body or a spinous process, but is composed of two lateral masses and an anterior and posterior arch (Martini, 2001). The lateral masses bear the weight of the globe-like cranium (Moore, 2006).

![Figure 2.2: Illustration of the Atlas and Axis (Netter, 2006)](image-url)
The TVP's of the atlas arise from the lateral masses, causing them to be more laterally placed than the typical vertebrae. The concave superior articular surfaces of the lateral masses receive the two large occipital condyles that are on either side of the foramen magnum. The anterior and posterior arch, each bears a tubercle in the centre of its external aspect. The posterior arch, which corresponds with the lamina of a typical vertebra, has a wide groove on its superior aspect for the vertebral artery (Moore, 2006).

The second cervical vertebra (Axis) is the strongest of the cervical vertebrae. The Atlas carrying the cranium rotates on the Axis, as when a person rotates their neck. The Axis has two large, flat bearing surfaces, the superior articular facets, on which the atlas rotates. The dens (odontoid process), which is a blunt tooth-like structure projects superiorly from the axis's body. Both the dens and the spinal cord are encircled by the atlas. The dens lies anterior to the spinal cord and serve as a pivot point. The dens is held in position against the posterior aspect of the anterior arch of the Atlas by the transverse ligament. The Axis has a large bifid spinous process (Moore, 2006).

2.1.4 Movement of the Upper Cervical Vertebrae

During flexion of the Atlas and cranium, the occipital condyles recede on the lateral masses of the Atlas. At the same time the posterior arch of the Atlas and the occipital bone move further apart. During extension, the opposite occurs. The occipital condyles move anteriorly on the lateral masses of the Atlas and the posterior arch and occipital bones approximate (Middleditch and Olivier, 2005).

During flexion/extension of the Atlas and Axis there is no opening at the atlanto-odontoid joint due to the support of the transverse ligament. There is however, opening at either facet joint (Middleditch and Olivier, 2005).

Rotation occurring at the atlanto-occipital joint is secondary to rotation at the Axis and Atlas. Rotation to the right displaces the left occipital condyle anteriorly on the left lateral mass. Tension developed in the atlanto-occipital ligament is what draws the left occipital condyle right. The tension is caused by the ligament wrapping around the odontoid process during rotation. Therefore, rotation to the right doesn’t only encompass a linear displacement to the right but also involves lateral flexion to the left (Middleditch and Olivier, 2005).
During rotation at the atlanto-axial joint, the odontoid remains stationary. With rotation to the right the ligaments and joint capsule on the right relaxes, whilst the articular capsule and ligaments on the left stretch. The left lateral mass of the atlas moves forward while the right lateral mass recedes. The articular surface of the Atlas is convex inferiorly and the superior surface of the Axis is convex. Thus at zero degrees of rotation the Atlas sits on the Axis at its highest point and with rotation there is a vertical drop as the Atlas slides inferiorly on the convex articular surface of the Axis (Kapandji, 2008). During lateral flexion, the atlanto-axial joint shows no movement whatsoever. Movement only occurs between the atlanto-occipital (C0-C1) joint and between the Atlas and the third cervical vertebra. When lateral flexion occurs between C0 and C1 the occipital condyles slip in the opposite direction to the lateral flexion. This is a very small range of movement (Middleditch and Olivier, 2005).

2.1.5 Movement of the Lower Cervical Vertebrae

The facet joints of the lower cervical vertebrae are angled obliquely inferiorly and posteriorly (Coetzee, 1987). During extension the superior articular facet tilts posteriorly and slides inferiorly and posteriorly on the inferior articular facet. The Anterior longitudinal ligament and the impaction of the articular processes and posterior arches limit the amount of extension that occurs (Middleditch and Olivier, 2005).

During flexion the superior vertebral body tilts and slides anteriorly. The inferior articular facet of the superior vertebra moves superiorly and anteriorly. Flexion is limited by tension in the Posterior longitudinal ligament, the Capsular ligament, Ligamentum flavum, Ligamentum nuchae and the Posterior cervical ligament (Middleditch and Olivier, 2005).

2.1.6 Range of Motion of the Cervical Spine

According to Middleditch and Olivier (2005) the range of motion of the cervical spine is:

- Flexion/extension of the suboccipital segment: 20-30 degrees
- Flexion/extension of the lower cervical spine: 100-110 degrees
- Flexion/extension of the complete cervical spine: 130 degrees
- Lateral flexion of the complete cervical spine: 45 degrees
Rotation of the complete cervical spine: 80-90 degrees

2.2  Acute Cervical Facet Syndrome

2.2.1  Introduction

The “facet syndrome” was first described in 1933, but only recently was it investigated as a source of neck pain. It was found that it is a legitimate underappreciated cause of both acute and chronic neck pain. Cervical facet syndrome implies the existence of axial pain in the neck, which often has a referred pain that is due to secondary involvement of the facet joints of the cervical spine (Wyatt, 2004). A facet syndrome of the cervical spine can occur when facets are subjected to increased loads during certain ranges of motion. This leads to capsular inflammation, which in turn leads to adhesions and persistent neck pain (Murphy, 2000). Facet syndromes may also present with a referred pain down the arm, but no neurological symptoms are present. An acute cervical facet syndrome is diagnosed by symptoms recognised as well as through direct palpation over the area leading to experienced tenderness (Wyatt, 2004).

The capsules of the facet joints are more lax in the cervical spine to allow for the gliding movements of the facets, this contributes to the greater range of motion in the cervical spine. This increased range of motion amplifies the chances of injury especially in the lower cervical spine, making an acute cervical facet syndrome a common occurrence (Wyatt, 2004).

2.2.2  Signs and Symptoms of acute cervical facet syndrome

The normal history is a patient comes in complaining of a dull, achy pain that may be sharp during an acute episode, headaches and a limited range of motion. The pain is localised, the patient is able to pinpoint the pain and the neck muscles are usually in spasm (Vizniak and Carnes, 2010).

According to Wyatt (2004), patients with cervical facet syndrome may present with:

1. Neck pain
2. Headaches
3. Decrease range of motion of the cervical spine
4. Referred pain to the shoulder, arm or mid-back
5. Tenderness to palpation over the facet joints or paraspinal muscles
6. Pain with cervical extension and/or rotation
7. Absence of neurological abnormalities
8. Kemp’s test produces local pain

2.2.3 Causes of Acute Cervical Facet Syndrome

According to Vizniak and Carnes (2010), potential causes may include:
1. Secondary to cervical injury
2. Cervical disc injuries is associated with facet pain in ~40% of cases
3. Whiplash
4. Sprain or strain of the neck
5. Osteo-arthritis
6. Rheumatoid Arthritis
7. Repetitive stress due to occupation
8. Poor posture

2.2.4 Physical Exams and Orthopaedic Tests for an Acute Cervical Facet

According to Wyatt (2004), the physical exam can include an increase of pain on cervical extension and rotation. This is due to the approximation of the acute facet joint. The patient may also present
with an antalgic posture (painful posture), that is typically away from the acute facet. The patient will achieve this by slight cervical spine flexion and lateral flexion to the opposite side.

The orthopaedic tests that may present positive include a positive joint play at the end range of motion; this may include positive results on lateral bending during the examination. Local pain may be reproduced during cervical compression test as well as during Jackson’s test. The patient may experience a decrease in pain during cervical distraction. During the examination no neurological deficits should be present during myotome, dermatome and reflex testing (Vizniak and Carnes, 2010).

A positive Kemp’s tests needs to be elicited for this study. The Kemp’s test consists of the patient sitting looking ahead. The examiner stands behind the patient. The examiner places their thumb over a cervical facet. The examiner then moves the patients neck with their other hand, into lateral flexion, rotation and extension (on the same side) to maximally compress the facet underneath their thumb. A positive test will be when the patient experiences local pain (Vizniak and Carnes, 2010).

2.3 Therapeutic Ultrasound

2.3.1 Introduction

According to Watson (2008), ultrasound is one of the most widely used of the ‘electrotherapy’ modalities in current clinical practice. In addition to its widespread use by physiotherapists, it is also commonly used by numerous therapists from other professional groups (e.g. osteopaths, chiropractors and sports therapists). Although widely considered as a form of electrotherapy, this is not strictly true in that ultrasound energy is a form of mechanical rather than electrical or electromagnetic energy.

While therapeutic ultrasound has been used for over 40 years, its current use in the clinical environment has changed significantly over this period, and whereas in the past its use was primarily for its thermal effect, it is now more widely employed for its non-thermal effects, especially in relation to tissue repair and wound healing (Watson, 2008).
2.3.2 Clinical Use of Therapeutic Ultrasound

The application of ultrasound therapy is one of the modalities that can be used to treat the acute stage of a facet syndrome (Wyatt, 2004). Ultrasound has physiologic effects on tissue, such as, thermal and non-thermal effects and micromassage: however it can also be used therapeutically for acute and subacute traumatic and inflammatory conditions, arthritic conditions as well as reduction of pain and muscle spasm (Low and Reed, 1995).

Ultrasound can be used to treat any stage of tissue repair. During the inflammatory phase ultrasound accelerates the repair process by interacting with the mast cells, platelets, macrophages and neutrophils that are present in the affected area. There is evidence that therapeutic ultrasound can interact with the above cells, influencing their activity and leading to quicker resolution of the inflammatory phase (Watson, 2008).

During the proliferative phase ultrasound also has a stimulative effect, although the primary active targets are now the fibroblasts, endothelial cells and myofibroblasts. These are all cells that are normally active during scar production and ultrasound is therefore pro-proliferative in the same way that it is pro-inflammatory. It does not change the normal proliferative phase, but maximises its efficiency, producing the required scar tissue in an optimal fashion (Watson, 2008).

During the remodelling phase, the wound becomes relatively acellular and avascular, collagen content increases and the tensile strength of the wound increases. The mechanical properties of the scar are related to both the amount of collagen present and the arrangement or alignment of the collagen fibres within the repaired tissue. The application of therapeutic ultrasound influences the remodelling scar tissue. It seems to enhance the appropriate orientation of the newly formed collagen fibres and to change the collagen profile, thus increasing tensile strength and enhancing scar mobility (Watson, 2008).

Ultrasound therapy can also be used during wound healing (acute or chronic) and fracture repair. This is achieved by the enhancing of any cellular activity taking place at the affected site. Ultrasound can also be used to achieve pain relief. It is known that ultrasound can accelerate the inflammatory phase of wound healing, leading to a rapid resolution of oedema, and possibly relieving pain caused by it. The reduction of metabolite, toxin and chemical mediators may effectively reduce irritation of nerve endings and hence pain. Ultrasound can be utilised in
combination with specific medication, this will increase the penetration of the compound transdermally. This process is referred to as phonophoresis (Kozanoglu et al., 2003)

2.3.3 Physiological Changes from Ultrasound

According to Bracciano (2008) and Draper et al., (2010) the following physiological changes of the involved tissue can occur:

- An increase in temperature
- An increase in metabolism
- An increase in blood flow
- An increase in tissue permeability
- An increase in viscoelasticity of the connective tissue
- Alteration of nerve conduction velocity, therefore elevating the pain threshold
- Stimulation of the local immune system

2.3.4 Biophysical Effect of Therapeutic Ultrasound

When ultrasound enters the body, it exerts and affects the cells and tissues via two physical mechanisms: thermal and non-thermal. It is important that these mechanisms are understood, as some are stimulatory in their effect on the tissue repair process whereas others are potentially dangerous. The nature of the tissue being treated also affects the effect that therapeutic ultrasound will have on the particular tissue. This is because certain tissues absorb ultrasound better than others (Watson, 2008). In the beginning research on ultrasound focused primarily on its thermal effects. Recently the non-thermal effects of ultrasound have been investigated such as tissue repair, wound healing and the administration of medication phonophoretically (Bracciano, 2008).
When ultrasound travels through tissue a percentage of it is absorbed, this absorption leads to heat being generated within the tissue. The amount of absorption depends upon the nature of the tissue and its degree of vascularisation, and the frequency of the applied ultrasound. Tissues with a high protein content absorb ultrasound more readily and the greater the frequency the greater the absorption rate. A biologically significant thermal effect can be achieved if the temperature of the tissue is raised to between 40 and 45°C for at least 5 minutes. Controlled heating can produce desirable effects, which include pain relief, decrease in joint stiffness and increase in local blood flow (Watson, 2008). Gallo et al (2004) demonstrated that both continuous and pulsed ultrasound interventions generated measurable thermal changes in tissues.

