The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome

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I, Ryan Patrick Booyens, do declare that this dissertation is representative of my own work in both conception and execution, except where specific assistance is sought and duly acknowledged.

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Approved for final submission

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Dedication

It is with great pleasure that I dedicate this dissertation to my parents, Gary and Joan, and my brother, Darren. Without your continued support and guidance this would have not been possible.

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My sincere thanks go to the following people:

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Abstract

Background: The most common shoulder complaint seen by physicians is shoulder impingement syndrome. There has been limited success with the current conservative treatment that has been provided for this condition. Thoracic spine and rib manipulation is purported to aid in the treatment of this condition; however there is a paucity of controlled investigations. The purpose of this study was to determine the short term efficacy of thoracic and prone rib manipulation on shoulder impingement syndrome.

Methods: A randomised, placebo controlled pre-test post-test experimental design was used. Informed consent was obtained and 30 participants were recruited according to inclusion criteria and allocated to either a placebo or intervention group. Intervention consisted of thoracic spinal and rib manipulation. Data was collected, pre and post the first treatment and at a 48 hours follow up. SPSS was used to analyse the data with a p value of 0.05.

Results: No statistically significant differences were seen between the groups for pain rating, range of motion of the glenohumeral joint, lateral scapula slide test or scapula isometric pinch test. The shoulder pain and disability index (SPADI) showed significant (p = 0.04) differences between the groups in terms of disability scores, with the intervention group having a great improvement in disability. No clinically significant differences were observed between the groups.

Conclusion: Thoracic spine and rib manipulation appears to improve the disability associated with shoulder impingement syndrome, however further research is required with a larger sample size.

Key words: shoulder impingement syndrome, spinal manipulation

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Definitions

Arthrogenic Muscle Inhibition

A presynaptic, ongoing reflex inhibition of musculature surrounding a joint after distension or damage to structures of that joint. It is a natural response designed to protect the joint from further damage Hopkins (Hopkins et al., 2001).

Joint Dysfunction

Altered joint mechanics without structural change, affecting the quality and range of joint motion. Embodies disturbances in function that can be represented by decreased motion, increased motion or aberrant motion (Hyde and Gengenbach, 2007).

Joint Fixation

The state whereby an articulation has become temporarily immobilized in a position that it may normally occupy during any phase of physiologic movement. The immobilization of an articulation in a position of movement when the joint is at rest, or in a position of rest when the joint is in movement (Hyde and Gengenbach, 2007).

Joint Subluxation

A motion segment in which alignment, movement integrity, and/or physiologic function are altered, although contact between the joint surfaces remains intact (Hyde and Gengenbach, 2007).

Kinematic Chain

The kinematic chain may be defined as a combination of several successively arranged joints constituting a complex unit (Bergmann and Peterson, 2002).

Subluxation Complex

A theoretical model of motion segment dysfunction that incorporates the complex interaction of pathologic changes in nerve, muscle, ligamentous, vascular and connective tissue (Hyde and Gengenbach, 2007).

Spinal Manipulative Therapy

This is a manual procedure that utilizes controlled force, direction, amplitude and velocity, which is directed at a specific joint or anatomical region. The direct thrust moves the joint past the physiological range of motion, without exceeding the anatomical limitations of that joint (Chapman-Smith, 2000).

Abbreviations

SIS	Shoulder Impingement Syndrome
SC	Shoulder complex
GHJ	Glenohumeral Joint
ACJ	Acromioclavicular Joint
SCJ	Sternoclavicular Joint
STJ	Scapulothoracic Joint
AMI	Arthrogenic Muscle Inhibition
SP	Spinous Process
CP	Coranoid Process
TVP	Transverse Process
CNS	Central Nervous System
PNS	Peripheral Nervous System
TSM	Thoracic Spine Manipulation
SMT	Spinal Manipulative Therapy
HVLA	High Velocity Low Amplitude
AMI	Arthrogenic Muscle Inhibition
ROM	Range of Motion
LSST	Lateral Scapular Slide Test
DUT	Durban University of Technology
CDC	Chiropractic Day Clinic

CHAPTER ONE: INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

The most common cause of shoulder pain is shoulder impingement syndrome (SIS). This occurs when the rotator cuff muscles (supraspinator muscle, infraspinator muscle, tere's minor and subscapularis) become impinged underneath the coracoacromial arch (Senbursa, Baltaci and Atay, 2007; Boyles et al., 2009). It accounts for 44-60% of all complaints of shoulder pain (Senbursa, Baltaci and Atay, 2007). If the condition persists, it can result in complete rupture of the rotator cuff tendon which has a high socioeconomic impact on the working ability of the patient (Senbursa, Baltaci and Atay, 2007; Hattam and Smeatham, 2010). According to Senbursa, Baltaci and Atay, (2007) there are a wide variety of treatments used for shoulder impingement syndrome with very few producing favourable outcomes, hence the necessity to find the best method of managing this condition.

Treatments are usually localised to the shoulder joint, however a common cause of SIS is impaired alignment of a scapulae, where the inferior angle of the scapula is medial to the root of the spine of the scapula (Sahrmann, 2005), resulting in altered biomechanics and ultimately pain. Associated with this are changes in length of the scapulothoracic muscles, with the levator scapula and rhomboid becoming shorter and the upper trapezius and serratus anterior becoming longer (Sahrmann, 2005), resulting in scapulae dyskinesis (Hyde and Gengenbach, 2007; Hammer, 2007). The muscles stabilising the scapula attach to either the thoracic spine and/or the ribs (Moore and Dalley, 2006). The theory of regional interdependence states that a patient's primary complaint may be directly or indirectly related to impairments from various body regions and systems regardless of proximity to that complaint (Sueki and Chaconas, 2013); this may have relevance for the role of the thoracic spine and ribs in SIS.

Spinal manipulation is a therapeutic modality used to treat joint dysfunction through a dynamic thrust to a specific vertebra or joint (Schiller, 2001; Picker, 2002).

Associated with this is altered spinal range of motion and function (Potter, McCarthy and Oldham, 2005). Feil and Morgan (2010) recommend manipulation of the thoracic spine to prevent injuries to athletes and also to help improve their performance. Wainner et al. (2007) recommend using thoracic spinal manipulation as an adjunct to other treatments for shoulder impingement syndrome in non-athletic patients to improve the management of shoulder impingement syndrome. Although recommended there is little scientific evidence to support the use of thoracic spinal manipulation in the treatment of shoulder pain. Two one-group pre-test, post-test investigations (Boyles et al., 2009; Strunce et al., 2009) showed that thoracic spine and rib manipulation decrease disability and pain in participants with shoulder pain (impingement syndrome). However these studies were exploratory and lacked a control group. Thus, further research is required to determine the role of thoracic spinal manipulation in the management of shoulder pain.

1.2 AIMS AND OBJECTIVES

The aim of this study was to compare the short term effect of thoracic spine and prone rib manipulation to a placebo intervention in the management of shoulder impingement syndrome.

Objective one:
To determine the effect of thoracic spinal manipulation, in terms of subjective and objective measurements, in the management of shoulder impingement syndrome.

Objective two:
To determine the effect of placebo manipulation of the thoracic spine, in terms of subjective and objective measurements in the management of shoulder impingement syndrome.

Objective three:
To compare the effect of the thoracic spinal manipulation to a placebo intervention, in terms of the subjective and objective measurements in the management of shoulder impingement syndrome.

1.3 HYPOTHESIS

The null hypothesis (H_o) stated that:

1. There would be no difference between thoracic spinal manipulation and placebo intervention in terms subjective measurements of in the treatment of impingement syndrome.
2. There would be no difference between thoracic spinal manipulation and placebo intervention in terms objective measurements of in the treatment of impingement syndrome.

The alternate hypothesis (H_a) stated that:

1. Thoracic spinal manipulation would be more effective than placebo intervention in terms of subjective measurements in the treatment of impingement syndrome.
2. Thoracic spinal manipulation would be more effective than placebo intervention in terms of objective measurements in the treatment of impingement syndrome.

1.4 LIMITATIONS OF THE STUDY

The diagnosis of shoulder impingement syndrome is challenging, with the signs and symptoms of various shoulder pathologies, especially shoulder impingement syndrome, being very similar. This is also complicated by the different types of shoulder impingement syndromes (Hyde and Gengenbach, 2007). Early onset degenerative joint disease may result in oestophyte formation on the inferior surface of the acromion (Koester, George and Kuhn, 2005) and acromial morphology could affect shoulder impingement syndrome. Ultrasound or radiographic examination was not utilised in this study to determine a diagnosis.

1.5 SCOPE OF THE STUDY

This was a quantitative study design with a population of 30 participants from the greater Durban area. Participants underwent a case history, physical examination, thoracic and shoulder regional examination, following which baseline measurements were taken and then participants were randomly allocated into one of two groups and treated accordingly. A second set of measurements were taken straight after the

intervention and a third set of measurements at a 48 hour follow up appointment. Statistical analysis was performed using SPSS and a p value of 0.05 was utilised.

1.6 FLOW OF THE DISSERTATION

- Chapter One

Chapter one is a brief introduction of the entire dissertation, and chapter includes the aim and objectives of the study the hypothesis and limitations behind the study.

- Chapter Two

Chapter two is a review of the literature. This chapter includes the anatomy of the shoulder complex and thoracic spine, biomechanics of the thoracic spine, discussion on spinal manipulative therapy, shoulder impingement syndrome and related research studies.

- Chapter Three

Chapter three is the methodology that was used in study, including the study design, methods, clinical procedures that were used, the tools that were used for measurements and manipulative procedure that was used.

- Chapter Four

Chapter four presents the results of the statistical analysis.

- Chapter Five

Chapter five discusses the results in relation to the existing literature.

- Chapter Six

Chapter six is the conclusion of the study and highlights recommendations for future research.

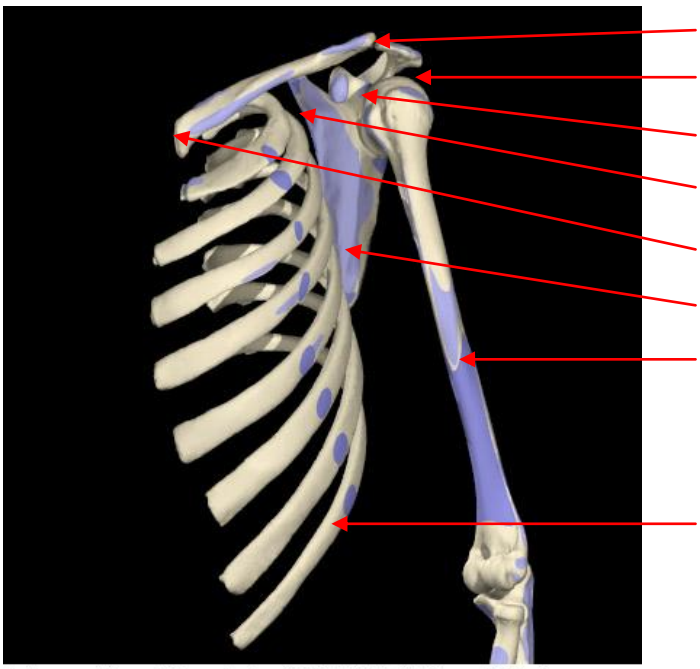
CHAPTER TWO: LITERATURE REVIEW

2.1 INTRODUCTION

Shoulder problems are among the most common of all extremity joint complaints with shoulder impingement syndrome being the most common cause of pain in the shoulder (Bang and Deyle, 2000; Hyde and Gengenbach, 2007). There are several factors that may lead to the development of shoulder impingement syndrome and there are many different ways to treat it (Oscar, 2012). In order to understand this complex problem this chapter will review the relevant anatomy and biomechanics of the shoulder complex and review the relevant literature surrounding impingement syndrome and spinal manipulation.

2.2 REVIEW OF THE RELEVANT ANATOMY OF THE SHOULDER COMPLEX

The shoulder complex, as seen in Figure 2.1, consists of three true articular joints (sternoclavicular, acromioclavicular and glenohumeral) and two physiologic joints (scapulothoracic joint and subacromial space) (Culham and Peat, 1993; Hyde and Gengenbach, 2007). In order for the shoulder complex to function correctly there must be coordinated, synchronous movement in all the joints of the shoulder complex simultaneously when the arm is moved (Culham and Peat, 1993; Hyde and Gengenbach, 2007; Hamill and Knutzen, 2009).



Interactive Shoulder © 2000 Primal Pictures Ltd.

Figure 2.1: The shoulder complex (Reprinted with permission from Primal pictures, 2000)

2.2.1 Joints of the Shoulder Complex

2.2.1.1 The Glenohumeral Joint

The glenohumeral joint (GHJ) is a ball and socket, synovial type joint. The articulation occurs between the humeral head and the glenoid cavity of the scapula, which is deepened by the glenoid labrum (a fibrocartilage ring attached to the margins of the glenoid cavity). The glenoid cavity accepts little more than a third of the humeral head, which allows for the greatest range of motion when compared to other joints in the body, making it a relatively unstable joint (Culham and Peat, 1993; Moore and Dalley, 2006; Hamill and Knutzen, 2009). The range of motion (ROM) of the GHJ is 165°-180° of flexion, 30°-60° of extension, 150°-180° of abduction, 75° of adduction, 60°-90° of internal and external rotation for a total of 120°-180° of rotation, the joint also allows 135° of horizontal adduction and 45° horizontal abduction (Hamill and Knutzen, 2009).

The capsule of the GHJ attaches medially to the glenoid cavity and laterally to the anatomical neck of the humerus (Moore and Dalley, 2006; Culham and Peat 1993). Superiorly it encroaches onto the coracoid process, including the attachment of the

long head of the bicep brachii on the supraglenoid tubercle within the joint (Moore and Dalley, 2006). Inferiorly the capsule is lax and lies in folds when the arm is adducted, but tightens when the arm is abducted and externally rotated (Moore and Dalley, 2006; Hamill and Knutzen, 2009). This is the only part of the capsule that is not reinforced by the rotator cuff muscles and is the weakest (Moore and Dalley, 2006). The capsule has two apertures, one between the tubercles of the humerus for the long head of the bicep's brachii and the other is situated anteriorly, inferior to the coracoid process for communication between the subscapular bursa and the synovial cavity of the joint (Moore and Dalley, 2006), as seen in Figure 2.2

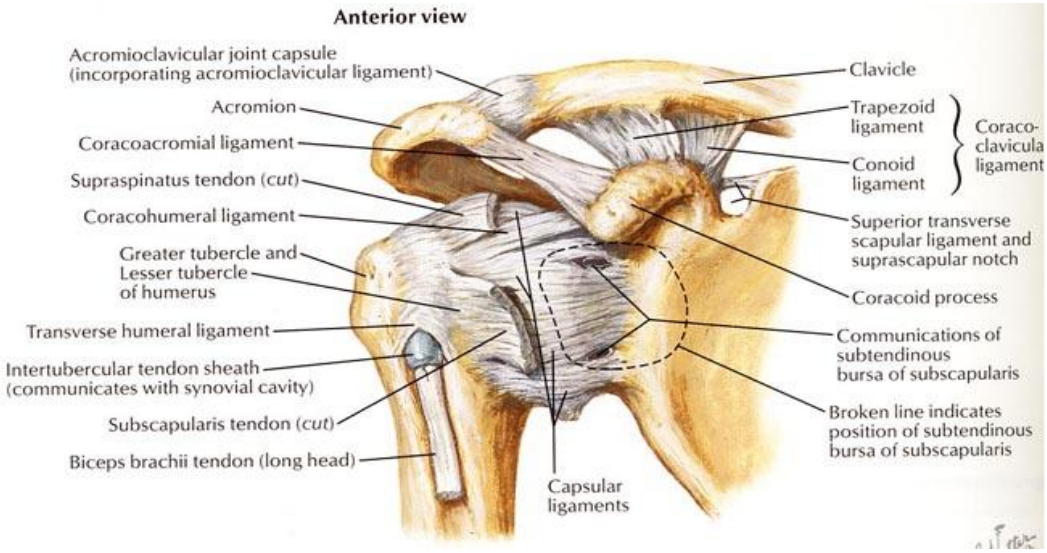


Figure 2.2: The glenohumeral joint capsule (Netter, 2011)

A synovial membrane lines the GHJ capsule and reflects from it onto the glenoid cavity and humerus, as far as the articular margins of the head of the humerus. The GHJ is further supported by several ligaments, as described in Table 2.1, which strengthen the joint capsule anterior and superiorly. The GHJ is innervated by the supraclavicular, axillary and lateral pectoral nerves (Moore and Dalley, 2006).

Table 2.1: Ligaments of the GHJ (adapted from Culham and Peat, 1993; Moore and Dalley, 2006)

Ligaments	Attachments	Function
Glenohumeral	Glenoid labrum at the supraglenoid tubercle of the scapula to anatomical neck of the humerus.	Strengthens the joint capsule anteriorly.
Coracohumeral	Base and lateral border of the coracoid process (CP) of the scapula to greater tubercle of the humerus.	Strengthens the joint capsule superiorly.
Coracoacromial	Lateral border of the CP of the scapula to superior aspect of the acromion.	Forms a protective arch that prevents superior displacement of the humeral head.
Transverse Humeral	Lesser tubercle to great tubercle of the humerus.	Holds the synovial sheath and bicep brachii tendon in place during movement.

2.2.1.2 The Acromioclavicular Joint

The acromioclavicular joint (ACJ) is a synovial plane joint that articulates between the distal end of the clavicle and the acromion of the scapula. The articular surfaces are covered by fibrocartilage and are separated by an incomplete wedge shaped disc (Culham and Peat, 1993; Moore and Dalley, 2006; Hamill and Knutzen, 2009). This stable joint has relevantly small movements which include varying degrees of sliding, rolling and spinning that are significant even though the ROM of the ACJ is relatively small. The fibrocartilage disc allows further movements that are not allowed by the bony surfaces alone (Tovin and Greenfield, 2001). The ACJ capsule is a relatively loose, sleeve like, fibrous structure lined by a synovial membrane. It offers little support to the joint. The ACJ relies on the ligaments, described in Table 2.2, for support. The ACJ is innervated by the lateral pectoral and axillary nerve; this joint is also innervated by the subcutaneous lateral supraclavicular nerve (Moore and Dalley, 2006).

Table 2.2: Ligaments of the ACJ (adapted from Hamill and Knutzen, 2009; Culham and Peat, 1993)

Ligaments	Attachments	Function
Coracoclavicular	Trapezoid: CP of the scapula to clavicle. Conoid: CP of the scapula to clavicle.	Maintains relationship between the clavicle and scapula, prevents anterior/posterior displacement and superior/inferior displacement.
Acromioclavicular	Acromial process of scapula to clavicle.	Prevents ACJ separation and anterior and posterior displacement.

2.2.1.3 The Sternoclavicular Joint

The sternoclavicular joint (SCJ) is a saddle type synovial joint that functions as a ball and socket joint (Moore and Dalley, 2006; Culham and Peat, 1993), formed by the proximal end of the clavicle and the manubrium of the sternum which are separated by an articular disc (Moore and Dalley, 2006; Hamill and Knutzen, 2009; Culham and Peat, 1993). The SCJ is the only skeletal attachment between the axial skeleton and the upper limb (Moore and Dalley, 2006; Hamill and Knutzen, 2009). The movement of the clavicle at the SCJ has three degrees of freedom, the range of motion of the SCJ is 30°-40° of elevation and depression, 30°-35° of protraction and retraction and finally 40°-50° rotation anteriorly or posteriorly along it axis (Hamill and Knutzen, 2009).

The SCJ joint capsule attaches to the margins of the articular surfaces and the periphery of the articular disc. The fibrous layer of the joint capsule is lined by the synovial membrane (Moore and Dalley, 2006). The stability of the SCJ is dependent on the ligaments described in Table 2.3, its articular disc and strong capsule (Moore and Dalley, 2006; Culham and Peat, 1993). The SCJ is innervated by branches of the medial supraclavicular nerve and the nerve to the subclavius (Moore and Dalley, 2006).

Table 2.3: Ligaments of the SCJ (adapted from (Moore and Dalley, 2006; Hamill and Knutzen, 2009; Culham and Peat, 1993)

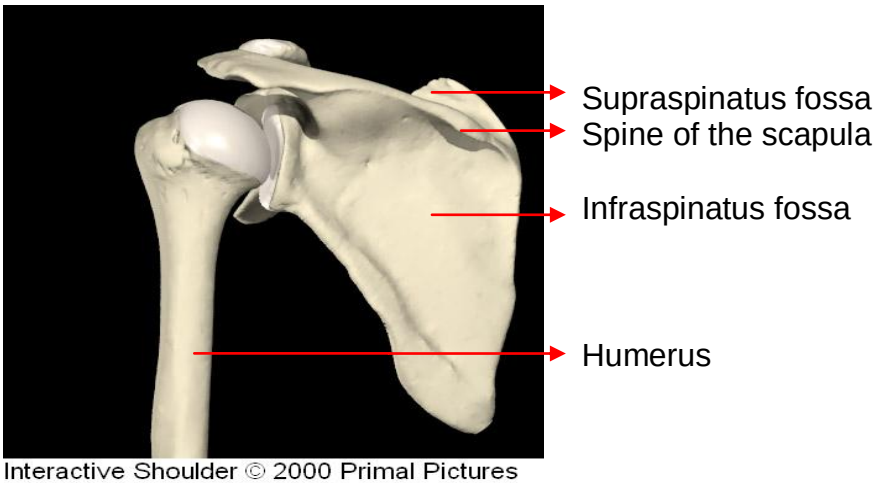
Ligaments	Attachments	Function
Sternoclavicular	Anterior: Anterior sternum to clavicle. Posterior: Posterior sternum to clavicle.	Reinforces the joint capsule and prevents anterior and posterior movement.
Interclavicular	Sternal end of the clavicle to opposite clavicle.	Strengthens the joint capsule superiorly and limits downward movement of the proximal clavicle.
Costoclavicular	Superior border of the first rib to inferior clavicle.	Limits clavicular protraction and checks clavicular elevation.

2.2.1.4 Scapula and Scapulothoracic Joint

As shown in Figure 2.3, the scapula is a triangular flat bone that lies on the posterior lateral aspect of the thorax between the second and seventh thoracic vertebra (Culham and Peat, 1993; Sahrmann, 2005; Moore and Dalley, 2006). The scapula

provides the base from which the upper limb operates, and is capable of considerable movement on the thoracic wall and plays an important role in controlling the position of the glenoid (Sahrmann, 2005; Moore and Dalley, 2006). According to Donatelli (2012) and Wilk, Reinold and Andrews (2009), there are three variations to the shape of the acromion; it can be either flat, curved or hooked. Chang (2004) found that a curved acromium was the most common. The curved or hooked shape acromion has an increased incidence of rotator cuff tears and is clinically important as it helps indicate the type of management that will be most beneficial to the patient (Gill et al., 2002).