The thermal effects of ultrasound are due to the production of heat and heat dissipation and transfer in the tissue. The production of heat occurs through the oscillation of tissue molecules as a result of the sound waves produced. This causes internal stress, motion and collision of the molecules which convert the sound waves into heat. As soon as there is an appreciable rise in temperature mechanisms for heat dispersion and transfer are activated. Heat dispersion results in vasodilation and shunting of the blood via microcirculatory reflexes. Heat is then conducted through the tissue and is dispersed (Reid, 1992).

Thermal ultrasound has a number of therapeutic physiological effects. These include an increase in the extensibility of collagen rich structures such as tendons, ligaments, fascia and joint capsules. This causes a resultant decrease in joint stiffness. There is a decrease in muscle pain and spasm as well as a decrease in chronic inflammation. The resolution of the inflammation is caused by an
increase in blood flow to the involved area (Watson, 2008). Increased tissue temperatures also cause an increase in the rate of cellular metabolism. This results in an increase in metabolite production, which in turn causes and increase in local blood supply to the tissue. Increased blood supply leads to an increased supply of oxygen and chemical nutrients available to the involved tissue, which then prevents venous stasis from occurring in the area. All of the involved factors lead to an induced relaxation of the muscle tissue (Reid, 1992). The same theory was proved by Lee et al., (1997) and Draper et al., (2010). Therapeutic heat plays an important role when facilitating tissue healing and repair and in certain cases in pain relief. Heat produced through the utilisation of pulsed or continuous modes of ultrasound is important in treating joint stiffness and pain (Draper et al., 2010).

2.3.6 Non-Thermal Effect of Ultrasound

According to Watson (2008), there are many situations were ultrasound produces bioeffects and yet significant temperature change is not involved. The term non-thermal is not strictly true since the absorption of energy in the tissue will cause a rise in temperature. The term relates to the fact that there is no apparent thermal accumulation in the tissue and is sometimes referred to as a microthermal effect.

There is evidence indicating that non-thermal mechanisms play a primary role in producing a therapeutically significant effect. These effects are: Stimulation of tissue regeneration, soft tissue repair, blood flow in chronically ischaemic tissue, protein synthesis and bone repair. The physical mechanism thought to be involved in producing non-thermal effects are one or more of the following: cavitation and acoustic streaming (Watson, 2008).

Cavitations refer to the behaviour of the bubbles within an acoustic field. They are defined as the physical forces of the sound waves on the micro-environmental gases within a fluid. The gases are mainly composed out of oxygen and carbon dioxide. As the sound waves from the ultrasound move through the involved medium, the compression and refraction causes the gas bubbles in the gas to contract and expand. The resulting rapid changes in the pressure in and around the cell are thought to alter the functions of the cells (Martinez, 2010).

Acoustic streaming refers to the unidirectional movement of a fluid in an ultrasound field. High-velocity gradients develop next to boundaries between fluids and structures such as cells, bubbles
and tissue fibres. It can stimulate cell activity if it occurs at the boundary of the cell membrane and the surrounding fluid. The resultant viscous stress on the membrane can alter the membrane’s permeability and second messenger activity. This could result in therapeutically advantageous changes such as increases protein synthesis, increased secretion of mast cells, fibroblast mobility changes, increased uptake of the second messenger calcium and increased production of growth factors by macrophages. All these effects could account for the acceleration of repair following ultrasound therapy (Watson, 2008).

### 2.3.7 Therapeutic Ultrasound Techniques

There are two therapeutic ultrasound techniques that can be used. These techniques are pulsed ultrasound and continuous ultrasound. Based on literature available, the more acute the presentation, the more pulsed the machine output should be. For a very acute condition a 1:4 or 20% duty cycle can be used. If the condition is more subacute the duty cycle should be changed to 1:3 (25%) or 1:2 (33%). If the condition is a chronic lesion, the continuous ultrasound technique should be used. The duty cycle for continuous ultrasound is 1:1 or 100% (Watson, 2008).

### 2.3.8 Ultrasound Dosage and Settings

According to Reid (1992) the following are settings for desired effects:

<table>
<thead>
<tr>
<th>Effect of Ultrasound</th>
<th>Dosage in W/cm²</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stimulation of tissue healing</td>
<td>0.1-1.0</td>
<td>Pulsed mode. Frequency 1 MHz</td>
</tr>
<tr>
<td>Relief of pain and spasm</td>
<td>0.5-1.0</td>
<td>Continuous mode. Used only with a small trigger area or small area of pathology</td>
</tr>
<tr>
<td>Anti-inflammatory action</td>
<td>0.5-1.5</td>
<td>Continuous mode. For trauma after first 24-48 hours</td>
</tr>
<tr>
<td>Haematoma re-absorption</td>
<td>0.5-1.5</td>
<td>Pulsed mode for acute inflammation, continuous mode for subacute or chronic inflammation</td>
</tr>
<tr>
<td>-------------------------</td>
<td>---------</td>
<td>----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Increased plasticity of connective tissue, scars and contractures</td>
<td>1.5-3.0</td>
<td>Continuous mode. Frequency according to depth: 3 MHz is superficial, 1 MHz is deep</td>
</tr>
</tbody>
</table>

A dosage of 1.2 W/cm², pulsed mode, 2 MHz for five minutes was selected. The settings encompassed most of the beneficial effects listed above (Reid, 1992).

### 2.3.9 Depth of Ultrasound Penetration

The depth of the ultrasound output is determined by the set frequency of the ultrasound. The basic principle is that the higher the frequency, the more rapidly the ultrasound energy is attenuated. This leads to a more superficial depth of penetration of the ultrasound energy. The lower the frequency, the slower the ultrasound energy is attenuated, the more energy reaches the deeper tissue. The half value layer is the thickness of tissue that is needed to reduce the intensity of the ultrasound by a factor of two. Muscle’s half value layer for 1 MHz and 3MHz are 1-2cm and 3-6mm respectively. 2 MHz’s half-value layer will be in-between the above mentioned and would be ideal depth to treat an acute cervical facet (Watson, 2008).

### 2.3.10 Methods of Application of Ultrasound

There are two methods of applying ultrasound to a treatment area. The first is the continuous method, where the ultrasound head is continually moved in a stroking or circular pattern over the treatment area. The second is the stationary method, where the ultrasound head is held still over the treatment area. The stationary method causes a rapid rise in tissue temperature, which increases the chance of causing burns due to gaseous cavitations. For this reason the stationary method is not widely used. The continuous method is the more widely used technique, since it causes a more uniform way of heating, thus making it the safer method. The transmission of the ultrasound energy is crucial to maintain adequate treatment. Adequate transmission can be ensured by using the correct coupling medium. These can consist of either mineral oils, gels or water (Frontera, 2007).
2.3.11 Treatment Frequency of Ultrasound

Therapeutic ultrasound is an effective and easy to apply form of treatment. It can be administered every second day for a course of nine to twelve treatment sessions. The treatment can continue as long as there is improvement in the patient’s condition. The amount of time that an area can be treated is determined by the size of the area, the level of heating desired and the frequency and intensity of the ultrasound (Bracciano, 2008). High frequency ultrasound is an effective enhancer of transcutaneous drug delivery and can be safely used for short periods of time (Byle, 1995).

2.4 Phonophoresis

2.4.1 Introduction

Phonophoresis is defined as the migration of drug molecules through the skin under the influence of ultrasound (Watson, 2008). Phonophoresis utilises ultrasound for the transdermal delivery of the topically applied drug (Tiidus, 2008). Phonophoresis has been used in the treatment of many musculoskeletal disorders (Kozanoglu et al., 2003). Phonophoresis allows for active transport, through thermal and non-thermal mechanisms of medication into the underlying target tissue. Phonophoresis is a safe and painless technique and allows for medication to cross the stratus corneum to reach the underlying area (Bracciano, 2008). It is also a transdermal drug delivery system that provides less chance of overdose and of under dose (Byle, 1995).

The goal of phonophoresis is to deliver the medication topically instead of taking the drug systemically, thus increasing the effectiveness of the drug on the target tissue. Transdermal drug delivery has two main advantages over oral medication and injections. When using phonophoresis the drug concentration within the injured area is initially higher than if one took an oral drug. It also prevents the utilisation of the first pass effect, the medication does not have to pass through the gastrointestinal tract and then be digested by the liver (Tiidus, 2008). This non-invasive technique also prevents renal injury (Kozanoglu et al., 2003). Pain and inflammation associated with muscle damage can be effectively treated with phonophoresis as the medication is driven through the skin into the involved tissue by pressure exerted from the ultrasound beam (Tiidus, 2008).
2.4.2 Phonophoresis Mechanism of Action

The permeability of the stratum corneum appears to be amplified when utilising ultrasound but more precisely when using thermal ultrasound. The medication will diffuse from a higher concentration across the stratum corneum to a lower concentration because of the higher concentration and the increased pressure gradient under the transducer of the ultrasound head (Bracciano, 2008). Ultrasound results in the mechanical interruption of the absorbing medium. The thermal change that occurs during ultrasound treatment is thought to facilitate the phonophoretic drug delivery (Radomski and Latham, 2008). Thermal and non-thermal characteristics of ultrasound both play a very vital role when treating the involved area, they both increase the permeability of the cells to the medication being used (Tiidus, 2008).

2.4.3 Phonophoresis Variables

The factors that influence phonophoresis effectiveness are ultrasound frequency, ultrasound intensity, the time that the area is exposed and the skin site itself. The frequency of ultrasound is the physical inconstant, which is associated to the effects of the ultrasonic energy. When a deeper penetration and an increased spread of ultrasonic energy are required a lower frequency is designated (Jain, 2008). The favoured range of frequency for phonophoresis is from 0.5 to 1.5 MHz. The intensity of the ultrasound is the rate at which energy is absorbed per unit area. When connected to phonophoresis optimum intensity varies from 0 to 3 W/cm² (Tyle and Agrawala, 1989). The exposure time that the skin is irradiated by ultrasound can affect phonophoresis. A minimum exposure of five minutes should occur, but a significant response may occur within two minutes of exposure (Jain, 2008). The thickness and permeability of the skin site can in turn affect all the treatment variable such as frequency, intensity and exposure time (Tiidus, 2008).

The coupling agent plays an important role in transferring the ultrasonic energy between the ultrasound source and the skin. A good coupling agent should have an absorption coefficient similar to that of water. In order for the coupling agent to maintain contact between the ultrasound source and the skin, it should retain a paste or gel consistency at body temperature. Examples of the agents are mixtures of mineral oil and glycerine, cream and aqua-sonic gel. The coupling agent may also serve as a drug carrier (Jain, 2008). Cameron and Monroe (1992) proved that plain ultrasound gel has transmitting capabilities of 96%.
Table 2.2: Coupling Agent Transmission (Cameron and Monroe, 1992)

<table>
<thead>
<tr>
<th>Transmission relative to water</th>
<th>Products that transmit ultrasound well</th>
</tr>
</thead>
<tbody>
<tr>
<td>96%</td>
<td>Standard Ultrasound Gel</td>
</tr>
<tr>
<td>97%</td>
<td>Mineral Oil</td>
</tr>
<tr>
<td>90%</td>
<td>Ultrasound Lotion</td>
</tr>
<tr>
<td><strong>Products that transmit ultrasound poorly</strong></td>
<td></td>
</tr>
<tr>
<td>29%</td>
<td>Hydrocortisone Powder Dissolved in 1% of Ultrasound Gel</td>
</tr>
<tr>
<td><strong>Products that have zero transmission</strong></td>
<td></td>
</tr>
<tr>
<td>0%</td>
<td>Hydrocortisone Cream</td>
</tr>
<tr>
<td>0%</td>
<td>White Petroleum</td>
</tr>
</tbody>
</table>

2.4.4 Factors Affecting Transdermal Delivery

According to Tiidus (2008) and Byle (1995), there are a number of factors with regard to the medication being employed that will determine the success of phonophoresis. These are the amount and concentration of the medication being used, the rate of delivery to the involved area, the depth of penetration of the medication and the anatomical area being treated.