The anterior surface of the scapula is concave and sits flush on the convex posterior thoracic wall. Therefore, any postural changes that affect the thorax compromise the stability of the scapulothoracic joint (Oscar, 2012). The thorax forms a mobile yet steady base for the scapula to rest upon. Due to the STJ's lack of ligamentous support it requires muscular attachments from the scapula to the thorax, as described in Table 2.6, for stability of the joint, the trapezius and serratus anterior are the most important stabilizing muscles of the STJ (Mottram, 1997).



Interactive Shoulder © 2000 Primal Pictures Ltd.

Figure 2.3: Posterior aspect of the scapula (Reprinted with permission from Primal pictures, 2000)

The scapulothoracic joint (STJ) is a pseudo-articulation of the scapula on the thorax, this joint has no ligamentous support, joint capsule, synovial membrane or synovial fluid and is therefore not a true joint; however, it has an intimate relationship with the integrity of the shoulder complex (Oscar, 2012). The function of the scapulothoracic

joint is to place the humerus in the optimal positional alignment that improves the functional support of the glenohumeral joint (Oscar, 2012).

2.2.1.5 The Coracoacromial Arch and the Subacromial Space

The coracoacromial arch forms an osteoligamentous chamber over the humeral head; between the arch and the humeral head is the subacromial space. The subacromial space, also known as the supraspinatus outlet, is formed by the acromion, the coracoacromial ligament, inferior surface of the ACJ and the coracoid process (the coracoacromial arch) superiorly and the greater tuberosity of the humerus and the superior aspect of the humeral head inferiorly (Levangie and Norkin, 2011; Bigliani and Levine, 1997). The following soft-tissue structures exist in this space:

- The rotator cuff tendons;
- The long head of the biceps tendon; and
- The subacromial bursa (Levangie and Norkin, 2011).

The coracoacromial arch protects the subacromial space from direct trauma superiorly and acts as a physical barrier to superior translation of the humeral head, preventing superior dislocation of the shoulder (Levangie and Norkin, 2011).

2.2.2 Muscles of the Shoulder Complex

The shoulder complex (SC) relies on the mobility and stability of the GHJ and STJ (Moore and Dalley, 2006). The muscular support for the SC comes from the rotator cuff muscles, scapula stabilizers and rotator and muscles of the arm (biceps brachii, triceps brachii and the coracobrachialis), as seen in Tables 2.4 and 2.5 (Culham and Peat, 1993; Mottram, 1997). These muscles help resist against dislocation of the shoulder (Moore and Dalley, 2006). For the purpose of this study the discussion will be limited to the rotator cuff, scapula stabilizers and rotator muscles.

Table 2.4: Rotator cuff muscles (adapted from Travell, Simons and Simons, 1999 and Moore and Dalley, 2006)

Muscles	Proximal Attachment	Distal Attachment	Innervation	Action
Supraspinatus	Supraspinatous fossa of the scapula.	Greater tubercle of the humerus.	Suprascapular nerve.	Abduction of the arm, pulls the humeral head into the glenoid fossa, this prevents downward displacement of the humeral head and stabilizes the humeral head in the glenoid cavity during movement of the arm.
Infraspinatus	Infraspinous fossa of the scapula.	Greater tubercle of the humerus.	Suprascapular nerve.	Laterally rotates the arm at glenohumeral joint and helps stabilize the humeral head in the glenoid cavity during movement of the arm.
Teres Minor	Upper two-thirds of the lateral border of the scapula.	Greater tubercle of the humerus.	Axillary nerve.	Helps stabilise the glenohumeral joint and laterally rotates the humerus.
Subscapularis	Subscapular fossa of the scapula.	Lesser tubercle of the humerus.	Superior and inferior subscapular nerves.	Acting alone medially rotates and adducts the arm, helps stabilize the humeral head in the glenoid cavity and prevent anterior displacement of the humerus.

The rotator cuff muscles help stabilize the GHJ as they blend with and reinforce the GHJ capsule (Culham and Peat, 1993). The scapula muscles play an important role in stabilizing the STJ during arm movement, especially the serratus anterior and trapezuis muscles (Mottram, 1997), and are also involved in rotation of the scapula.

Table 2.5: Scapulae stabilizers and rotator muscles (adapted from Travell, Simons and Simons, 1999 and Moore and Dalley, 2006)

Muscles	Proximal Attachment	Distal Attachment	Innervation	Action
Trapezius	Upper: medial 1/3 of the superior nuchal line and ligamentum nuchae. Middle: SP; interspinous ligaments of C6 to T3. Lower: SP and the interspinous ligaments of the T4 to T12.	Upper: posterior border lateral 1/3 of clavicle. Middle part: medial margin of the acromion; superior lip of the scapulae spine. Lower: tubercle at the medial end of the spine of the scapula.	Spinal portion of the accessory nerve (cranial nerve XI).	Upper: elevates the clavicle and the scapula and rotates the glenoid cavity superiorly. Middle: adduction of the scapula. Lower: depresses the scapula and inferiorly rotate the glenoid cavity.

Levator Scapulae	TVP of C1 to C4.	Medial border of the scapula.	3rd and 4th cervical nerves and sometime by fibres from the dorsal scapula nerve.	When the neck is stabilized, causes rotation of the scapula causing downward rotation of the glenoid fossa and elevate the scapula as a whole.
Serratus Anterior	Superior: superior angle of the scapula. Middle: vertebral border of the scapula. Inferior: inferior angle of the scapula.	Superior: first rib. Middle: half the length of the second and third ribs. Inferior: 4th to 8th/9th ribs.	Long thoracic nerve.	Move the scapula upward, laterally and forward.
Rhomboid Minor	Ligamentum nuchae and to the SP of the C7 and T1 vertebra.	Medial border of the scapula.	Dorsal scapula nerve.	Adduction and elevation of the scapula.
Rhomboid Major	SP of the T2 to T5.	Medial border of the scapula.	Dorsal scapula nerve.	Medial rotation of the scapula, turning the glenoid fossa downwards.
Pectoralis Major	Clavicular fibres: anterior surface of the medial half of the clavicle. Sternal fibres: anterior surface of the sternum. Costal fibres: superior 6 costal cartilages and aponeurosis of the external oblique muscle.	Lateral lip of the intertubercular groove of the humerus.	Lateral and medial pectoral nerves.	Adducts and medially rotates the humerus, draws the scapula anteriorly and inferiorly.
Pectoralis Minor	3rd to 5th ribs near their costal cartilages.	Medial border and superior surface of the CP of the scapula.	Medial pectoral nerve.	Stabilizes the scapula by drawing it inferiorly and anteriorly against the thoracic wall.
Latissimus Dorsi	SP of the lower 6 thoracic vertebrae and all the lumbar vertebrae, sacrum via the lumbar aponeurosis and the posterior part of the crest of the ilium.	Floor of the intertubercular groove of the humerus May be directly or indirectly attached to the inferior angle of the scapula.	Thoracodorsal nerve.	Extends the arm at the shoulder joint, adducts and assists in medial rotation of the arm, and depression of the humerus. Acting through the glenohumeral joint, adducts the scapula and draws the shoulder girdle downward and backwards.

2.3 THE THORACIC SPINE

The thoracic spine lies between the cervical and lumbar spine, and consists of twelve vertebrae with interposing intervertebral discs (Moore and Dalley, 2006). Its role is to provide protection to the thoracic portion of the spinal cord (Crossman and Neary, 2005) and through its attachments with the ribs it protects the thoracic viscera and some of the abdominal organs (Moore and Dalley, 2006).

The thoracic spine consists of both typical (T2-T9) and atypical (T1, 10-12) vertebrae (Moore and Dalley, 2006). The structures of a thoracic vertebra are illustrated in Figure 2.4. Unique features of the typical thoracic vertebrae include bilateral superior and inferior demifacets on their body for articulation with the tubercles of the ribs, a facet on the anterior surface of the transverse processes (TVP) for articulation with the corresponding rib, a smaller vertebral canal which is round in shape compared to the other spinal regions, and long inferiorly slanting spinous processes (Moore and Dalley, 2006; Cramer and Darby, 2005).

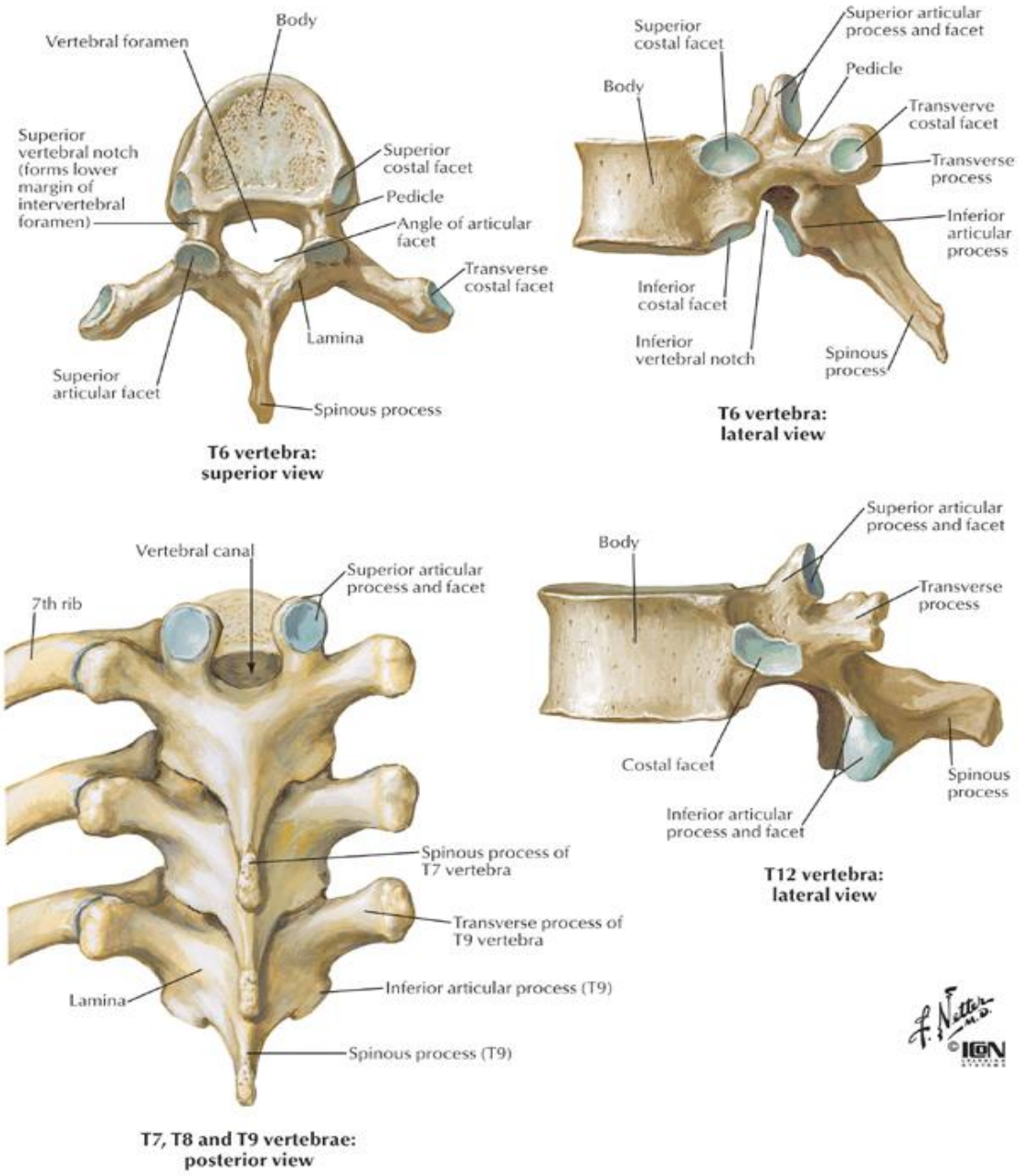


Figure 2.4: Structure of the thoracic vertebra (Netter, 2011)

The first thoracic vertebra is the only atypical vertebra that contains a single facet for articulation with the first fib and a typical inferior demifacet and has uncinate processes to articulate with the seventh cervical vertebrae (Moore and Dalley, 2006). Atypical vertebrae (T10-12) have a single facet on either side of the vertebral body for articulation with the corresponding ribs. The twelfth thoracic vertebral body is larger with smaller transverse processes and no costal facet on the TVP (Moore and Dalley, 2006; Cramer and Darby, 2005).

2.3.1 Range of Motion of the Thoracic Spine

In the thoracic spine range of motion is limited by the ratio of intervertebral disc to vertebral body height and the attachment of the ribs (Maigne, 2006). As seen in Table 2.6, flexion and extension is the most limited, with rotation and lateral flexion demonstrating nearly equal movement. Movement in the thoracic spine is generally decreased in the upper segments, with the exception of rotation which decreases dramatically in the lower segments (Bergmann and Peterson, 2002).

Table 2.6: Range of motion of the thoracic spine (Bergmann and Peterson, 2002)

	Flexion	Extension	Lateral Flexion	Rotation
Upper thoracic	± 4°	± 4°	± 6°	± 8° - 9°
Middle thoracic	± 6°	± 6°	± 7° - 9°	
Lower thoracic	± 12°	± 12°	± 7° - 9°	± 2°

2.3.2 Joints of the Thoracic Spine

2.3.2.1 The Zygapophyseal Joints

The zygapophyseal joints are synovial, planar joints (Cramer and Darby, 2005) that are orientated in close approximation to the frontal plane and are inclined 60° from the horizontal (Maigne, 2006). The surface of each articular process is covered by hyaline cartilage (Cramer and Darby, 2005).

The zygapophyseal joints are surrounded by a capsule that posteriolaterally attaches to the superior and inferior articular facets of adjacent vertebra, is relatively thin and loose and does not limit motion but helps stabilise the joint during motion (Cramer and Darby, 2005). Anterio-medially the joints are covered by the ligamentum flavum. The synovial membrane lines the articular capsule, ligamentum flavum and the synovial folds but does not line the articular facets (Cramer and Darby, 2005).

The zygapophyseal joint receives sensory innervation from the medial branch of the posterior primary division at the level of each joint and additional innervation from the level above and below (Cramer and Darby, 2005). The zygopophyseal joint has four types of sensory receptor endings as described in Table 2.7.

Table 2.7: Sensory receptors of the zygopophyseal joint (Wyke, 1985)

Fibres	Morphology	Situated	Diameter	Functional Characteristic
Type I	Globular or ovoid.	Outer layer of the fibrous joint capsule.	5-8	Mechanoreceptor, low threshold, slow adapting.
Type II	Cylindrical or tapered.	Fibrous joint capsule.	8-12	Mechanoreceptor, low threshold, fast adapting.
Type III	Spindle-like.	Surface of the joint ligament.	13-17	Mechanoreceptor, high threshold, very slow adapting.
Type IV	Non myelinized plexus.	Entire thickness of the joint capsule.	2-5	Pain receptor.
	Non myelinized free endings.		< 2	Pain receptor.

Stimulation of the joint receptors results in an afferent input to the CNS via the sensory nerves, which is then processed by the CNS and an appropriate response is sent via an efferent output to the relevant muscles (Tortora and Derrickson, 2006). Type I and II receptors have a pain suppressive effects as well as a reflexogenic effect, which causes normalization of muscle activity of the spinal column when stimulated. The reflexogenic effect is thought to occur at the level above and below as well as at the site of stimulation (Cramer and Darby, 2005).

2.3.2.2 The Costovertebral Joints

There are two places where the rib articulates with the vertebrae. The first which is the costocorporeal joint, where the rib head articulates with the superior demifacet of the same vertebra and the inferior demifacet of the vertebra above. A short, flat ligament attaches the crest of the rib head to the adjacent intervertebral disc (Cramer and Darby, 2005).

The second is the costotransverse joint which consists of the costal tubercle of the rib articulating with the transverse costal facets of the transverse process. A thin, fibrous capsule lined by a synovial membrane attaches to the two adjacent articular surfaces (Cramer and Darby, 2005). According to Sizer, Phelps and Azevedo, (2001) the costovertebral and costotransverse joints are innervated by the ventral rami at the thoracic space which are known as the intercostals nerves except for the 12^{th} ventral rami which is the subcostal nerve.

2.4 OVERVIEW OF THE NERVOUS SYSTEM

The nervous system is divided into the central nervous system (CNS) and peripheral nervous system (PNS) (Crossman and Neary, 2005). The CNS consists of the brain and spinal cord, which is protected by the skull and vertebral column, and the PNS includes all the nervous tissue outside of the CNS (Crossman and Neary, 2005; Tortora and Derrickson, 2006). The PNS connects the spinal cord to the spinal nerves via the anterior and posterior roots (Crossman and Neary, 2005).

The anterior and posterior roots emerge from the spinal cord and unite to form a spinal nerve at the intervertebral foramen (Tortora and Derrickson, 2006). The spinal nerve connects the CNS to the sensory receptors, muscles and glands.

Afferent neurons carry information that is detected from external and internal stimuli from the sensory receptors to the CNS via the posterior root and dorsal root ganglion. The efferent neurons carry information from the CNS via the anterior root to muscles and glands where an appropriate response will occur (Tortora and Derrickson, 2006).

When an injury occurs in a joint an arthrogenic muscle response may occur. Arthrogenic muscle inhibition (AMI) is a presynaptic, ongoing reflex inhibition of muscles surrounding a joint after damage or distension to that joint. AMI is a natural response by the nervous system which protects a joint from further damage (Hopkins et al., 2001; Hart et al., 2010). AMI causes an inability to completely contract a muscle despite no structural damage to the innervating nerve or muscle (Hart et al., 2010). It is proposed that spinal manipulation results in the activation of mechanoreceptors and proprioceptors in and around the manipulated joint which causes an altered afferent input to the motor neuron pool (Suter et al., 2000). This causes a change in the motor neuron excitability, resulting in an increase in motor neuron recruitment and thus a decrease in AMI (Suter et al., 2000). Decreased muscle inhibition and an increase in muscle strength has been observed after spinal manipulation (Suter et al., 1999).

2.5 BIOMECHANICS OF THE SHOULDER COMPLEX

The four joints of the shoulder complex must work together to create coordinated arm movement. As the arm is flexed or abducted the scapula rotates upward to allow full flexion and abduction at the GHJ and for this scapula motion to occur the clavicle must elevate and rotate upwards (Hamill and Knutzen, 2009). During the early stages of flexion and abduction, the movement occurs primarily at the GHJ with a stabilizing motion (either towards or away from the vertebral column) of the scapula (Hamill and Knutzen, 2009). After 30° abduction and/or 46° to 60° flexion of the glenohumeral joint, the glenohumeral to scapula movement ratios become 5:4 (therefore there is 5° of humeral movement for every 4° of scapula movement) (Hamill and Knutzen, 2009). This scapulohumeral rhythm is fundamental to maintaining the subacromial space (Feil and Morgan, 2010).

Optimal shoulder motion requires normal scapula and thoracic spine motion (Feil and Morgan, 2010). The thoracic spine moves with movement of the shoulder; during shoulder flexion the thoracic spine extends and when the shoulder extends the thoracic spine flexes, as the shoulder goes into abduction the thoracic spine laterally flexes away from the abducting shoulder. Altered alignment, joint fixation and/or changes in the motion of the thorax will result in compensatory motion of the shoulder complex (Oscar, 2012).

The scapula resting position may be altered in individuals with abnormal cervical and thoracic spine sagittal alignment, which will lead to decreased range of motion of the upper extremity, shoulder dysfunction and weakness and/or contraction of the scapula stabilizing muscles (Culham and Peat, 1993).

The scapula's only bony attachment to the axial skeleton is through the sternoclavicular joint (Donatelli, 2012). Thus, maintaining the scapula's proper position is highly reliant on the coordinated efforts of the surrounding musculature such as the serratus anterior, rhomboids, trapezius and levator scapulae muscles. Pathology in one or all of these muscles may lead to biomechanical changes which may cause or contribute to various shoulder pathologies, such as shoulder impingement syndrome (Hyde and Gengenbach, 2007). Scapular dyskinesis is the term given to alteration of the normal motion of the scapula during humeral

movements or an altered scapula position (Sahrmann, 2005; Voight and Thomson, 2000). Three visible patterns occur:

- Type I: prominence of the inferior medial scapula border;
- Type II: prominence of the medial scapula border; and
- Type III: prominence of the superomedial scapula border.

Scapula dyskinesis has been associated with shoulder impingement syndrome, rotator cuff tears, glenoid labrum tears and glenohumeral instability (Tate et al, 2009; Kawasaki et al, 2012; Clarsen et al, 2014). The most common cause of scapular dyskinesis is alteration in the function of the muscles that control the movement of the scapula (Paine and Voight, 2013), and has therefore been related to alterations in posture Kibler (1998). In patients with increased thoracic kyphosis, rounded shoulders and forward head carriage, the scapula rotates forward and downward, depressing the acromial process and changing the direction of the glenoid fossa. The supraspinatous tendon may become impinged against the anterior portion of the acromion as the patient attempts to elevate their arm (Gumina et al, 2008). Gumina et al (2008) suggests that the subacromial space is directly related to the severity of thoracic kyphosis. Therefore scapular dyskinesis and the lack of scapula stabilization have been related to impingement syndromes (Oscar, 2012).

2.6 EPIDEMIOLOGY OF SHOULDER PAIN

The one year prevalence of shoulder pain is approximately 51% and its lifetime prevalence is about 10% in the general population. Shoulder pain is the third most common musculoskeletal problem encountered and is exceeded only by low back and neck pain. Approximately 50% of shoulder pain patients seek medical care, 95% of those are treated in primary health care practices (Pribicevic et al, 2009). The most prevalent medical clinical diagnosis for shoulder pain is shoulder impingement syndrome, accounting for 44-65% of all shoulder pain complaints (van der Windt et al, 1995; Pribicevic et al, 2009).

In the athletic population shoulder pain is prevalent with 66% of competitive swimmers, 57% of professional pitchers, 44% of collegiate volleyball players and javelin throwers (29%) suffering shoulder pain (Pribicevic et al, 2009).

Pribicevic et al (2009) showed that there is a moderate prevalence of shoulder pain in the chiropractic clinical practice with the most prevalent diagnosis of shoulder pain includes rotator cuff tendinitis/tendinosis with impingement (18%), followed by rotator cuff tendinitis/tendinosis without impingement (15%) and impingement syndrome (13%). It was shown by Kandhai (2007) and McDonald (2012) that the shoulder was most common upper extremity region treated in the DUT Chiropractic Day Clinic second only to the knee in the lower extremity.