The anatomical structure of the skin is also an important factor to take into account. The thickness and blood flow of the skin also play a role. According to Tiidus (2008) there are four main points of entry that allow for transdermal drug delivery. These are the erector pili muscle, hair follicles, sweat glands and sebaceous glands. The stratum corneum also needs to be hydrated for effective transmission of the drug. The stratum corneum serves as a rate restrictive barrier to noxious substances into the skin. Due to the mechanical effects that ultrasound has on the skin, it thus has the capabilities of changing the permeability of the stratum corneum and varying the porous pathway to allow diffusion of the drug into the skin (Tiidus, 2008). According to Byle (1995) ultrasound has the ability to increase drug absorption, by altering the intercellular structure between the corneocytes of the skin. As soon as the medication has gone through the skin barriers it is distributed to adjacent tissue through diffusion, once again the medication moves from a higher concentration to an area that has a lower concentration. The medication then saturates the dermis and is then absorbed into the local capillary network to be conveyed into the blood stream (Tiidus,
2008). Any transcutaneous medications will enter the skin, permeate the vascular system and will have some systemic effect (Byle, 1995).

2.4.5 Validity of Phonophoresis

According to Tiidus (2008) drawing suppositions on the validity of phonophoresis have been made problematic due to numerous papers on phonophoresis that have failed to include details about the research parameters. Byle (1995) tested the effects of drug delivery by phonophoresis and concluded that ultrasound effectively improved local and systemic drug delivery.

During a study where patients suffered from a painful shoulder syndrome, they were treated utilising phonophoresis and diclofenac gel. At the conclusion of the study the treatment was found to be highly effective. In a different study they also determined that the phonophoresis enhanced the dispersion of ibuprofen into deeper tissues (Kozanoglu et al., 2003). Merrick (2000) concluded that the literature strongly suggests that phonophoresis increases drug transmission across the skin barrier and might lead to improved patient outcomes.

In 1998 Klaiman and colleagues treated 49 patients with a variety of muscle injuries with 1 MHz of ultrasound at 1.5 W/cm² for 8 minutes. They then compared the effects of the ultrasound treatment with fluocinonide gel and ultrasound alone. They assessed the patient’s pain according to the visual analogue scale and pressure algometer readings. They concluded that the fluocinonide gel improved all the muscle injuries. In 1986 Smith and colleagues conducted a study using phonophoresis in the treatment of pain. They reported successful reduction in pain with 1 MHz of ultrasound at 1.5 W/cm² for 5 minutes (Tiidus, 2008).

2.5 Methylsulfonylmethane (MSM)

2.5.1 Introduction

MSM (Methylsulfonylmethane) is an organosulfur compound with the formula (CH₃)₂SO₂. It is also known by several names including DMSO₂, methyl sulfone and dimethyl sulfone. It is a colorless pure crystalline powder and is considered relatively inert chemically (Jacob et al., 1999). It is a naturally occurring nutrient found in some primitive plants and is present in small amounts in many...
foods, beverages and is marketed as a dietary supplement (Total Health, 1998; Williams, 1997; Jacob and Appleton, 2002).

Dimethyl sulfoxide ((CH₃)₂SO, DMSO), is a natural organic form of sulfur. It is a water soluble compound that has a strong and bitter taste and is absorbed rapidly through the skin. DMSO not only tastes bitter but can sometimes cause skin irritation. Oxidation of DMSO produces MSM. MSM is not only more stable but has the same properties as DMSO without any of the negative qualities. MSM in 99% soluble in water and is used as a high-temperature solvent for both organic and inorganic substances. It is used as a medium in organic synthesis. MSM is an important dietary source of sulfur for the human body (Herschler, 1985).

MSM is available in many forms. It can be found in combination with chondroitin and glucosamine as in a joint supplementation. MSM can be found in capsules on its own as its pure crystalline form. The crystalline powder can also be bought on its own and may be combined in a rub with arnica. When MSM is combined with a solvent like water, it will only hold 25% of its own weight in this combination. This means that there is only 25% of MSM in these liquid combinations. Nonetheless, this liquid, cream or gel mixture will itself penetrate through the skin and carry other ingredients with it (Jacob and Herschel, 1983).

2.5.2 Clinical Use of MSM

Sulfur is a structural part of connective tissue, hair, skin, nails and joint cartilage. Therefore sulphur depletion will affect all the above mentioned. MSM is seen as safe, side effect free remedy for many types of pain and inflammatory conditions. According to Jacob et al (1999) is can relieve the following pain conditions:

- Degenerative arthritis
- Chronic back pain
- Chronic headache
- Muscle pain
- Fibromyalgia
- Tendinitis and bursitis
- Carpal tunnel syndrome
- TMJ syndrome
- Post traumatic pain and inflammation

MSM reduces pain, inflammation and swelling, consequently allowing for increased range of motion (Lovelock, 1972). According to Jacob et al (1999), the way that MSM impacts pain is explained by the following mechanisms:

- MSM is a natural analgesic in that it blocks the transfer of pain impulses through pain sensitive C-fibres
- MSM down regulates inflammation and inflammatory processes
- MSM enhances the activity of cortisol, which is a natural anti-inflammatory hormone produced by the body
- MSM increases the permeability of cell membranes, which improves the uptake of nutrients and vitamins and excretes waste products and excess cellular fluids
- MSM enhances blood circulation by dilating local blood vessels. This will also excrete waste product which allows for quicker healing
- MSM is a muscle relaxant
- MSM regulates prostaglandin metabolism, which can help regulate the formation of antibodies and immune complexes

Studies of Lignisul MSM in tablet form in conjunction with chiropractic treatment, ultrasound treatment and muscle stimulation had shown that patients using Lignisul MSM had 40% fewer visits to the practitioner’s office, than those that used the placebo tablet (Ronald et al, 2010). Another study of MSM and glucosamine showed a reduction in pain and swelling in addition to improving the functional ability of the patients (Usha et al., 2004)

MSM may also be used as a supplement for allergies, asthma, auto-immune diseases, diabetes, constipation and skin disorders (Mindell, 1997).

### 2.5.3 MSM Mechanism of Action with Inflammation and Pain

Approximately half of the total body sulfur is concentrated in the muscles, skin and bones. When rigid fibrous tissue cells swell and become inflamed, pressure and pain will result. Since MSM can
restore the flexibility and permeability of cells, excess fluid can pass through the tissues more readily. This will help to equalise the pressure within the cell and will therefore decrease the inflammation and pain caused by it. Toxic by-products that build-up like lactic acid can then flow out of the cell. Nutrients on the other hand are allowed to enter the cells. Theodosakis et al (2006) found a strong trend for MSM to reduce mRNA expression of inflammatory markers; this reduces the expression of inflammatory cytokines, thus reducing inflammation. MSM has also shown the ability to reduce muscle stiffness, soreness and cramps both in athletes and geriatric patients (Total Health, 1998).

The following study was done on DMSO but since MSM has the same properties as DMSO, the information gained through the study may be applied to MSM. DMSO is readily absorbed through the skin and relieves musculoskeletal pain when applied topically to pain full areas. The study parameters were to study the effect that DMSO has on C-type nerve fibres, which mediate pain sensation, to exposed cat sural nerves. The experiment suggested that DMSO can be used as an effective topical analgesic. The experiment also proved that DMSO selectively affects somatic C-fibres leading to a selective analgesia and loss of temperature sensation rather than complete anaesthesia. This would mean that DMSO abolishes deep aching pains, which is often found in musculoskeletal injuries. The mechanism through which DMSO reduces C-fibre conduction is unclear. It is on the underhand fast reversible and stable. The conduction velocity reduction may be caused by the effects that DMSO has on potassium channels. One possibility is that persistent membrane depolarisation could facilitate sodium channel inactivation, which in turn slows the action potential generation. A second possibility is that an increase in membrane resistance due to blockage of the potassium channels might affect the conduction velocity of the nerves (Evans et al., 1992).

2.5.4 Safety of MSM

No known serious or adverse effects have been reported. MSM can be safely taken with NSAIDs and is often combined with glucosamine, chondroitin and vitamins (Jacob and Appleton, 2003). MSM ranks in the “extremely low” toxicity category. The lethal dose of MSM for mice is 20 grams per kilogram body weight. This would mean that the average lethal dose for humans is more than one and a half kilograms. MSM does not fall under sulfites and sulfa drugs, which can cause allergic reactions (Jacob, 1983).
CHAPTER THREE: METHODOLOGY

3.1 Introduction

This chapter serves to elaborate on the construction of this study and the procedures involved.

3.2 Study Design

This study was a double-blinded, comparative study that compared the outcomes and efficacy of the two treatment regimens.

3.3 Participant Recruitment

Any candidate who met the inclusion criteria and presented with an acute cervical facet syndrome to the University of Johannesburg Chiropractic Day Clinic was given the opportunity to volunteer to be a potential candidate for the study. Candidates were recruited via word of mouth and posters that were placed throughout the University of Johannesburg, Doornfontein campus (Appendix A). The agreeable participant was then briefly screened through a case history (Appendix I), a physical examination (Appendix J) and a cervical spine regional examination (Appendix K), which was performed at the first consultation to determine their suitability for the study.

3.4 Sample Selection and Size

Thirty participants between the ages of eighteen and thirty were recruited to participate in the study. Suitable participants drew papers labelled A or B out of a container which randomly divided the participants into two groups of fifteen participants each. Equal male and female numbers were guaranteed by keeping only a limited amount of spaces open for each gender in both groups.

3.4.1 Inclusion Criteria

- Participants could have been male or female
- Participants must have been between the ages of 18 to 30 years of age
- Participant must have presented with an acute cervical facet syndrome. It presents as pain on a facet joint challenge or Kemps test. Neck pain with referred symptoms may have
been present, however no radicular symptoms indicating nerve root involvement could have been present (Wyatt, 2004)

3.4.2 Exclusion Criteria

- Participants who presented with any contra-indications to ultrasound therapy (Appendix C)
- Participants who presented with any contra-indications to MSM or ultrasound gel (Appendix D)
- Participants who presented with any pre-existing condition that may have affected the acute facet syndrome in the cervical spine, namely surgery
- Participants who had received any other form of treatment outside the study for the duration of the study that could have interfered with the results of this study
- Participants who had used any form of analgesics, anti-inflammatory or muscle relaxant medications

3.5 Group Randomisation

The participants were randomly divided into two groups by drawing papers labelled A or B out of a container. Neither the participants nor the researcher was informed as to which group they were placed in until the end of the study. Both the MSM incorporated into ultrasound gel and the standard ultrasound gel were contained within opaque bottles marked either A or B. Since MSM is both colourless and scentless, the gel itself could not be distinguished from standard ultrasound gel. Only at the end of the trials was the identity of the groups and bottles made known to the researcher. Group A received ultrasound therapy with MSM incorporated into the ultrasound gel, over the acute cervical facet. Group B received ultrasound therapy with ultrasound gel over the acute cervical facet.

3.6 Treatment Approach

3.6.1 First visit

- Signing of an Information and consent form (Appendix B)
- Participants underwent a detailed case history
Participants underwent a physical examination
Participants underwent a cervical spine regional examination
Participants were requested, prior to treatment, to complete a Numerical Pain Rating Scale (NPRS) in order to evaluate pain or discomfort levels (Appendix F)
Before treatment, the full cervical spine range of motion was measured using a Cervical Range of Motion Measuring Instrument (CROM) (Appendix G)
Before the treatment the sensitivity of the acute cervical facet syndrome was assessed using a Pressure Algometer (Appendix H)

3.6.2 Follow-Up Visits

The objective and subjective data was collected at the beginning of the 4th and 7th sessions
Participants went through a chiropractic assessment and completion of clinical assessment notes prior to the treatment
Treatments were applied according to the participant’s allocated group. The final (7th) consultation was used for data collection alone
A total of 6 treatments (including the first visit) took place over a three week period

3.6.3 Treatments

All participants received two ultrasound consultations per week over a three week period
All participants in group A and group B received ultrasound treatment utilising the Dynatron 850 Plus machine
Dynatron 850 Plus ultrasound machine was set at 3MHz at 1.2 W/cm² for a period of 10 minutes in total. Five minutes on the left and five minutes on the right hand side. These ultrasound settings are in line with normal treatment settings for an acute inflammatory condition (Carnes and Vizniak, 2010)
Participants were seated facing away from the researcher and machine, with their necks and shoulders exposed
All participants in group A received ultrasound therapy utilising ultrasound gel from bottle A. The gel inside bottle A was placed over the acute cervical facet on the right and the left hand side
• All the participants in group B received ultrasound therapy utilising ultrasound gel from bottle B. The gel inside bottle B was placed over the acute cervical facet on the right and left hand side.