2.7 SHOULDER IMPINGEMENT SYNDROME

Shoulder impingement syndrome can be defined as a collection of shoulder signs and symptoms caused by pathology within the rotator cuff tendon or structures external to it, causing impingement in the space between the acromion and humeral head (De Yang Tien and Hwee Chye Tan, 2014).

Shoulder impingement syndrome is divided into three stages (Neer 1983; Van Holsbeeck et al., 1991; Donatelli, 2012; Khan et al., 2013):

- Stage One

This stage is characterized by oedema and haemorrhage of the rotator cuff and Subacromial bursa (Van Holsbeeck et al., 1991; De Yang Tien and Hwee Chye Tan., 2014; Escamilla, Hook, and Wilk., 2014). The clinical presentation includes pain along the anterior or lateral aspect of the shoulder; the pain is usually characterised as a deep, dull ache, and can be sharp during elevation of the arm (Donatelli, 2012). It usually occurs in patients younger than 25 years of age and the most common precipitating factor is overuse of the shoulder (Van Holsbeeck et al., 1991; Khan et al., 2013; De Yang Tien and Hwee Chye Tan, 2014; Escamilla, Hook, and Wilk, 2014). Many patients in this stage will exhibit scapula postural changes which including excessive downward rotation and anterior tilting of the scapula (Donatelli, 2012). This stage is usually reversible with conservative treatment (Chang, 2004; Khan et al., 2013; Escamilla, Hook, and Wilk, 2014).

- Stage Two

This stage is characterized by tendonitis of the involved tendons and fibrosis of the glenohumeral capsule, and subacromial bursa (Van Holsbeeck et al., 1991; Khan et

al., 2013; De Yang Tien and Hwee Chye Tan, 2014 Escamilla, Hook, and Wilk, 2014). The clinical presentation is similar to that of Stage One but there is loss of active and passive range of motion, which normally occurs in the capsular pattern (loss of lateral rotation, abduction and medial rotation (Magee, 2008)). Usually seen in patients between age 20 and 40 (Van Holsbeeck et al., 1991; Khan et al., 2013; De Yang Tien and Hwee Chye Tan, 2014; Escamilla, Hook, and Wilk, 2014). This stage may not respond to conservative treatment and may need operative intervention (Chang, 2004; Khan et al., 2013).

- Stage Three

This stage is characterised by disruption of the rotator cuff tendons and changes in the coracoacromial arch with osteophyte formation on the anterior acromion. Usually seen in patients that are over the age of forty (Van Holsbeeck et al., 1991; Chang, 2004; Khan et al., 2013; Escamilla, Hook, and Wilk, 2014). Clinically, the patients presents with weakness in external rotation and abduction (Donatelli, 2012). This stage commonly requires operative intervention (Chang, 2004).

2.7.1 Aetiology

The aetiology is divided into three broad categories: primary, secondary and internal impingement syndrome (Hattam and Smeatham, 2010; Magee, 2008; Ferro et al., 2003). Studies have shown that people who suffer with shoulder pain have a decreased subacromial space (7-13 mm) as compared to non-painful shoulders (6-14 mm) (Donatelli, 2012).

2.7.1.1 Primary Impingement

Primary impingement is due to mechanical compression of the bursa or the superior aspect of the rotator cuff, mainly involving the supraspinatous tendon, against the anterior, inferior aspect of the acromion and/or the coracoacromial ligament (Hattam and Smeatham, 2010; Wolin and Tarbet, 1997).

This impingement occurs when there is an anatomical structure which exerts a direct influence on the supraspinatus outlet (Hyde and Gengenbach, 2007), such as

acromial morphology. A hooked type acromion has been strongly associated with full-thickness tears of the rotator cuff; other causes could be from an inferior acromial spur, hypertrophy of the coracoacromial ligament, increased subacromial loading, trauma (direct macrotrauma or repetitive microtrauma), overhead activity and subacromial bursitis and fibrosis (Khan et al., 2013; Chang, 2004).

2.7.1.2 Secondary Impingement

Secondary impingement occurs as a result of glenohumeral instability or functional scapulothoracic instability which causes a relative decrease in the subacromial space (Kamkar, Irrgang and Whitney, 1993). Weakness of the scapulothoracic muscles leads to abnormal positioning of the scapula and anterior impingement of rotator cuff underneath the coracoacromial arch (Kamkar, Irrgang and Whitney, 1993; Hattam and Smeatham, 2010), such as compression of the subacromial bursa, supraspinatus and long head of the bicep tendon. This is supported by Hyde and Gengenbach (2007) who state that the stabilizing muscles of the scapula and the rotator cuff muscles are most commonly involved.

The subacromial space is where impingement occurs if there is abnormal depression by the rotator cuff muscle or abnormal scapulothoracic joint position such as when the scapula is held in a protracted and inferior position. The more inferior the scapula moves the less able it is to elevate and avoid impingement during abduction and forward flexion of the glenohumeral joint (Hyde and Gengenbach, 2007; Gumina et al, 2008; Paine and Voight, 2013). This results in a scapula dyskinesis (Hyde and Gengenbach 2007; Hammer, 2007; Paine and Voight, 2013).

2.7.1.3 Internal Impingement

Internal impingement occurs primarily with repetitive overhead activity especially in throwers, when their arm is abducted to 90 degrees and maximally externally rotated, but it may also occur in the general population (Wolin and Tarbet 1997; Castagna et al, 2010; Escamilla, Hook, and Wilk, 2014). Impingement of the posterior inferior aspect of the supraspinatus and infraspiantus tendons occurs between the humeral head and labrum, the joint capsule may also be involved (Wolin and Tarbet, 1997; Castagna et al, 2010; De Yang Tien and Hwee Chye Tan., 2014), leading to fraying

of the posterosuperior aspect of the labrum and a tear to the under surface of the rotator cuff (Wolin and Tarbet, 1997, Escamilla, Hook, and Wilk, 2014). The typical symptom includes posterior superior shoulder pain (Beltran, Nikac, and Beltran, 2012).

2.7.2 Diagnosis

The diagnosis of shoulder impingement syndrome remains a clinical one and initial assessment is crucial (Khan et al, 2013). The assessment includes a thorough history and detailed physical examination to make the correct diagnosis (Ferro et al., 2003). During the history the patient will typically complain of anterolateral acromion pain that may radiate to lateral aspect of the humerus, normally with an insidious onset but may be associated with trauma (Koester, George and Kuhn, 2005).

2.7.2.1 Orthopaedic Tests

Common clinical orthopaedic tests used to diagnose shoulder impingement syndrome are described:

- Impingement test

The patients arm is forcefully elevated and medially rotated in the scapula plane by the examiner. This will approximate the greater tuberosity against the anteroinferior border of the acromion (Ferro, 2003; Chang, 2004). A positive test is indicated by the participant reporting pain or their face displaying pain (Chang, 2004). According to Park et al. (2005) the impingement test is the most sensitive (85.7%) and specific (49.2%) with the highest positive (20.9%) and negative (95.7%) predictive values for rotator cuff tendinitis or bursitis.

- Empty can test

In this test the patients arm is abducted to 90º and then medially rotated so that the thumbs pointed towards the floor in the scapula plane. The examiner provides resistance to abduction (Ferro, 2003; Chang, 2004). A positive test is indicated by the participant reporting pain or if weakness is noted by the examiner (Ferro, 2003). Itoi et al. (1999) show that the empty can test is sensitive (63%) and specific (55%) for

pain and sensitive (77%) and specific (68%) for muscle weakness of the supraspinatus.

- Hawkins-Kennedy impingement test

The patient stands while the examiner forward flexes the arm to 90 degrees and then forcibly medially rotates the shoulder (Ferro, 2003; Chang, 2004). This movement pushes the supraspinatus tendon against the anterior surface of the coracoacromial ligament and coracoids process (Ferro, 2003; Chang, 2004). A positive test is indicated if the participant reports pain during the test (Ferro, 2003; Chang, 2004). According to Park et al. (2005) the Hawkin-Kennedy impingement test is sensitive and specific for rotator cuff tendinitis or bursitis. This test is more sensitive when combined with the impingement test for partial rotator cuff tear (Park et al., 2005).

- Apprehension test and/or relocation test

As the patient lies supine their arm is abducted to 90° by the examiner and slowly laterally rotated. A positive test is indicated when the participant looks or feels apprehensive or alarmed and resists further motion (Chang, 2004). The examiner then applies a posteriorly directed pressure to the humeral head, a positive test being indicated if the participant becomes more at ease with the apprehension test due to the pressure on the anterior humeral head (Chang, 2004). According to Magee (2008) the apprehension test is reliable and specific.

2.7.2.2 Scapular Dyskinesis Tests

The following tests may be used to determine scapula dyskinesis.

- Scapular isometric pinch test

The patient is asked to stand and then instructed to actively “pinch” or retract the scapulae together as hard as possible and to hold the position for as long as possible. This is timed if the participant feels burning in less than 15 seconds or relaxes slightly in order to hold the contraction in a more comfortable position for longer periods without burning. This indicates weakness in the scapula retractors (Voight and Thomsom, 2000; Magee, 2008). According to Voight and Thomson (2000) the scapula isometric pinch test is valid and properly objectifies scapula muscle weakness when used in conjunction with the lateral scapula slide test.

- Lateral scapula slide test

This test determines the stability of the scapula during movement of the glenohumeral joint. The patient is seated with their arm at their side, then the examiner measures the following distances:

  - The base of the spine of the scapula to the spinous process of T2 or T3; and
  - The inferior angle of the scapula to T7-T9.

These measurements are taken again at the following angles of glenohumeral abduction: 45 degrees with the hands on waist with thumbs pointing posteriorly, 90 degrees with arm straight and thumb down, 120 degrees and 150 degrees (Voight and Thomsom, 2000; Magee, 2008). According to Voight and Thomsom (2000); Kibler (1998) the lateral scapula slide test is reliable and valid.

- Lennie test

This test determines the normal scapula resting position in the frontal plane (Sobush et al., 1996). It is performed with the participant's arms by their sides. A measurement is then taken from the spinous processes horizontally to three scapula positions: the superior angle, the spine of the scapula and the inferior angle (Sobush et al., 1996 and Magee, 2008). Sobush et al. (1996) showed that this test is valid and reliable.

2.7.2.3 Diagnostic Imaging

The clinical orthopaedic examination is often supported by imaging investigations (Lewis, 2011). Plain film shoulder x-rays are not considered to be useful for soft tissue shoulder disorders such as tendonitis and bursitis(Bussieres, Peterson and Taylor., 2008; Hopman et al, 2013). Shoulder x-rays could display subacromial spurs or anomalies of the acromion and are important in the differential diagnoses of shoulder impingement syndrome as they may demonstrate calcific tendinitis, fractures and neoplasm (Khan et al., 2013).

Ultrasound (US) examination is widely utilized for evaluation of rotator cuff pathology of the shoulder. It is sensitive and accurate in identifying full thickness tears and can help confirm, but not exclude, a clinical diagnosis of impingement syndrome (Khan et al., 2013). US is non-invasive, cost effective and has high sensitivity but it is operator, interpreter and technique dependent (Chang, 2004).

Magnetic resonance imaging is considered the imaging study of choice for shoulder pathology (Chang, 2004), but it is comparable to US in both sensitivity and specificity, therefore it should be reserved for complex cases due to its cost (Chang, 2004; Khan et al., 2013).

2.7.2.4 Differential Diagnosis

Shoulder impingement syndrome is a challenge to diagnose, as there is a potential for multiple disorders to occur and there are many different aetiologies to consider (Stevenson and Trojian, 2002). Some of the more common differential diagnoses are:

- Calcific tendonitis: characterized by an acute onset of intense shoulder pain that is neither positional nor activity dependent. There is generally no history of trauma or overuse of the effected extremity and the onset of pain and loss of motion is typically rapid. The rapid onset differentiates it from impingement syndrome. Calcium deposits may be seen on plain x-rays and on ultrasound of the effected extremity (Wolf, 1999).
- Cervical radiculopathy: patients may present with unilateral shoulder pain and experience pain, numbness or paresthesias radiating to the arm and hand. Shoulder pain of a cervical origin may be associated with limited cervical range of motion and pain and spasm in the muscles in the neck (Koester, George and Kuhn, 2005).
- Coracoids impingement: a relatively rare cause of anterior shoulder pain. This is generally caused by chronic overuse with a history of microtrauma as a result if the shoulder being forward flexed, adducted and internally rotated (Khan et al., 2013).
- Acromioclavicular joint arthritis: this is commonly seen in individuals with a history of heavy labour or weightlifting but may occur in anyone. Pain is localized to the acromioclavicular joint itself or it could refer to the upper shoulder and neck. The diagnosis is normally made by the physical examination, with marked tenderness over the acromioclavicular joint and pain with compression of the joint through adduction of the elevated arm. Osteoarthritic changes will be seen on shoulder radiographs (Koester, George and Kuhn,2005).

- Adhesive capsulitis (frozen shoulder): the aetiology of this condition is unknown but it is thought to be an inflammatory process, which is more commonly seen in women in their 50s and 60s. The early stage may present like impingement syndrome but the later stage results in loss of active and passive motion. This differentiates adhesive capsulitis from shoulder impingement where passive motion is unrestricted (Koester, George and Kuhn,2005).

2.7.3 Management

Conservative management is the optimal approach when treating shoulder impingement syndrome. The treatment should be aimed at addressing the underlying aetiology (Escamilla, Hook and Wilk, 2014). Operative management should be considered when, a six month trail of conservative management fails to produce results (Bigliani and Levine, 1997).

2.7.3.1 Conservative Treatment

Conservative treatment has proven very effective and is the treatment of choice for shoulder impingement syndrome (Wilk, Reinold and Andrews, 2009). Most patients with shoulder impingement syndrome will recover with non-operative treatment (Bigliani and Levine, 1997).

The first phase of treatment is aimed at normalizing motion, decreasing pain and inflammation, educating the patient on activity modification and avoidance (Escamilla, Hook, and Wilk, 2014), maintaining joint mobility of the shoulder, treating spinal dysfunction and preventing atrophy (Chang, 2004; Wilk, Reinold and Andrews, 2009). During this phase of treatment it is important not to aggravate the impingement symptoms, which can be accomplished by resting from the activity which is producing the pain and applying cyrotherapy and short term non-steroidal anti-inflammatory drugs, if not contraindicated (Wilk, Reinold and Andrews, 2009). Tendinopathies that are associated with shoulder impingement syndrome are characterized by the absence of inflammatory cells (Magra and Maffulli, 2006; Loppini and Maffulli, 2011). However, the literature that discusses the treatment of shoulder impingement syndrome indicates that decreasing inflammation is a primary

goal even with the studies showing the absence of inflammation (Escamilla, Hook and Wilk, 2014).

The second phase of treatment is similar to the first phase with the primary difference being an emphasis on circulatory advancement (including ultra-sound, effleurage massage, ice and transverse friction massage). Joint mobility is increased as the patient can tolerate this and the prevention of atrophy must be maintained (Wilk, Reinold and Andrews, 2009). Isometric exercises should start in non-painful planes below the shoulder level. In the second phase of treatment strengthening of the scapula stabilizers (which include the trapezius, levator scapulae, rhomboid major, rhomboid minor and the serratus anterior muscles) can restore proper scapulohumeral motion (Wolin and Tarbet, 1997).

The third phase of treatment aims at normalizing range of motion of the shoulder by aggressive mobilization, self-capsular stretching, regaining and improving strength and improving neuromuscular control of the shoulder (Wilk, Reinold and Andrews, 2009). Strength can be improved by introducing isometric exercises for the rotator cuff, deltoid and scapula stabilizers; this stabilizes the humeral head in the glenoid and prevents superior movement leading to impingement. The isotonic exercises are initially done with light weights or elastic bands and below shoulder level to prevent re-injury (Wolin and Tarbet, 1997). According to Hyde and Gengenbach (2007) rehabilitation for shoulder impingement syndrome should be focused on the scapula as it is the foundation for the treatment of this condition, as distal mobility is only possible with proximal stability.

The above therapies have had limited success and in an effort to increase clinical efficacy, clinicians and researchers have started to expand their treatment to include regions adjacent to the shoulder which includes thoracic spinal manipulation (Sueki and Chaconas, 2011). Manipulation of the thoracic spine is a common therapy used in the treatment of shoulder pain and dysfunction (Sueki and Chaconas, 2011).

In general, conservative treatments continue for 3-6 months. If the patient continues to improve, which occurs in approximately 60-90 percent of the patients then conservative treatment should continue beyond the 3-6 month time frame (Bigliani and Levine, 1997).

2.7.3.2 Operative Treatment

If there is no reduction in symptoms with conservative treatment or a complete rupture of the rotator cuff is identified then operative treatment may be indicated, particularly in younger patients (Bigliani and Levine, 1997; Khan et al., 2013). There are two structures that need to be addressed when using surgery for shoulder impingement syndrome, which are the acromion and the rotator cuff (Khan et al., 2013).

The operative treatment is an acromioplasty with resection of the anterior-inferior portion of the acromion (Neer, 1972). This allows for a decreased degree of impingement of the rotator cuff under the acromion and an increase in the volume of the subacromial space (Khan et al., 2013). According to Bigliani and Levine (1997) anterior acromioplasty with resection of the coracoacromial ligament is the preferred treatment as there have been complications and unsatisfactory results with lateral resection of the acromion. An acromioclavicular resection is not a routine procedure unless the joint is tender or there are inferiorly protruding excrescences or osteophytes contributing to the impingement (Bigliani and Levine, 1997).

According to Dorrestijn et al (2009) there was no difference between surgically and conservatively treated patients with shoulder impingement syndrome, in terms of improved shoulder function and reduction of pain. Kromer et al (2009) showed that there was equal effectiveness of physiotherapy-led exercises compared to surgery in patients with shoulder impingement syndrome, especially in the long term (Kromer et al, 2009), however the authors suggested that that patients should be treated conservatively before undergoing surgery.

2.8 SPINAL MANIPULATIVE THERAPY

Spinal manipulative therapy (SMT) is a broad term that encompasses manual therapy procedures to passively introduce movement to the joint and soft tissue (Redwood and Cleveland, 2003). The therapeutic goals can be met by slight variations in velocity, rhythm and depth of the SMT combined with contact hand placement and patient positioning. There are many types of manipulative procedures that are possible throughout the spine (Olson, 2009).

SMT used by chiropractors is a unique form of manipulation characterised by a specific high-velocity, low-amplitude (HVLA) thrust within or at the end range of motion (Pickar, 2002). The thrust is designed to induce joint distraction and cavitation without exceeding the limits of anatomic joint motion. This is further characterised by a transmission force that uses a combination of muscle power and the body weight of the practitioner (Olson, 2009; Gatterman, 2005).

A manipulation can be delivered in one of two ways:
(1) The joint is held in the neutral position while specific contacts are made, neutral joint slack and tissue elasticity are removed and then the thrust is delivered;
(2) The joint is moved through its active and passive ranges of motion in the specific direction of the adjustment, and then the thrust is given at the end point of movement beyond the elastic barrier and into the paraphysiological space as illustrated in Figure 2.5 (Gatterman, 2005).

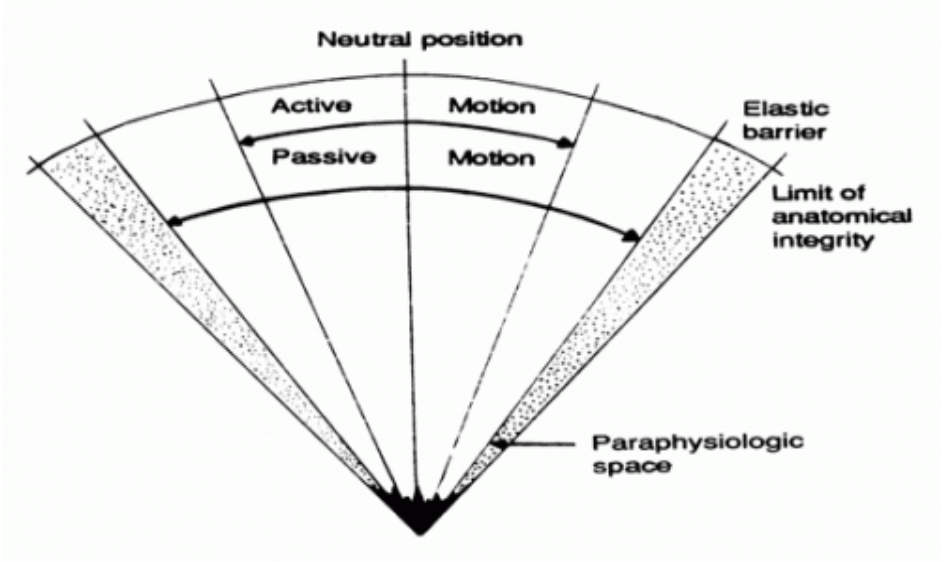


Figure 2.5: Anatomical and paraphysiological space (Gatterman, 2005)

2.8.1 Joint Dysfunction

The theoretical model for this motion segment dysfunction is the subluxation complex (SBLX) that incorporates the complex interaction of pathologic changes in nerves, muscles, ligaments, vascular and connective tissue (Gatterman, 2005; Redwood and

Cleveland, 2003). This clinical entity can be established by any of the following (Hyde and Gengenbach, 2007):

- Neurologic changes that may include irritation, compression, or both as well as possible autonomic changes;
- Kinesiologic changes including joint hypomobility, hypermobility, aberrant motion and/or loss of joint play;
- Myologic changes including hypertonicity, hypotonicity, or both, changes in muscle length and strength as well as muscle physiology changes leading to myofascial syndromes;
- Histologic changes including evidence of oedema and products of the inflammatory process as well as connective tissue pathology; and
- Biochemical changes including the effects of histamines, kinins, prostaglandins, serotonin and substance P.

All the components of the SBLX may not be effectively addressed with the adjustment alone, but the adjustment is thought to affect the movement component directly and this may have an indirect effect on the other components (Gatterman, 2005).

If the joint becomes immobilized in the incorrect position or will not move from the resting position, it is referred to as a joint fixation and results in decreased motion of that segment (Hyde and Gengebach, 2007). When the term joint dysfunction is used it refers to an alteration of the normal dynamics of the spine due to biomechanical derangement of the joint and disc. The process stimulates sustained hypertonicity of muscles, which alters the muscle metabolism; this muscle contraction maintains the dysfunction (Hyde and Gengebach, 2007). When joint dysfunction occurs it is characterised by pain, discomfort, stiffness, muscle spasm and chronic muscle shortening. Joint dysfunction may present in conjunction with other pathology or as an isolated diagnosis. The joint dysfunction does not have to give rise to local pain in the joint (Haldeman, 2005) and therefore the patient may be asymptomatic in the spinal region that the joint dysfunction occurs.