• The ultrasound head was placed over the gel and moved in a circular motion over the acute facet, for a period of five minutes. The treatment was then repeated on the non-acute side. This was due to Kirkaldy-Willis’s three joint complex. The functional unit of the complex consists of two adjacent vertebrae’s facet joints and the intervertebral disc. The three joint complex states that if one joint is dysfunctional, it will lead to dysfunctional changes within the other two joints. Thus to allow for optimal range of motion improvements during this study both facet joints were treated.

3.7 MSM Mixing Protocols

The MSM used for this study was in a 100% pure crystalline form. The MSM and ultrasound gel mixture was mixed at Medipost Pharmacy by a pharmacist, Gerda Potgieter (B Pharm). 75 grams of MSM was mixed within 300 grams of ultrasound gel.

The weighing of the MSM and the ultrasound gel was done on a Vibra A.J. by Shinko Denshi Co limited. The scale is accurate to a hundredth of a gram.

To ensure that this study was a double-blinded study, the pharmacist used opaque bottles wrapped with silver duct tape which was either marked A or B. MSM is both colourless and scentless and has the appearance of standard ultrasound. The researcher was not informed which bottle (A or B) contained the MSM ultrasound mixture.

3.8 Subjective Data

Numerical Pain Rating Scale

The participants were subjectively evaluated by completing a NPRS (Appendix F). This questionnaire was completed at the first, fourth and seventh visits. The participants were asked to indicate the level of pain experienced at that moment on a scale from 0 to 10. 0 indicates no pain whereas 10 indicate worst pain ever felt (Mc Dowell and Newell, 1996). According to Williamson and Hoggart (2004), the NPRS is reliable, valid and appropriate for use in clinical practice. The
NPRS was answered by participants before the first, fourth and during the seventh visits. None of the participants were told his/her scores following completion of the questionnaire, nor were they shown the scores from previously completed questionnaires.

3.9 Objective Data

Pressure Algometer

The Algometer is reliable, valid and measures the “pressure threshold” experienced by the participants (Ylinen, 2007). The Algometer is widely accepted for clinical use as a quantitative measure of pressure pain threshold (Charlton, 2005). Pressure threshold measures the pressure pain sensitivity of tender areas. It is the minimum pressure that causes pain (Rachlin, 1994). The Algometer is a force gauge, spring operated plunger calibrated in kg/cm² fitted with a rubber disc of 1cm² surface. Algometer readings were measured only on the acute cervical facet’s side. The Algometer was placed over the acute cervical facet at a 90 degree angle to the skin. Pressure was then applied downwards until the participant indicated that the pressure was causing pain. The Algometer was removed and a reading in kg/cm² was taken and recorded (Appendix H). Measurements were taken with the Algometer before the first, fourth and during the seventh visits. None of the participants were told their measurements following completion, nor were they shown the measurements from previous visits.

Cervical Range of Motion Measuring Instrument (CROM)

The CROM was used to assess cervical spine ranges of motion in active flexion, extension, lateral flexion and rotation (Appendix G). The CROM has been shown to have some of the best ratings on clinometric aspects such as reproducibility, responsiveness and validity (de Koning et al., 2008). The CROM is a reproducible method for assessing changes in mobility after treatment (Palmer and Epler, 1998). The CROM measures three degrees of movement: flexion and extension are measured in the sagittal plane, right and left lateral flexion are measured in the coronal plane and right and left rotation are measured in the transverse plane.

The CROM was strapped to the participant’s head. The participants were asked to place their head in a neutral position and the CROM dial was checked that the neutral position was at 0 degrees of movement. From the neutral position, the participants slowly flexed as far as possible then
returned to neutral. The same procedure was repeated for extension, bilateral lateral flexion and bilateral rotation. At the end of each movement, the participant was asked to return to the neutral position. Three measurements were taken at the end range for each movement and averaged to obtain the mean measurement for that range of movement. Measurements were taken with the CROM before the first, fourth and during the seventh visits. None of the participants were told their measurements following completion, nor were they shown the measurements from previous visits.

### 3.10 Data Analysis

The data was collected by the researcher after which analysis was done with the help of a statistician. The results were based on the subjective and objective measurements gathered during the study. After consultation with Ms Juliana van Staden from STATKON, it was concluded that the results were analysed using the Shapiro-Wilk test for normality and Levene's test for equal variances. Parametric tests revealed that normality and equal variances were not present, due to the small sample size of the study. Subsequently, the non-parametric Wilcoxon signed ranks and Friedman tests were performed to compare intra-group results and the Mann-Whitney U test was done to compare inter-group results.

### 3.11 Ethical Considerations

All participants that wished to partake in this particular study were requested to read and sign the information and consent form specific to this study. The information and consent form outlined the names of the researcher, purpose of the study and benefits of partaking in the study, participant assessment and treatment procedure. Any risks, benefits and discomforts pertaining to the treatments involved were explained and that the participant’s safety would be ensured (prevention of harm). The information and consent form were also explained that the participant’s privacy was protected as only the doctor, patient and clinician would be in the treatment room and that anonymity would be ensured as the patient information would be converted into data and therefore cannot be traced back to the individual. The form also stated that standard doctor/patient confidentiality would be adhered to at all times when compiling the research dissertation. The participants were informed that their participation was on a voluntary basis and that they were free to withdraw from the study at any stage without prejudice. Should the participant have had any further questions, those would have been explained by the researcher, whose contact details were
made available. The participants were then required to sign the information and consent form, signifying that they understood all that was required of them for this particular study.

With regards to this particular study, possible post ultrasound muscle stiffness could have occurred which should have settle within a few days at the most. If these symptoms persisted the treatment would have been stopped and the patient would have been referred to the appropriate health professional. Benefits from treatment may have involved complete or partial, permanent or temporary relief of pain and an increase in cervical range of motion.

Results of this study were made available on request.
CHAPTER FOUR-RESULTS

4.1 Introduction

The findings obtained from the study are presented in this chapter. The sample group consisted of thirty participants that were divided into Group A and Group B. Group A represents the fifteen participants treated with MSM incorporated into ultrasound gel utilising phonophoresis. Group B represents the control group, of fifteen participants treated with standard ultrasound gel. The statistical results only represent a small group of subjects and therefore no assumptions can be made with respect to the population as a whole.

The p-value for the tests was set at 0.05 and represented the level of significance of the results. If the p-value was less than or equal to 0.05 (p ≤ 0.05) there was a statistically significant finding. If the p-value was greater than 0.05 (p ≥ 0.05) there was no statistically significant finding. Statistical significance means that a given result is unlikely to have occurred by chance.

The analyses included:

1. Demographic data analysis consisting of the gender and age of the participants.
2. Subjective measurements consisting of the Numerical Pain Rating Scale.
3. Objective measurements consisting of Pressure Algometer readings and cervical range of motion measuring instrument (CROM), which included flexion, extension, left and right lateral flexion and left and right rotation.
4.2 Demographic Data Analysis

The population group of this study consisted of sixteen female and fourteen male participants (n=30). Group A consisted of fifteen participants (n=15); eight females and seven males. Group B also consisted of fifteen participants (n=15); also eight females and seven males. The mean age of group A was 24.67 years and of group B was 24.07 years, making the total population mean 24.37 years.

Table 4.1: Comparison of Demographic Data Between Groups

<table>
<thead>
<tr>
<th>Data</th>
<th>Group A</th>
<th>Group B</th>
<th>Combined total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age distribution (Years)</td>
<td>22.29</td>
<td>19.27</td>
<td>19.29</td>
</tr>
<tr>
<td>Mean age (Years)</td>
<td>24.67</td>
<td>24.07</td>
<td>24.37</td>
</tr>
<tr>
<td>Gender distribution</td>
<td>8 Females</td>
<td>8 Females</td>
<td>16 Females</td>
</tr>
<tr>
<td></td>
<td>7 Males</td>
<td>7 Males</td>
<td>14 Males</td>
</tr>
</tbody>
</table>

4.2.1 Demographic Algometer Data

All Pressure Algometer readings were only taken on the side of the acute facet. Group A had 3 participants who presented with an acute facet on the left side and 12 on right side. Group B had 8 participants who presented with an acute facet on the left side and 7 on the right side.

Table 4.2: Comparison of Algometer Data Distribution

<table>
<thead>
<tr>
<th></th>
<th>Left Side Acute Facet</th>
<th>Right Side Acute Facet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A (MSM in U/S)</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Group B (Standard U/S)</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>
4.3 Subjective Data Analysis

4.3.1 Evaluation of Numerical Pain Rating Scale Readings (NPRS)

The Shapiro-Wilk test, that tests for normality was inconclusive. Therefore the non-parametric Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The non-parametric Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

Intragroup Analysis: Group A Numerical pain Rating Scale Readings

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time ($p=0.001$).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment ($p=0.008$) and for the 4th treatment to the 7th treatment ($p=0.001$).

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.008</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Table 4.3: Test of Within-Subjects Contrasts Group A

Intragroup Analysis: Group B Numerical Pain Rating Scale Readings

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time ($p=0.001$).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment ($p=0.000$) and for the 4th treatment to the 7th treatment ($p=0.001$).
Table 4.4: Tests of Within-Subjects Contrasts Group B

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-values</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.000</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T test, that tests for normality were inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on the numerical pain rating scale.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \(p=0.396\), the 4th visit \(p=0.396\) and the 7th visit \(p=0.135\). This means that the groups started out comparable and that they remained like that throughout the study with no significant difference in improvement between them.

Table 4.5: Tests of Between-Subject Effects of NPRS

<table>
<thead>
<tr>
<th>P-values</th>
<th>1st Visit</th>
<th>4th Visit</th>
<th>7th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.396</td>
<td>0.396</td>
<td>0.135</td>
</tr>
</tbody>
</table>

Clinical Interpretation of Median NPRS Values

The NPRS results on the first visit, group A and Group B had median values of 5.27 and 4.8 for numerical pain rating scale measurements respectively. On the fourth visit group A and group B had median values of 3.87 and 3.33 respectively. On the seventh visit group A and group B had median values of 1.4 and 2 respectively.
The median difference between the 1st and 4th visit for group A and group B was 1.4 and 1.47 resulting in a median percentage improvement of 27% and 31% consecutively. The median difference between the 4th and 7th visit for group A and group B was 2.47 and 1.33 resulting in a median percentage improvement of 64% and 40% consecutively. At the end of the study group A had a median difference of 3.87 and a median percentage improvement of 73%. Group B had a median difference of 2.8 and a median percentage improvement of 58%.
Table 4.6: NPRS Median Values.

<table>
<thead>
<tr>
<th>Group A</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM in U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>5.27</td>
<td>1.4</td>
<td>27%</td>
</tr>
<tr>
<td></td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>3.87</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>4.8</td>
<td>1.47</td>
<td>31%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>3.33</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>3.87</td>
<td>2.47</td>
<td>64%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>3.33</td>
<td>1.33</td>
<td>40%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>5.27</td>
<td>3.87</td>
<td>73%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>4.8</td>
<td>2.8</td>
<td>58%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.4 Objective Data Analysis

4.4.1 Evaluation of Pressure Algometer Readings

The Shapiro-Wilk test, that tests for normality was inconclusive, therefore the Friedman Test was used to determine intragroup results between the 1<sup>st</sup> and 7<sup>th</sup> treatment. The Wilcoxon Signed Rank Test was used to determine intragroup results between the 1<sup>st</sup> and 4<sup>th</sup> and the 4<sup>th</sup> and the 7<sup>th</sup> treatment. All pressure algometer readings were only taken on the side of the acute facet.

Intragroup Analysis: Group A Algometer Readings

The Friedman test was used to compare group A’s 1<sup>st</sup> treatment to the 7<sup>th</sup> treatment. The results indicated that group A demonstrated a statistically significant improvement over time (p=0.001).
The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment (p=0.001) and for the 4th treatment to the 7th treatment (p=0.001).

**Table 4.7: Tests of Within-Subjects Contrasts Group A**

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Intragroup Analysis: Group B Algometer Readings**

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time (p=0.001).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment (p=0.001) and for the 4th treatment to the 7th treatment (p=0.001).