2.8.2 Causes of Joint Dysfunction

2.8.2.1 Vertebral Malposition

One of the theories of chiropractic is altered joint position due to trauma. These altered positions have been demonstrated radiographically. Trauma, disc degeneration, erosive arthritides and congenital factors have been shown to result in joint dysfunction but manipulation has not been shown to reduce these mechanical alterations (Mootz, as cited in Gatterman, 2005). More subtle mechanical alterations, which are difficult to demonstrate radiographically, are more likely treated by the chiropractic manipulation. This mechanical approach may potentially point to abnormal segmental position, it also may be representative of activity of surrounding musculature. Mechanically the “bone out of place” theory is not likely to be the sole explanation for chiropractic subluxation (Mootz, as cited in Gatterman, 2005).

2.8.2.2 Adhesions

Soft tissue and articulate adhesion may form in and around the synovial joints, as a result of trauma causing extracellular accumulation of inflammatory exudates and blood. Platelets release thrombin converting fibrinogen into fibrin, which forms a collagenous scar, this can be aggravated by the dehydration associated with immobilisation of the joint. Both trauma and immobilization are frequent causes of subluxation. Manipulation may breakdown newly deposited adhesions (Mootz as cited in Gatterman, 2005).

2.7.2.3 Meniscoid Entrapment

Intraarticular synovial meniscoids may cause fixation when the fibrocartilaginous edge gets caught between the articular surfaces. The resulting deformation and restrictions are thought to stress the joint capsule which may irritate the capsular nerve endings and contribute to pain and spasm. The manipulation is said to release the entrapment (Leach, Phillips, and Lantz, 1994).

2.8.2.4 Nuclear Fragments

Weakness in the annular fibrosis of the intervertebral disc allows the nucleus pulposus to push through during movement. This may cause decreased normal movement between the end plates affecting the motion segment of the spine, resulting in a joint fixation. Manipulation may suction the fragment centrally improving the joint movement (Mootz, as cited in Gatterman, 2005).

2.8.2.5 Disc Deformity

Prolonged compressive loading of a disc has been shown to lead to tissue creep that results in degenerative changes in annular composition. Manipulation has little effect on tissues that have undergone creep, however it may address the mechanical stresses associated with creep helping slow the progression of degenerative changes (Mootz, as cited in Gatterman, 2005).

2.8.2.6 Mechanical Joint Locking

Tropism in the lumbar spine, where one facet is orientated more coronal and the other more sagittal, can lead to the facets mutually locking on one another. This will cause diminished mechanical efficiency, resulting in decreased motion which may be relieved by manipulation (Mootz, as cited in Gatterman, 2005).

2.8.2.7 Korr's Theory

Korr (1975) postulated that joint dysfunction could result from the muscle spindle which coordinates an increase or decrease of muscle contraction. This reflex muscle contraction could prevent joint motion. The muscle spindle is made of muscle fibres that are called intrafusal muscle fibres. These fibres contain sensory nerve endings near the middle of the fibres and gamma motor neurons that terminate at the ends of the fibres. Normal skeletal muscle fibres known as the extrafusal muscle fibre surround the muscle spindle and contain alpha motor neurons as seen in figure 2.6 (Tortora and Derrickson, 2006).

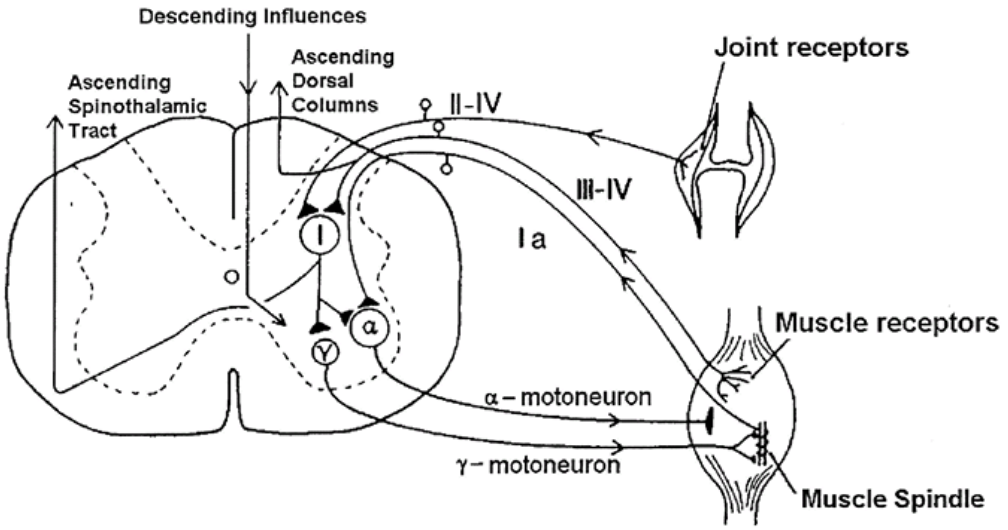


Figure 2.6: Sensory pathway (Pickar, 2002)

When skeletal muscle is stretched the intrafusal muscle fibres are stretched, causing activation of the sensory nerve endings (Ia afferent) which synapse directly at the alpha motor neuron in the anterior horn of the spinal cord. This then causes a reflex contraction of the extrafusal muscle fibres of the skeletal muscle involved. Relaxation of the muscle then follows; the contraction shortens the intrafusal muscle fibres and stops the sensory nerve endings activating. The intrafusal muscle fibres receive efferent innervations from the gamma motor neuron (Leach, Phillips, and Lantz, 1994).

The central nervous system (CNS) adjusts the muscle spindle slack that occurs when there is contraction of the extrafusal muscle fibres by adjusting the background gamma motor neuron activity. Therefore the slack is not only taken up by the increased gamma motor neuron activity but the background activity is turned up or down by the CNS (Leach, Phillips, and Lantz,1994). The wrong sensitivity of the muscle spindle may be set by the CNS, this is termed “gamma gain”. If “gamma gain” is set too high the muscle may be tense and resistant to change in length, resulting in muscle spasm (Leach, Phillips, and Lantz,1994).

It has been proposed that manipulation can turn down the “gamma gain” and relax the muscle spasm (Leach, Phillips, and Lantz,1994). By increasing joint mobility this produces a barrage of afferent impulses which is strong enough to signal the CNS to

silence the activated gamma motor neurons (Leach, Phillips, and Lantz,1994; Pickar, 2002).

2.8.3 Effects of Manipulation

The exact mechanism underlying the effectiveness of SMT is not well understood (Pickar, 2002; Potter, McCarthy and Oldham, 2005). There are four proposed mechanisms biomechanical, neurophysiological, muscular reflexogenic and psychological (Potter, McCarthy and Oldham, 2005).

2.8.3.1 Biomechanical Effect

The biomechanical effect is as a result of changes in joint alignment, improvement in dysfunctional joint motion and spinal curvature dynamics (Gatterman, 2005; Hyde and Gengenbach, 2007). This effect is brought about by a mechanical separation of the facet joint, which may often be accompanied with a cavitation, resulting in an increase in range of motion at the joint after manipulation (Potter, McCarthy and Oldham, 2005).

2.8.3.2 Muscular Reflexogenic Effects

It has been shown that following spinal manipulative therapy there is a reflex effect, measured with surface EMG, occurring in the muscles around and distant to the spine (Herzog, Scheele and Conway, 1999; Symons et al., 2000; Colloca and Keller, 2001). The reflexogenic effect is considered to be responsible for the reflex reduction in pain, muscle hypertonicity and improvement in functional ability (Potter, McCarthy and Oldham, 2005).

2.8.3.3 Neurophysiological Effect

There is growing evidence that the effects of SMT are as a result of neurophysiological consequences (Picker, 2002; Potter, McCarthy and Oldham, 2005). Pickar (2002) states that changes in the normal anatomical, physiological or biomechanical dynamics of the vertebra can negatively affect the function of the

nervous system; it is thought that spinal manipulation will correct these change. According to Hyde and Gengenbach, (2007) manipulation can stimulate the mechanoreceptors associated with the synovial joints and thereby affect joint pain. This is accomplished by restoring normal function to the joint by applying manipulative therapy which will allow type I, II and III mechanoreceptors to function and inhibit the type IV pain receptors, thereby decreasing the patients pain. The neurophysiological effect is not only excitatory, but in one study with symptomatic patients that have spontaneous muscle activity there was a reduction in paraspinal EMG activity (Suter et al., 1994; Pickar, 2002). Cleland et al. (2004) stated that clinical assessment and intervention should address both muscle imbalances and joint dysfunction. They suggest that manipulation of the lower thoracic spine may be beneficial in improving the strength of the lower trapezius muscles.

2.8.3.4 Psychological Effect

The psychological mechanism of spinal manipulation is not fully understood, but it is clear that as with any intervention there is likely to be a placebo effect (Potter, McCarthy and Oldham, 2005). The psychological effect of placing the hands on the patient can be associated with healing. The patient's belief in the practitioner and the treatment plays an important role in the healing process (Gatterman, 2005). With SMT the audible crack and the feeling that the vertebra has been returned to a normal position may give the patient a perception that the treatment has been effective and contributes to the placebo effect (Maigne and Vautravers, 2003).

2.9 SMT AND SHOULDER IMPINGEMENT SYNDROME

Several investigations into the effect of spinal manipulation, mainly of the thoracic spine, in the management of shoulder problems, have been conducted, as outlined in Table 2.8. In a systematic review and meta-analysis Walser, Meserve and Boucher, (2009) found limited evidence supporting the use of thoracic spine manipulation for shoulder pathologies, but stated that the evidence suggested that there may be accelerated improvements in those pathologies treated.

Table 2.8: Studies evaluating the effects of thoracic manipulation on shoulder pain and dysfunction

Reference	Sample size	Age range	Condition	Study design	Intervention	Outcome measures	Results
Bang and Deyle, 2000	n = 52	24-65	SIS	RCT	G1: standard shoulder flexibility and strengthening program.. G2: standard shoulder program + manual therapy to the shoulder and/or thoracic spine	Functional shoulder questionnaire, isometric strength and VAS during resisted shoulder abduction, external rotation and internal rotation.	Significantly greater improvement in the manual therapy group for pain, function and strength.
Bergmann et al., 2004	n = 150	Over 18	Shoulder dysfunction and pain	RCT	G1: usual medical care. G2: usual medical care + c/s, upper t/s; adjacent rib manipulation.	Patients perceived shoulder pain score, functional disability and general health.	Pain, function and general health no significant difference at 6 weeks. At 12 weeks significant difference in favour of manipulation for pain levels.
Strunce et al., 2007	n = 22	18-65	Primary complaint of shoulder pain.	Single group pre/post-test.	HVLA manipulation to c-t junction, mid t/s and upper ribs.	VAS Neer, Hawkin-Kennedy and drop arm tests. AROM, GRCS.	Statistically and clinically important results for AROM and VAS in entire group. immediately after manipulative therapy. GRC – varied improvement across the group.
Boyles et al., 2009	n = 56	18-50	SIS	Single group pre/post-test.	HVLA manipulation to C-T junction, T/S and ribs.	SPADI, GRCS; NPRS during resisted abduction, internal rotation, external rotation.	Decreased pain; improved function – no significant change.

						Neer, Hawkins-kennedy and empty can test.	
Muth et al., 2012	n = 30	18 – 45 yrs	Rotator cuff tendino-pathy.	Single group pre/post-test.	HVLA manipulation to c-t junction and mid T/S.	NPRS, NPRS during Jobe empty can, Hawkins-kennedy and Neer test and with loaded humeral elevation in frontal, scapula and sagittal planes. Break test, EMG and scapula motion where measured.	Pain – decreased during orthopaedic tests + during shoulder flexion. Significant increase in middle trapezuis activity.