**Table 4.8: Tests of Within-Subjects Contrasts Group B**

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Intergroup Analysis**

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on the pressure algometer readings over the acute facet.
The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1\textsuperscript{st} visit \((p=0.916)\), the 4\textsuperscript{th} visit \((p=0.802)\) and the 7\textsuperscript{th} visit \((p=0.533)\). This means that the groups started out comparable and that they remained like that throughout the study.

**Table 4.9: Tests of Between-Subject Effects of Right side Algometer**

<table>
<thead>
<tr>
<th>P-values</th>
<th>1\textsuperscript{st} Visit</th>
<th>4\textsuperscript{th} Visit</th>
<th>7\textsuperscript{th} Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.916</td>
<td>0.802</td>
<td>0.533</td>
</tr>
</tbody>
</table>

**Clinical Interpretation of Pressure Algometer Measurements Median Values**

On the first visit group A and group B had median values of 2.5 kg/cm\(^2\) and 2.1 kg/cm\(^2\) respectively for the algometer measurements. On the fourth visit group A and group B had median values of 3 kg/cm\(^2\) and 2.5 kg/cm\(^2\) respectively. On the seventh visit group A and group B had median values of 3.9 kg/cm\(^2\) and 3.4 kg/cm\(^2\) respectively.

![Graph of Pressure Algometer Median Values](image)

**Figure 4.2: Pressure Algometer Median Values on the 1\textsuperscript{st}, 4\textsuperscript{th} and 7\textsuperscript{th} visits**

The median difference between the 1\textsuperscript{st} and 4\textsuperscript{th} visit for group A and group B was 0.5 and 0.4 resulting in a median percentage improvement of 20% and 19% consecutively. The median difference between the 4\textsuperscript{th} and 7\textsuperscript{th} visit for group A and group B was 0.9 and 0.9 resulting in a
median percentage improvement of 30% and 36% consecutively. At the end of the study group A had a median difference of 1.4 kg/cm² and a median percentage improvement of 56%. Group B had a median difference of 1.3 kg/cm² and a median percentage improvement of 62%.

### Table 4.10: Pressure Algometer Median Values.

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>1st</td>
<td>2.5</td>
<td>0.5</td>
<td>20%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>4th</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st</td>
<td>2.1</td>
<td>0.4</td>
<td>19%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4th</td>
<td>2.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4th</td>
<td>3</td>
<td>0.9</td>
<td>30%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4th</td>
<td>2.5</td>
<td>0.9</td>
<td>36%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1st</td>
<td>2.5</td>
<td>1.4</td>
<td>56%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th</td>
<td>3.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st</td>
<td>2.1</td>
<td>1.3</td>
<td>62%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th</td>
<td>3.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 4.4.2 Evaluation of Cervical Spine range of Motion Readings

The Shapiro-Wilk test, which tests for normality within intragroup results, was inconclusive with all the cervical ranges of motion. Therefore the non-parametric Friedman Test was used to determine intragroup results between the 1st and 7th treatment. The non-parametric Wilcoxon Signed Rank Test was used to determine intragroup results between the 1st and 4th and the 4th and the 7th treatment.

**Intragroup Analysis: Group A Cervical Forward Flexion Range of Motion**

The Friedman test was used to compare group A's 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time (p=0.001).
The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \((p=0.093)\) and for the 4th treatment to the 7th treatment \((p=0.001)\).

**Table 4.11: Tests of Within-Subjects Contrasts Group A**

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.093</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Intragroup Analysis: Group B Cervical Flexion Range of Motion**

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time \((p=0.001)\). The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \((p=0.002)\) and for the 4th treatment to the 7th treatment \((p=0.001)\).

**Table 4.12: Tests of Within-Subjects Contrasts Group B**

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.002</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Intergroup Analysis**

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical spine flexion range of motion.
The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \( (p=0.370) \), the 4th visit \( (p=0.318) \) and the 7th visit \( (p=0.835) \). This means that the groups started out comparable and that they remained like that throughout the study.

<table>
<thead>
<tr>
<th>Table 4.13: Tests of Between-Subject Effects of Cervical Spine Flexion</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P-values</strong></td>
</tr>
<tr>
<td>-------------</td>
</tr>
<tr>
<td>P-values</td>
</tr>
</tbody>
</table>

**Clinical Interpretation of Median Cervical Spine Flexion Measurements Values**

On the first visit group A and group B had median values of 64.2° and 66° respectively for cervical spine flexion measurements. On the fourth visit group A and group B had median values of 66.47° and 68.93° respectively. On the seventh visit group A and group B had median values of 72.93° and 72.2° respectively.

![Figure 4.3: CROM Flexion Median Values on the 1st, 4th and 7th visits](image)

The median difference between the 1st and 4th visit for group A and group B was 2.27° and 2.93° resulting in a median percentage improvement of 3.5% and 4.4% consecutively. The median difference between the 4th and 7th visit for group A and group B was 6.46° and 3.27° resulting in a
median percentage improvement of 9.7% and 4.7% consecutively. At the end of the study group A had a median difference of 8.73° and a median percentage improvement of 13.6%. Group B had a median difference of 6.2° and a median percentage improvement of 9.4%.

Table 4.14: CROM Flexion Median Values

<table>
<thead>
<tr>
<th></th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Group A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>1st</td>
<td>64.2°</td>
<td>2.27°</td>
<td>3.5%</td>
</tr>
<tr>
<td></td>
<td>4th</td>
<td>66.47°</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard U/S</td>
<td>1st</td>
<td>66°</td>
<td>2.93°</td>
<td>4.4%</td>
</tr>
<tr>
<td></td>
<td>4th</td>
<td>68.93°</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group A</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>4th</td>
<td>66.47°</td>
<td>6.46°</td>
<td>9.7%</td>
</tr>
<tr>
<td></td>
<td>7th</td>
<td>72.93°</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Group B</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4th</td>
<td>68.93°</td>
<td>3.27°</td>
<td>4.7%</td>
</tr>
<tr>
<td></td>
<td>7th</td>
<td>72.2°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Intragroup Analysis: Group A Cervical Extension Range of Motion**

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time \( p=0.004 \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \( p=0.006 \) and for the 4th treatment to the 7th treatment \( p=0.001 \).
Table 4.15: Tests of Within-Subjects Contrasts Group A

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.004</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.006</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Intragroup Analysis: Group B Cervical Extension Range of Motion

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time \( p=0.001 \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \( p=0.008 \) and for the 4th treatment to the 7th treatment \( p=0.003 \).

Table 4.16: Tests of Within-Subjects Contrasts Group B

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.008</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.003</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical extension range of motion.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \( p=0.618 \), the 4th visit \( p=0.129 \) and the 7th visit \( p=0.026 \). This means that the groups started out comparable and that they remained like that throughout the study.
Table 4.17: Tests of Between-Subject Effects of Cervical Spine Extension

<table>
<thead>
<tr>
<th>P-values</th>
<th>1st Visit</th>
<th>4th Visit</th>
<th>7th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.618</td>
<td>0.129</td>
<td>0.026</td>
</tr>
</tbody>
</table>

Clinical Interpretation of Median Cervical Spine Extension Measurements Values

On the first visit group A and group B had median values of 57.33° and 55.13° respectively for cervical spine extension measurements. On the fourth visit group A and group B had median values of 63.27° and 57.13° respectively. On the seventh visit group A and group B had median values of 68.47° and 60.6° respectively.

Figure 4.4: CROM Extension Median Values on the 1st, 4th and 7th visits

The median difference between the 1st and 4th visit for group A and group B was 5.94° and 2° resulting in a median percentage improvement of 10.36% and 3.62% consecutively. The median difference between the 4th and 7th visit for group A and group B was 5.2° and 3.47° resulting in a median percentage improvement of 8.2% and 6.1% consecutively. At the end of the study group A had a median difference of 9.14° and a median percentage improvement of 16%. Group B had a median difference of 5.57° and a median percentage improvement of 10.1%.
**Table 4.18: CROM Extension Median Values**

<table>
<thead>
<tr>
<th>Group A</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM in U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>57.33°</td>
<td>5.94°</td>
<td>10.4%</td>
</tr>
<tr>
<td></td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>63.27°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>55.13°</td>
<td>2°</td>
<td>3.6%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>57.13°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>63.27°</td>
<td>5.2°</td>
<td>8.2%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>68.47°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>57.13°</td>
<td>3.47°</td>
<td>6.1%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>60.6°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>57.33°</td>
<td>9.14°</td>
<td>16%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>68.47°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>55.13°</td>
<td>5.57°</td>
<td>10.1%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>60.6°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intragroup Analysis: Group A Cervical Left Lateral Flexion Range of Motion

The Friedman test was used to compare group A’s 1<sup>st</sup> treatment to the 7<sup>th</sup> treatment. The results indicated that group A demonstrated a statistically significant improvement over time \(p=0.001\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1<sup>st</sup> treatment to the 4<sup>th</sup> treatment \(p=0.014\) and for the 4<sup>th</sup> treatment to the 7<sup>th</sup> treatment \(p=0.001\).

**Table 4.19: Test of Within-subjects contrasts Group A**

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Treatment - 7&lt;sup&gt;th&lt;/sup&gt; Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1&lt;sup&gt;st&lt;/sup&gt; Treatment - 4&lt;sup&gt;th&lt;/sup&gt; Treatment</td>
<td>0.014</td>
</tr>
<tr>
<td>4&lt;sup&gt;th&lt;/sup&gt; Treatment - 7&lt;sup&gt;th&lt;/sup&gt; Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Intragroup Analysis: Group B Cervical Left Lateral Flexion Range of Motion

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time \( p=0.001 \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \( p=0.028 \) and for the 4th treatment to the 7th treatment \( p=0.001 \).

Table 4.20: Tests of Within-Subjects Contrasts Group B

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.028</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical left lateral flexion range of motion.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \( p=0.544 \), the 4th visit \( p=1.000 \) and the 7th visit \( p=0.270 \). This means that the groups started out comparable and that they remained like that throughout the study.

Table 4.21: Tests of Between-Subject Effects of Cervical Spine Left Lateral Flexion

<table>
<thead>
<tr>
<th></th>
<th>1st Visit</th>
<th>4th Visit</th>
<th>7th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-value</td>
<td>0.544</td>
<td>1.000</td>
<td>0.270</td>
</tr>
</tbody>
</table>
Clinical Interpretation of Median Cervical Spine Left Lateral Flexion Measurements Values

On the first visit group A and group B had median values of 47° and 49.33° respectively for cervical spine left lateral flexion measurements. On the fourth visit group A and group B had median values of 51.13° and 51.27° respectively. On the seventh visit group A and group B had median values of 57.73° and 54.13° respectively.

![Figure 4.5: CROM Left Lateral Flexion Median Values on the 1st, 4th and 7th visits](image)

The median difference between the 1st and 4th visit for group A and group B was 4.13° and 1.94° resulting in a median percentage improvement of 9% and 4% consecutively. The median difference between the 4th and 7th visit for group A and group B was 6.6° and 2.86° resulting in a median percentage improvement of 13% and 5.3% consecutively. At the end of the study group A had a median difference of 10.73° and a median percentage improvement of 23%. Group B had a median difference of 4.8° and a median percentage improvement of 10%.
Table 4.22: CROM Left Lateral Flexion mean values

<table>
<thead>
<tr>
<th>Group A</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSM in U/S</td>
<td>1st Visit</td>
<td>47°</td>
<td>4.13°</td>
<td>9%</td>
</tr>
<tr>
<td></td>
<td>4th Visit</td>
<td>51.13°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st Visit</td>
<td>49.33°</td>
<td>1.94°</td>
<td>4%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4th Visit</td>
<td>51.27°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4th Visit</td>
<td>51.13°</td>
<td>6.6°</td>
<td>13%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th Visit</td>
<td>57.73°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4th Visit</td>
<td>51.27°</td>
<td>2.86°</td>
<td>5.3%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th Visit</td>
<td>54.13°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1st Visit</td>
<td>47°</td>
<td>10.73°</td>
<td>23%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th Visit</td>
<td>57.73°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st Visit</td>
<td>49.33°</td>
<td>4.8°</td>
<td>10%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th Visit</td>
<td>54.13°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intragroup Analysis: Group A Cervical Right Lateral Flexion Range of Motion

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time \(p=0.001\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \(p=0.007\) and for the 4th treatment to the 7th treatment \(p=0.001\).

Table 4.23: Test of Within-subjects contrasts Group A

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.007</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Intragroup Analysis: Group B Cervical Right Lateral Flexion Range of Motion

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time \(p=0.001\).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \(p=0.002\) and for the 4th treatment to the 7th treatment \(p=0.001\).

**Table 4.24: Tests of Within-Subjects Contrasts Group B**

<table>
<thead>
<tr>
<th>Visits (Group B)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.002</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T Test, that tests for normality were inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical right lateral flexion range of motion.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \(p=0.210\), the 4th visit \(p=0.632\) and the 7th visit \(p=0.404\). This means that the groups started out comparable and that they remained like that throughout the study.

**Table 4.25: Tests of Between-Subject Effects of Cervical Spine Right Lateral Flexion**

<table>
<thead>
<tr>
<th>P-value</th>
<th>1st Visit</th>
<th>4th Visit</th>
<th>7th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.210</td>
<td>0.632</td>
<td>0.404</td>
</tr>
</tbody>
</table>
Clinical Interpretation of Median Cervical Spine Right Lateral Flexion Measurements Values

On the first visit group A and group B had median values of 47.33° and 50.53° respectively for cervical spine right lateral flexion measurements. On the fourth visit group A and group B had median values of 51.93° and 53.33° respectively. On the seventh visit group A and group B had median values of 59.47° and 56.53° respectively.

The median difference between the 1st and 4th visit for group A and group B was 4.6° and 2.8° resulting in a median percentage improvement of 10% and 6% consecutively. The median difference between the 4th and 7th visit for group A and group B was 7.54° and 5.26° resulting in a median percentage improvement of 15% and 10.3% consecutively. At the end of the study group A had a median difference of 12.14° and a median percentage improvement of 26%. Group B had a median difference of 6° and a median percentage improvement of 12%.

Figure 4.6: CROM Right Lateral Flexion Median Values on the 1st, 4th and 7th visits
**Table 4.26: CROM Right Lateral Flexion Median Values**

<table>
<thead>
<tr>
<th>Group A</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>1st Visit</td>
<td>47.33°</td>
<td>4.6°</td>
<td>10%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>4th Visit</td>
<td>51.93°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st Visit</td>
<td>50.53°</td>
<td>2.8°</td>
<td>6%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4th Visit</td>
<td>53.33°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4th Visit</td>
<td>51.93°</td>
<td>7.54°</td>
<td>15%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th Visit</td>
<td>59.47°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4th Visit</td>
<td>51.27°</td>
<td>5.26°</td>
<td>10.3%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th Visit</td>
<td>56.53°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1st Visit</td>
<td>53.33°</td>
<td>12.14°</td>
<td>26%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th Visit</td>
<td>59.47°</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st Visit</td>
<td>50.53°</td>
<td>6°</td>
<td>12%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th Visit</td>
<td>56.53°</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Intragroup Analysis: Group A Cervical Left Rotation Range of Motion**

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time (p=0.001).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment (p=0.002) and for the 4th treatment to the 7th treatment (p=0.001).

**Table 4.27: Test of Within-subjects contrasts Group A**

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
<td>0.002</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Intragroup Analysis: Group B Cervical Left Rotation Range of Motion

The Friedman test was used to compare group B's 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time \( p=0.001 \).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment \( p=0.005 \) and for the 4th treatment to the 7th treatment \( p=0.005 \).

<table>
<thead>
<tr>
<th>Table 4.28: Tests of Within-Subjects Contrasts Group B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visits (Group B)</td>
</tr>
<tr>
<td>------------------</td>
</tr>
<tr>
<td>1st Treatment - 7th Treatment</td>
</tr>
<tr>
<td>1st Treatment - 4th Treatment</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical left rotation range of motion.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit \( p=0.144 \), the 4th visit \( p=0.531 \) and the 7th visit \( p=0.307 \). This means that the groups started out comparable and that they remained like that throughout the study.

| Table 4.29: Tests of Between-Subject Effects of Cervical Spine Left Rotation |
|---------------------------------|--------|--------|--------|
|                                 | 1st Visit | 4th Visit | 7th Visit |
| P-value                         | 0.114   | 0.531   | 0.307   |
Clinical Interpretation of Median Cervical Spine Left Rotation Measurements Values

On the first visit group A and group B had median values of 66.2° and 70.73° respectively for cervical spine left rotation measurements. On the fourth visit group A and group B had median values of 72.07° and 74.27° respectively. On the seventh visit group A and group B had median values of 77.93° and 76.73° respectively.

The median difference between the 1st and 4th visit for group A and group B was 5.87° and 3.54° resulting in a median percentage improvement of 9% and 5% consecutively. The median difference between the 4th and 7th visit for group A and group B was 5.86° and 2.46° resulting in a median percentage improvement of 8.1% and 3.3% consecutively. At the end of the study group A had a median difference of 11.73° and a median percentage improvement of 18%. Group B had a median difference of 5.73° and a median percentage improvement of 8.3%.

Figure 4.7: CROM Left Rotation Median Values on the 1st, 4th and 7th visits

The median difference between the 1st and 4th visit for group A and group B was 5.87° and 3.54° resulting in a median percentage improvement of 9% and 5% consecutively. The median difference between the 4th and 7th visit for group A and group B was 5.86° and 2.46° resulting in a median percentage improvement of 8.1% and 3.3% consecutively. At the end of the study group A had a median difference of 11.73° and a median percentage improvement of 18%. Group B had a median difference of 5.73° and a median percentage improvement of 8.3%.
Table 4.30: CROM Left Rotation Median Values

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>1st</td>
<td>66.2º</td>
<td>5.87º</td>
<td>9%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>4th</td>
<td>72.07º</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st</td>
<td>70.73º</td>
<td>3.54º</td>
<td>5%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>4th</td>
<td>74.27º</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>4th</td>
<td>72.07º</td>
<td>5.86º</td>
<td>8.1%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th</td>
<td>77.93º</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>4th</td>
<td>74.27º</td>
<td>2.46º</td>
<td>3.3%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th</td>
<td>76.73º</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>1st</td>
<td>66.2º</td>
<td>11.73º</td>
<td>18%</td>
</tr>
<tr>
<td>MSM in U/S</td>
<td>7th</td>
<td>77.93º</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>1st</td>
<td>71º</td>
<td>5.73º</td>
<td>8.3%</td>
</tr>
<tr>
<td>Standard U/S</td>
<td>7th</td>
<td>76.73º</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Intragroup Analysis: Group A Cervical Right Rotation Range of Motion

The Friedman test was used to compare group A’s 1st treatment to the 7th treatment. The results indicated that group A demonstrated a statistically significant improvement over time (p=0.001).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment (p=0.002) and for the 4th treatment to the 7th treatment (p=0.001).

Table 4.31: Test of Within-subjects contrasts Group A

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st treatment - 4th Treatment</td>
<td>0.002</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>
Intragroup Analysis: Group B Cervical Right Rotation Range of Motion

The Friedman test was used to compare group B’s 1st treatment to the 7th treatment. The results indicated that group B demonstrated a statistically significant improvement over time ($p=0.001$).

The Wilcoxon Signed Rank test revealed that the values demonstrated a statistically significant improvement for the 1st treatment to the 4th treatment ($p=0.005$) and for the 4th treatment to the 7th treatment ($p=0.001$).

Table 4.32: Tests of Within-Subjects Contrasts Group B

<table>
<thead>
<tr>
<th>Visits (Group A)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
<tr>
<td>1st treatment - 4th Treatment</td>
<td>0.002</td>
</tr>
<tr>
<td>4th Treatment - 7th Treatment</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Intergroup Analysis

The Independent T Test, that tests for normality was inconclusive, therefore the Mann-Whitney U tests were used to determine if there is a statistical significance between group A and B on cervical right rotation range of motion.

The Mann-Whitney U test revealed that there was no statistical significance between group A and group B at the 1st visit ($p=0.088$), the 4th visit ($p=0.318$) and the 7th visit ($p=0.630$). This means that the groups started out comparable and that they remained like that throughout the study.

Table 4.33: Tests of Between-Subject Effects of Cervical Spine Right Rotation

<table>
<thead>
<tr>
<th></th>
<th>1st Visit</th>
<th>4th Visit</th>
<th>7th Visit</th>
</tr>
</thead>
<tbody>
<tr>
<td>P-value</td>
<td>0.088</td>
<td>0.318</td>
<td>0.630</td>
</tr>
</tbody>
</table>
Clinical Interpretation of Median Cervical Spine Right Rotation Measurements Values

On the first visit group A and group B had median values of 65.13° and 70.87° respectively for cervical spine right rotation measurements. On the fourth visit group A and group B had median values of 70.53° and 74.07° respectively. On the seventh visit group A and group B had median values of 76.67° and 77.6° respectively.

![Figure 4.8: CROM Right Rotation Median Values on the 1st, 4th and 7th visits](image)

The median difference between the 1st and 4th visit for group A and group B was 5.4° and 3.2° resulting in a median percentage improvement of 8.29% and 4.5% consecutively. The median difference between the 4th and 7th visit for group A and group B was 6.14° and 3.53° resulting in a median percentage improvement of 8.7% and 5% consecutively. At the end of the study group A had a median difference of 11.54° and a median percentage improvement of 18%. Group B had a median difference of 6.73° and a median percentage improvement of 10%.
Table 4.34: CROM Right Rotation Median values

<table>
<thead>
<tr>
<th>Group</th>
<th>Visit</th>
<th>Median Value</th>
<th>Median Difference</th>
<th>Percentage Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>MSM in U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>65.13º</td>
<td>5.4º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>70.53º</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>Standard U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>70.87º</td>
<td>3.2º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>74.07º</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>MSM in U/S</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>70.53º</td>
<td>6.14º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>76.67º</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>Standard U/S</td>
<td>4&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>74.07º</td>
<td>3.53º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>77.6º</td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>MSM in U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>65.13º</td>
<td>11.54º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>76.67º</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>Standard U/S</td>
<td>1&lt;sup&gt;st&lt;/sup&gt; Visit</td>
<td>70.87º</td>
<td>6.73º</td>
</tr>
<tr>
<td></td>
<td></td>
<td>7&lt;sup&gt;th&lt;/sup&gt; Visit</td>
<td>77.6º</td>
<td></td>
</tr>
</tbody>
</table>
CHAPTER 5: DISCUSSION

5.1 Introduction

The results of this study are discussed with reference to the previous results chapter. Any statistically significant results are highlighted in this chapter. Where it was possible, relevant results of previous studies and aspects of the above literature review are included.

5.2 Demographic Data Analysis

5.2.1 Age and Gender Distribution

Participants in this study had to meet the selection criteria of 18 to 30 years of age. Table 4.1 shows that the gender distribution was set at 16 females and 14 males. Table 4.1 also shows that the average age was 24.37. This ensured that gender related variables were kept to a minimum.

5.3 Analysis of Subjective Data

This study was a double blinded study. This means that both the examiner and the participant had no knowledge of which group or ultrasound gel bottle contained the MSM. This was done in order to ensure impartiality and avoid errors arising from bias during the subjective testing.

5.3.1 Numerical Pain Rating Scale (NPRS)

5.3.1.1 Discussion of NPRS results

To discuss the findings of the NPRS, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of ultrasound gel versus MSM incorporated into ultrasound gel may then be made.

5.3.1.2 Ultrasound Gel

In comparing the 1st treatment to the 7th, ultrasound gel proved to have a statistical significance with regards to pain perception (p=0.001), this was mirrored when comparing the 1st treatment to
the 4th (p=0.000) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with a decrease of pain perception of 58%, when comparing the beginning of the study to the end.

Ultrasound therapy is a valuable tool in the rehabilitation of many different injuries, primarily in these situations it would stimulate the repair of soft tissue injuries and relieve pain (Knight and Draper, 2008). It has been proved that standard ultrasound gel has the transmission capabilities of 96% (Cameron and Monroe, 1992). Therapeutic ultrasound has the ability to alter the nerve conduction velocity and therefore there is a resultant elevation in the pain threshold (Draper et al., 2010).

5.3.1.3 MSM Incorporated into Ultrasound Gel

In comparing the 1st treatment to the 7th, MSM proved to have a statistical significance with regards to pain perception (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.008) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that MSM had a positive effect over time, with a decrease of pain perception of 73%, when comparing the beginning of the study to the end.

The MSM group should have presented at minimum with the same amount of improvement as the ultrasound group, since the MSM group also received therapeutic ultrasound. But the MSM group had clinically better improvements than the ultrasound group. These results were expected as the results were representative of the knowledge that MSM profoundly reduces C-fibre conduction velocity. The C-fibres are responsible of sending pain sensations to the brain. MSM is also a topical analgesic (Evans et al., 1992). Intercellular pressure can cause inflammation and pain. MSM relieves the intercellular pressure by changing the permeability of the cell’s membrane, thus relieving any inflammation and pain (Jacob, 1999). MSM also reduces of inflammatory cytokines by reducing the mRNA expression of the inflammatory markers (Theodosakis et al., 2008).

5.3.1.4 Intergroup Analysis

Intergroup analysis compared measurements on the 1st, 4th and 7th sessions, between group A and group B and it resulted in p-values of 0.396, 0.396 and 0.135 consecutively. This proves that there was no statistical significance between the ultrasound and MSM with regards to pain perception.
This might be due to the small test size of the population (C.L. Aberson, 2010). However there was a clinical improvement during the intragroup analysis (58% versus 73%), which indicated that the MSM group may be better.

5.4 Analysis of Objective Data

5.4.1 Pressure Algometer

5.4.1.1 Discussion of Pressure Algometer

To discuss the findings of the algometer, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of ultrasound gel versus MSM incorporated into ultrasound gel could then be made.

5.4.1.2 Ultrasound Gel

In comparing the 1st treatment to the 7th, ultrasound gel proved to have statistical significance with regards to pain threshold (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.001) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase in pain threshold of 62% (1.3 kg/cm²), when comparing the beginning of the study to the end.

Since the NPRS and the pressure algometer readings both involve pain threshold and pain perception, the results of the pressure algometer prove similar to the NPRS results. This is in accordance to the popular belief that ultrasound can be used to rehabilitate many different injuries, primarily in the relief of pain and soft tissue repair (Knight and Draper, 2008). Therapeutic ultrasound has the ability to alter the nerve conduction velocity and therefore there is a resultant elevation in the pain threshold (Draper et al., 2010).

5.4.1.3 MSM Incorporated into Ultrasound Gel

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to pain threshold (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.001) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that
ultrasound gel had a positive effect over time, with an increase in pain threshold of 56% (1.4 kg/cm²), when comparing the beginning of the study to the end.

The MSM group should have presented with the same percentage improvement as the ultrasound group, since the MSM group also received therapeutic ultrasound. But the MSM group had lesser percentage improvement than the ultrasound group. This could be explained by the higher pressure Algometer readings taken on the first session in the MSM group than in the ultrasound gel group. If the mean value improvements were to be examined the MSM group had a 1.4 kg/cm² improvement and the ultrasound gel had only 1.3 kg/cm² improvement. MSM is proven to reduce C-fibre conduction velocity. The C-fibres are responsible of sending pain sensations to the brain (Evans et al., 1992). MSM is proven to relieve intercellular pressure by changing the permeability of the cell’s membrane; this relieves inflammation and subsequent pain (Jacob, 1999).

5.4.1.4 Intergroup Analysis

Intergroup analysis resulted in p-values of 0.249, 0.151 and 0.329 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM on the 1st, 4th and 7th sessions with regards to pain threshold.

5.4.2 Cervical Range of Motion Measuring Instrument (CROM)

To discuss the findings of the CROM, the study was divided into two separate analyses. They were an intragroup analysis and an intergroup analysis. A direct comparison of ultrasound gel versus MSM incorporated into ultrasound gel could then be made.

The resting position of the cervical spine is midway between flexion and extension. The closed packed position (when the joints surfaces are in maximal contact and the ligaments are in a shortened position) is in full extension. The capsular pattern for the cervical spine is side flexion and rotation equally limited and then extension. This means that if a joint capsule was involved with an injury, the first movement that would be lost is lateral flexion and rotation and then extension. This would mean that when a patient presents with an acute facet, the patient may present with a capsular pattern, reducing the patient’s lateral flexion and rotation more than extension and flexion (Magee, 2008).
5.4.2.1 Cervical Forward Flexion Range of Motion

5.4.2.2 Ultrasound Gel

In comparing the 1st treatment to the 7th, ultrasound gel proved to have a statistical significance with regards to cervical forward flexion range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.002) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase in cervical forward flexion range of motion of 9.4%, when comparing the beginning of the study to the end.

5.4.2.3 MSM Incorporated into Ultrasound Gel

In comparing the 1st treatment to the 7th, MSM proved to have a statistical significance with regards to cervical forward flexion (p=0.001), this was mirrored when comparing the 4th treatment to the 7th (p=0.001). However it was not the case when comparing the 1st treatment to the 4th (p=0.093). This proved to be statistical insignificant. The clinical interpretation also proved that MSM had a positive effect over time, with an increase in cervical forward flexion range of motion of 13.6%, when comparing the beginning of the study to the end.

5.4.2.4 Intergroup Analysis

Intergroup analysis resulted in p-values of 0.370, 0.318 and 0.835 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM with regards to cervical flexion range of motion. This might be due to the small test size of the population (C.L. Aberson, 2010). However there was clinical improvement during the intragroup analysis (9.4% versus 13.6%), which indicated that the MSM group may have done better.

5.4.2.5 Cervical Extension Range of Motion

5.4.2.6 Ultrasound Gel

In comparing the 1st treatment to the 7th, ultrasound gel proved to have a statistical significance with regards to cervical extension range of motion (p=0.001), this was mirrored when comparing
the 1st treatment to the 4th (p=0.008) and the 4th treatment to the 7th (p=0.003). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical extension range of motion of 10.10%, when comparing the beginning of the study to the end.

5.4.2.7 MSM Incorporated into Ultrasound Gel

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to cervical extension range of motion (p=0.004), this was mirrored when comparing the 1st treatment to the 4th (p=0.006) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that MSM had a positive effect over time, with an increase of cervical extension range of motion of 16%, when comparing the beginning of the study to the end.

5.4.2.8 Intergroup Analysis

Intergroup analysis resulted in p-values of 0.618, 0.129 and 0.026 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM on the 1st and 4th sessions with regards to cervical extension range of motion. There was however a statistical significance at the 7th session between the groups, which showed that the groups were not comparable anymore.

5.4.2.9 Cervical Left and Right Lateral Flexion Range of Motion

5.4.2.10 Ultrasound Gel

Left Lateral Flexion

In comparing the 1st treatment to the 7th, ultrasound gel proved to have statistical significance with regards to cervical left lateral flexion range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.028) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical left lateral flexion range of motion of 10%, when comparing the beginning of the study to the end.
Right Lateral Flexion

In comparing the 1st treatment to the 7th, ultrasound gel proved to have statistical significance with regards to cervical right lateral flexion range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.008) and the 4th treatment to the 7th (p=0.003). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical right lateral flexion range of motion of 12%, when comparing the beginning of the study to the end.

5.4.2.11 MSM Incorporated into Ultrasound Gel

Left Lateral Flexion

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to cervical left lateral flexion range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.014) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that MSM had a positive effect over time, with an increase of cervical left lateral flexion range of motion of 23%, when comparing the beginning of the study to the end.

Right Lateral Flexion

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to cervical right lateral flexion range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.007) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical right lateral flexion range of motion of 26%, when comparing the beginning of the study to the end.

5.4.2.12 Intergroup Analysis

Left Lateral Flexion

Intergroup analysis resulted in p-values of 0.544, 1.000 and 0.270 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM with regards to cervical left lateral flexion range of motion. This might be due to the small test
size of the population (C.L. Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the MSM group may have done better.

**Right Lateral Flexion**

Intergroup analysis resulted in p-values of 0.210, 0.632 and 0.404 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM with regards to cervical right lateral flexion range of motion. This might be due to the small test size of the population (C.L. Aberson, 2010). However there was a clinical improvement during the intragroup analysis, which indicated that the MSM group may have done better.

### 5.4.2.13 Cervical Left and Right Rotation Range of Motion

#### 5.4.2.14 Ultrasound Gel

**Left Rotation**

In comparing the 1st treatment to the 7th, ultrasound gel proved to have statistical significance with regards to cervical left rotation range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.005) and the 4th treatment to the 7th (p=0.005). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical left rotation range of motion of 8.32%, when comparing the beginning of the study to the end.

**Right Rotation**

In comparing the 1st treatment to the 7th, ultrasound gel proved to have statistical significance with regards to cervical right rotation range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.005) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical rotation range of motion of 9.5%, when comparing the beginning of the study to the end.
5.4.2.15 MSM Incorporated into Ultrasound Gel

Left Rotation

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to cervical left rotation range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.002) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical left rotation range of motion of 18%, when comparing the beginning of the study to the end.

Right Rotation

In comparing the 1st treatment to the 7th, MSM proved to have statistical significance with regards to cervical right rotation range of motion (p=0.001), this was mirrored when comparing the 1st treatment to the 4th (p=0.002) and the 4th treatment to the 7th (p=0.001). The clinical interpretation also proved that ultrasound gel had a positive effect over time, with an increase of cervical right rotation range of motion of 18%, when comparing the beginning of the study to the end.

5.4.2.16 Intergroup Analysis

Left Rotation

Intergroup analysis resulted in p-values of 0.114, 0.531 and 0.307 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM on the 4th and 7th sessions with regard to cervical left rotation range of motion. This might be due to the small test size of the population. However there was a statistical significance on the 1st session between the groups.

Right Rotation

Intergroup analysis resulted in p-values of 0.088, 0.318 and 0.630 on the 1st, 4th and 7th visits consecutively. This proves that there was no statistical significance between the ultrasound and MSM on the 4th and 7th sessions with regard to cervical right rotation range of motion. This might
be due to the small test size of the population. However there was a statistical significance on the 1st session between the groups.

5.4.2.17 Discussion of the Ranges of Motion

The range of motion changes in the ultrasound group was to be expected since ultrasound is proven to decrease soft tissue injuries, inflammation and pain (Watson, 2008). When there is a decrease in pain the participant would be able to move their necks into greater ranges of motion than that was previously possible.

The range of motion changes should have been at minimum the same in the MSM group as the ultrasound group; this is due to the fact that the MSM group also receives therapeutic ultrasound. Group A had a clinically greater improvement in all the ranges of motion. This can be due to a decrease in pain, through the slowing of the C-fibre conduction velocities and the fact that MSM is a topical analgesic (Evans et al., 1992). MSM also decreases inflammation which will also lead to a decrease in pain (Jacob, 1999). As discussed during the ultrasound discussions, a decrease of pain may lead to an increase of range of motion.

Flexion and extension (100-130°) have the greatest degrees of movement followed by rotation (80-90°) and then lateral flexion (45-60°) (Middleditch and Olivier, 2005). The cervical spine capsular pattern is the exact opposite of the previous statement, with lateral flexion first lost, then rotation, extension and flexion (Magee, 2008). What also needs to be taken into account is that there were more participants who presented with a right side acute cervical facet than the left side. The results followed the above mentioned trends. Right lateral flexion and rotation improved percentage wise the best when comparing it to the left side. Lateral flexion also improved the most followed by rotation, extension and flexion (applying group A results). Lateral flexion improved with 26% which is ~ a fifth of the available degrees of motion in that direction, whereas flexion only improved only with 13.6% which is ~ a tenth of available degrees of motion in that direction.

5.5 Conclusion

Group A was treated with ultrasound utilising MSM incorporated into ultrasound gel over an acute cervical facet. Group B was treated with ultrasound using standard ultrasound gel. Both Group A
and B proved to have a statistical and clinical improvement. At minimum group A should have shown the same results as group B if the therapeutic ultrasound was able to act upon the involved acute cervical facet. However group A proved to be better of clinically than group B. This can therefore indicates that the true effect of the therapeutic ultrasound plus the MSM was acting upon the involved acute cervical facet. However since acute conditions do resolve over time, it is my opinion that further testing needs to be done to determine how effective the above therapeutic treatments are.
CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

The aim of this double-blinded, controlled study was to determine the effect of MSM incorporated into ultrasound gel, over a three week period, in the treatment of an acute cervical facet syndrome.

At the end of the study it was concluded that both groups showed significant clinical and statistical improvement in both their subjective and objective perception of pain over the acute facet as well as an improvement in their range of cervical spine motion. Both treatments are thus effective in reducing the pain and dysfunction from an acute cervical spine facet, although statistically neither treatment is superior to the other. The lack of statistical significance in the subjective and objective tests may be due to the small sample size used in the study. Clinical results of the study showed that the MSM incorporated into ultrasound gel showed greater improvements over the duration of the study than the standard ultrasound gel on its own. However the percentage improvements with the MSM incorporated into the ultrasound gel with the pressure algometer were marginally lower than that of the ultrasound alone.

Based on these results, it can be concluded that both standard ultrasound gel on its own or when combined with MSM can be used effectively to treat an acute cervical spine facet. It could not be statistically concluded whether one treatment is superior to the other, although clinically MSM incorporated into ultrasound gel protocol seemed to be more effective and could thus be used in a clinical setting.

6.2 Recommendations

The following recommendations may aid in improving statistical significance for future studies in this field:

- A study that consists of a larger sample group would represent the population more accurately and would therefore provide an adequate clinical study so that sufficient statistical significance can be achieved
- Shorten the treatment intervals to determine if the ultrasound and MSM have the same therapeutic effect or if the therapeutic effect increases with shorter treatment intervals
• Increase the measurement frequency to determine when the optimal therapeutic effect is reached
• Conduct this study on only the side of the acute cervical facet alone; this will determine if the range of motion changes are due to changes with the acute cervical facet
• Analyse other peripheral musculoskeletal conditions or complaints, such as bicipital tendinitis to determine if ultrasound and MSM can produce the same therapeutic effect
• Add in a third group that receives placebo ultrasound therapy to analyse the placebo effect and determine if the improvement is due to ultrasound therapy or due to a psychological effect of the patient thinking the treatment should improve their condition. The added third group that is a placebo might also be beneficial to see if an acute condition does not resolve on its own after a certain amount of time has elapsed and that the improvements are actually because of the therapeutic treatments
• Analyse other acute facets within other parts of the spine, such as lumbar facets to determine if the same therapeutic effect of ultrasound therapy can be produced on a deeper facet joint
• Conduct the study on chronic facets syndromes; this will determine if the therapeutic ultrasound has an effect on chronic as well as acute cervical facet syndromes
REFERENCES


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APPENDIX B: CONSENT FORM

DEPARTMENT OF CHIROPRACTIC

INFORMATION AND CONSENT FORM

I, Anrie Potgieter, hereby invite you to participate in my research study. I am currently a Chiropractic student, completing my Masters degree in Chiropractic at the Faculty of Health Sciences of the University of Johannesburg.

The aim of this study is to determine the effect of MSM incorporated into ultrasound gel using phonophoresis, over a three week period, in the treatment of an acute cervical facet syndrome. Phonophoresis is the movement of drugs through skin into underlying tissue under the influence of ultrasound. MSM is an organic-sulfur that is currently sold as a supplement or cream, which is clinically used in the treatment of musculoskeletal injuries and inflammatory conditions. There are no reported side effects from the use of MSM. An acute cervical facet syndrome is one of the causes of acute neck pain and can be identified on a facet joint challenge test.

Group one (Test group) will receive phonophoresis utilizing MSM incorporated into ultrasound gel, over an acute cervical facet syndrome. Group two (Control group) will receive treatment with ultrasound gel over an acute cervical facet syndrome. All participants will receive six treatments out of a total of seven consultations over a three week trial period. Participants will receive two treatments per week and one follow up consultation in the third week where only measurements will be taken and no treatment will be administered. At the 1st and 4th consultation subjective and objective measurements will be taken followed by treatment of the acute cervical facet syndrome utilising the ultrasound machine. The 2nd, 3rd, 5th and 6th consultations will only involve treatment of the acute cervical facet syndrome utilising ultrasound. The 7th consultation only subjective and objective measurements will be taken and no treatment will be administered.

The research study will take place at the University of Johannesburg Doornfontein Campus Day Clinic. Your privacy will be protected as only the doctor, patient and clinician will be in the treatment room and
that anonymity will be ensured as the patient information will be converted into data and therefore cannot be traced back to the individual.

All procedures will be explained to you and all participation is entirely on a voluntary basis; withdrawal at any stage will not cause you any harm. Treatment is free of charge, and will occur under the supervision of a qualified clinician. The benefit of participating in this study is that you may experience relief from your symptoms in terms of pain and stiffness. Please note that a small risk of temporary exacerbation of symptoms does exist; however this is a normal response to the treatment, lasting only a few days. Results of this study will be made available to you on request.

I have fully explained the procedures and their purpose. I have asked whether or not any questions have arisen regarding the procedures and have answered them to the best of my ability.

__________________________________________  ______________________________
Date                                      Signature (Researcher)

I have been fully informed as to the procedures to be followed and have been given a description of the discomfort risks and benefits expected from the treatment. In signing this consent form I agree to this form of treatment and understand my rights and that I am free to withdraw my consent and participation in this study at any time. I understand that if I have any questions at any time they will be answered.

__________________________________________  ______________________________
Date                                      Signature (Participant)

__________________________________________
Participant’s name

Should you have any concerns or queries regarding the current study, the following persons may be contacted.

Researcher: Anrie Potgieter
Supervisor: Dr. C. Bester
APPENDIX C: CONTRA-INDICATIONS TO ULTRASOUND THERAPY

1. Arthritis
   • Ankylosing spondylitis
   • Osteoarthritis (unstable or late stage)
   • Psoriatic arthritis
   • Reiter’s syndrome
   • Rheumatoid arthritis
   • Unco-arthritis

2. Bone infections
   • Bacterial infection (osteomyelitis)
   • Tuberculosis

3. Metabolic disorders
   • Clotting disorders
   • Osteopenia (osteoporosis, osteomalacia)

4. Neurological complications
   • Disc lesions (advancing neurological deficits)
   • Sacral nerve root involvement from medial or massive disc protrusion
   • Space-occupying lesions
   • Sensory loss

5. Psychological considerations
   • Hypochondriasis
   • Hysteria
   • Malingering
   • Pain intolerance

6. Traumatic injuries
   • Fractures
   • Joint instability or hypermobility
• Severe sprains or strains
• Unstable spondylolisthesis

7. Tumors
• Bone
• Breast
• Lung
• Prostate
• Thyroid

8. Vascular complications
• Aneurysms
• Atherosclerosis of major blood vessels
• Vertebral-basilar insufficiency
APPENDIX D: CONTRA-INDICATIONS TO MSM AND ULTRASOUND GEL

CONTRA-INDICATIONS TO MSM

- Contra-indicated in patients who have previously shown hypersensitivity to MSM.

CONTRA-INDICATIONS TO ULTRASOUND GEL

- Contra-indicated in patients who have previously shown a hypersensitivity to any of the ingredients.
APPENDIX E: MSM MIXING PROTOCOL

The MSM used for this study is in a 100% pure crystalline form. The MSM and ultrasound gel mixture will be mixed at Medipost Pharmacy by a pharmacist, Gerda Potgieter (B Pharm). 75 grams of MSM will be mixed within 300 grams of ultrasound gel.

The weighing of the MSM and the ultrasound gel will be done on a Vibra A.J. by Shinko Denshi Co limited. The scale is accurate to a hundredth of a gram.
APPENDIX F: NUMERICAL PAIN RATING SCALE RECORDING SHEET

Name of patient: _____________________
File number: ________________________
Date: ______________________________

NUMERICAL PAIN RATING SCALE

Try to assign a number from 0 (zero) to 10 (ten) to your pain level. If you have no pain, use a 0. As the numbers get higher, they stand for pain that is getting worse. The middle of the scale describes a “moderate” pain. A 10 means the pain is the worst pain you have ever experienced.

1st Visit

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<th>Moderate pain</th>
<th>Worst pain</th>
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7th Visit

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APPENDIX G: CROM RECORDING SHEET

Name of patient: _____________________
File number: ________________________
Date: ______________________________

CROM RECORDING SHEET

Cervical spine extension readings:

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<th>Consultation 7</th>
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Cervical spine left rotation readings:

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Cervical spine right rotation readings:

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APPENDIX H: ALGOMETER RECORDING SHEET

Name of patient: _____________________
File number: ________________________
Date: ______________________________

ALGOMETER READINGS

ACUTE FACET READINGS

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<th>1ST VISIT</th>
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<td>RIGHT</td>
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APPENDIX I: CASE HISTORY FORM

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
Other Other

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


   General
   
   Skin
   
   Head
Eyes
Ears
Nose/sinuses
Mouth/throat
Neck
Breasts
Respiratory
Cardiac
Gastro-intestinal
Urinary
Genital
Vascular
Musculoskeletal
Neurologic
Haematologic
Endocrine
Psychiatric
APPENDIX J: PHYSICAL EXAMINATION FORM

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: _____

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<th>Arms: L</th>
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<table>
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<th>Legs: L</th>
<th>R</th>
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</table>

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°

L. Rot          Flex.          R. Rot

L. Lat Flex     ——     R. Lat Flex

Ext.

/ = pain-free limitation  // = painful limitation

5. Romberg’s sign
6. Pronator drift
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  
   - expiration  

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<tbody>
<tr>
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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

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

4. Ears:
   - auricle
   - 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
     - CN X
     - inspection

   - carotid arteries (thrills, bruit)
   - Cranial Nerves
     - CN V
     - CN VII
     - CN VIII (nystagmus)
     - CN IX
     - CN XI
     - CN X11

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

(ii) leg length

• Co-ordination - point to point
                - dysdiachokinesia

9. TMJ
• Inspection - ROM
               - deviation
• Palpation - crepitus
             - tenderness
10. Thorax

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

- Palpation
  - tenderness
  - masses
  - respiratory expansion
  - tactile fremitus

- Percussion
  - lungs (posterior)
  - diaphragmatic excursion
  - kidney punch

- Auscultation
  (i) breath sounds
  - vesicular
  - bronchial
  (ii) adventitious sounds
  - crackles (rales)
  - wheezes (rhonchi)
  - rubs
  (iii) voice sounds
  - broncophony
  - whispered pectoriloquey
  - 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

• Percussion  
  - general  
  - liver  
  - spleen

• Palpation  
  - superficial reflexes  
  - cough  
  - light  
  - rebound tenderness  
  - deep  
  - liver  
  - spleen  
  - kidneys  
  - aorta  
  - intra-/retro-abdominal wall mass  
  - shifting dullness  
  - fluid wave

• Acute abdomen  
  - where pain began and now  
  - cough  
  - tenderness  
  - guarding/rigidity  
  - rebound tenderness  
  - roving’s sign  
  - psoas sign  
  - obturator sign  
  - cutaneous hyperaesthesia  
  - rectal exam  
  - Murphy’s sign

Mental Status

(i) Appearance and behaviour  
  - level of consciousness  
  - posture and motor behaviour  
  - dress, grooming, personal hygiene  
  - facial expression  
  - affect

(ii) Speed and language  
  - quantity  
  - rate  
  - volume  
  - fluency  
  - aphasia (pm)

(ii) Mood

(v) 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

### NEUROLOGICAL EXAMINATION (LUMBAR SPINE)

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APPENDIX K: CERVICAL SPINE REGIONAL EXAMINATION FORM

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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/ = Pain free limitation  
// = Painful limitation

**PALPATION**

- Lymph nodes
- Trachea
- Thyroid gland
- Pulses/thrills
- Tenderness
- Muscle Tone
- Active MF Trigger Points
  - SCM
  - Trapezius
  - Scaleni
  - Levator Scapulae
  - Posterior Cervical musculature

**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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**Visit No:**  
**Student:**  
**Clinician:**  

**S:**  
**O:**  

**A:**  
**P:**  

Comments:

**Patient:**  
**File No:**  
**Date:**  
**Visit No:**  
**Student:**  
**Clinician:**  

**S:**  
**O:**  

**A:**  
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Group: 1 - A - MSM in ultrasound gel
2 - B - Normal Ultrasound gel

Gender 1 - Female
2 - Male

Subjective data: Numerical Pain Rating Scale

Objective data: Pressure Algometer Right and left side

CROM: Extension
Flexion
Left lateral flexion
Right lateral flexion
Left rotation
Right rotation
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