Bang and Deyle (2000) were the first to show the benefit (decreased pain, improved function and strength) of adding manual therapy to a supervised shoulder exercise programme for patients with SIS. Bergmann et al. (2004) in a larger study found no significant differences after six weeks but at 12 weeks the participants receiving SMT had accelerated recovery, these participants were not diagnosed with SIS but had shoulder dysfunction and pain. These studies used a combination of SMT and other treatments therefore the benefit of SMT alone could not be determined.

In the following one-group pre-test post studies, the effect of cervical thoracic junction, thoracic spine and rib manipulations were investigated with all reporting improved shoulder pain and disability. Strunce et al. (2007) found an immediate improvement in shoulder range of motion and a decrease in pain with no adverse effects or worsening in shoulder pain after manipulation. Similarly, Boyles et al. (2009) found at a 48 hour follow up that shoulder pain and disability improved. The results found in Bolyes et al. (2009) study were not statistically significant but they believed that they were clinically important due to the results being consistently lower after a single intervention. They recommended that future studies with stronger designs could further clarify the clinical importance.

Muth et al. (2012) demonstrated a decrease in shoulder pain, increase in force production and improvement in shoulder function immediately and up to 7-10 days post-spinal manipulation. They found no changes in ROM or scapula kinematics, with

the exception of small decreases in scapula upward rotation. They found statistically significant increases in the middle trapezius muscle activity but no significant changes in upper and lower trapezius activation. The authors concluded that the intervention may have resulted in improved scapula stabilization.

The degree to which the results of these studies can be used is limited due to their study designs and exploratory nature. However they indicate that the thoracic spine and ribs may have a role in shoulder problems but further studies are needed with stronger designs. Therefore this study aimed to determine if there is any benefit in including thoracic spinal and rib manipulation in the management of shoulder impingement syndrome.

CHAPTER THREE: METHODOLOGY

3.1 STUDY DESIGN

The study was a quantitative, randomised, placebo controlled pre-test post-test experimental design. Quantitative designs involve gathering information via formal instrumentation which can either address physical or physiological parameters (Portney and Watkins, 2009). This design is used to investigate relationships between two or more variables and also explores cause and effect relationships (Baumgartner and Hensley, 2002). Pre-test post-test designs are widely used in research, primarily to compare groups and/or measurement changes resulting from an experimental treatment. This is undertaken by taking a measurement before the treatment then re-measuring after the treatment at certain intervals (Dimitrov and Rumrill, 2003).

The study was approved by the Durban University of Technology (DUT) Institutional Research Ethics Committee (reg no REC40/13, Appendix O) and was registered on the South African Clinical trials register (registration number: DOH-27-0813-4516, Appendix P). The study was conducted at the DUT Chiropractic Day Clinic (DUT CDC) after permission was obtained from the Clinic Director (Appendix N).

3.2 STUDY POPULATION

People residing in the greater Durban area were invited to join the study.

3.3 SAMPLING METHOD

3.3.1 Sample Recruitment

Participants were recruited for the study by placing advertisements at the DUT campuses, local sports clubs and shopping malls and other university campuses around the Durban area (Appendix I and L). Permission was obtained if necessary prior to placing the advert (Appendix J).

3.3.2 Sample Characteristics

Respondents to the advert called the researcher and were asked the following questions:

1. Will you be willing to answer a few questions?
2. Are you between the age of 18 and 35?
3. Where is your pain?
4. Are you undergoing treatment for shoulder pain?
5. Are you prepared to take part in research?

In order to be considered for the research they would have had to answer “yes” to questions one, two and five, have pain located on the anterior or lateral shoulder area and presently not receiving treatment for their shoulder pain to proceed with the study. Once meeting these criteria the respondent was requested to attend an appointment at the DUT CDC for their initial consultation.

At the initial consultation, all participants were given a Letter of Information outlining the study and a Consent form (Appendix A), along with a verbal explanation. Participants were informed that they were free to withdraw from the study at any time without any repercussions, and were given an opportunity to ask any questions.

Once written consent was obtained the participant then underwent a case history (Appendix B), general physical examination (Appendix C), shoulder orthopaedic examination (Appendix D) and thoracic spine orthopaedic examination (Appendix E), a summary of findings were recorded on a SOAPE note (Appendix F). The participant had to meet the study inclusion and exclusion criteria.

3.3.2.1 Inclusion Criteria:

1. Participants had to be between 18 to 35 years of age.
2. A diagnosis of shoulder impingement syndrome needed to be made using the following criteria:
    - Anterior and/or lateral shoulder pain during overhead activity Positive impingement and “empty can” orthopaedic test;
    - At least one of the following orthopaedic tests needed to be positive:

- Hawkins-Kennedy impingement test;
- Apprehension test and/or relocation test.

3. Participants had to have had at least one positive scapula stabilisation test:
   - Scapular isometric pinch and/or;
   - Lateral scapula slide test and/or;
   - Lennie test.
4. Using motion palpation the participant must have had at least one thoracic spinal motion dysfunction between C7-T5 with/without costo-vertebra joint dysfunction.
5. The participant must have had a pain rating score between 4-8 to allow for a homogenous group.
6. Signed letter of information and consent (Appendixes A and M).

3.3.2.2 Exclusion Criteria:

1. Contra-indications to thoracic spinal and rib manipulation such as neurological deficits, instability, unstable spondylolisthesis, arthritis, fractures, Potts disease, malignancy of the spine, dislocation of the vertebra. This was determined by the case history and physical examination.
2. The participant with a primary complaint of neck pain and/or cervical radiculopathy, and/or a positive result on a cervical distraction test or Spurling test
3. Any patient receiving treatment for shoulder impingement syndrome within the last week.
4. Patients that had received activator instrument adjusting, as the activator instrument was used as a placebo in the study and these people would have been more likely to know they may have received the placebo intervention.
5. Any patient that had participated in research in the past three months.
6. Neurological deficit of the dorsal scapula nerve (C4-C5), determined by an inability to perform the scapula isometric pinch test, and if the participant has a positive internal rotation resistance strength test indicating internal impingement syndrome (Zaslav and Richmond, 2001).
7. Those participants who present with shoulder instability as determined through orthopaedic testing (e.g. anterior instability test, posterior drawers and feagin test) were excluded, to ensure that the cause of secondary impingement was

from weakness of the scapulothoracic muscles and not glenohumeral instability.

8. Severe postural thoracic abnormalities such as gibbus, severe increase in the thoracic kyphosis and severe scoliosis.

3.3.3 Sample Size and Allocation

A sample size of 30 participants was required for this study. The sample size was selected in consultation with a statistician and by literature review of similar studies which were assessed for their sample sizes and outcome measures (Boyles et al., 2009; Strunce et al., 2009; Muth et al., 2012), and in acknowledgment of the constraints of the research in terms of time and budget.

The participants were randomly allocated by the research assistant, utilizing the hat method (Cottrell and Mackenzie, 2005) were 30 pieces of paper were inscribed with either group 1 or 2 (15 of each) on them then placed in a concealed bag that the research assistant was in charge of and the researcher or participant did not see, into two groups of 15 each:

- Group 1 = Treatment;
- Group 2 = Placebo.

3.4 MEASUREMENT TOOLS

Both subjective and objective measurement tools were used to collect data. All data collected was recorded onto a data collection sheet (Appendix Q). Pain, disability and glenohumeral range of motion were the primary outcomes with scapulohumeral rhythm and scapular stabilization being secondary outcomes.

3.4.1 Subjective Measurements

- Numerical Pain Rating Scale

This scale is used to determine the subjective pain intensity experienced by a participant. The participants were asked to pick a number between 0 and 10 which best described their pain that they were experiencing at that time, 0 being the least

pain and 10 being the most. The number noted represents the participant's level of pain intensity (Kahl and Cleland, 2005; Finch et al., 2002; Currier, 1984; Good et al., 2001).

The Numerical Pain Rating Scale (NRS-101) has been shown to be simple and effective. The questionnaire has a moderate to high test-retest reliability (Kahl et al., 2005; Finch et al., 2002; Currier, 1984; Good et al., 2001) a three point change indicates a clinical change in pain (Kahl and Cleland, 2005; Finch et al., 2002).

- Shoulder Pain and Disability Index

This self-administered questionnaire is used to determine the subjective pain and functional activity experienced by the participant (Roach et al., 1991). In the Shoulder Pain and Disability Index (SPADI) there are two dimensions (pain and disability); the pain dimension consists of five questions regarding the severity of the participant's pain (Roach et al., 1991). Functional activities are assessed with eight questions designed to measure the degree of difficulty the participant has with various activities of daily living that require the upper-extremity use (Roach et al., 1991). According to Roach et al. (1991) and Bolyes et al. (2007), this is the only reliable and valid region-specific measure for the shoulder. A minimum of a 13 point change was needed to demonstrate a clinical change in the SPADI (Roach et al., 1991).

3.4.2 Objective Measurements

3.4.2.1 Glenohumeral Joint Range of Motion

The digital inclinometer was used to determine GHJ joint range of motion (ROM). The Saunders® digital inclinometer was used for this study; an average of three readings for each motion was taken, Table 3.1, and recorded onto an information sheet (Appendix Q). According to Kolber and Hanney, (2012), this instrument has a reliability coefficient that exceeds 0.90 for flexion, abduction, external rotation and internal rotation. There is good concurrent validity (Kolber and Hanney, 2012).

Table 3.1: Digital inclinometer measurement of GHJ range of motion (Kolber et al., 2011)

	Participant position	Test arm	Inclinometer placement
Flexion	Standing.	Actively raises arm in the sagittal plane.	Placed on the superior/distal arm proximal to the end once active end range of motion was reached.
Abduction	Standing.	Actively raise arm in the coronal plane with the thumb pointed upwards.	Placed on the superior/distal arm proximal to the elbow once active end-range was reached.
External rotation	Supine with arm supported on the table and with hips and knees flexed to 45°.	Shoulder abducted to 90° and elbow flexed at 90°. A towel was placed under the humerus and then the arm was actively externally rotated until end range was reached.	Placed on the distal forearm just proximal to the wrist once active end-range reached.
Internal rotation	Prone with arm supported on the table.	90° abduction and elbow in 90° flexion, a towel placed under the arm for stability. Arm is then actively internally rotated until end range of motion.	Placed on the distal forearm just proximal to the wrist once active end-range is reached.

3.4.2.2 Scapular Stabilisation Tests

- Lateral scapula slide test

The participant was seated with their arms at their sides. The examiner measured the distance between the base of the spine of the scapula and the spinous process of T2/T3, and from the inferior angle of the scapula to the spinous process which was in line with either T7/T8/T9: This was done in five different positions of GHJ abduction:

- Neutral;
- 45° GHJ abduction with hands resting on the participants waists and thumbs posteriorly;
- 90°;
- 120°; and
- 150°.

The distance measured at 45°, 90°, 120° and 150° should not vary more than 1 to 1.5 cm from the neutral measurement (Magee, 2008). This test is valid (showing a correlation of 0.91), with intra-test reliability between 0.84 and 0.88 and inter-test reliability between 0.77 and 0.85 (Kibler, 1998; Voight and Thomsom, 2000).

- Scapular isometric pinch test

For the scapula isometric pinch test the participant is standing in neutral and then is asked to actively retract the scapulae together as hard as possible and hold the position for as long as possible. Normally, an individual can hold the contraction for 15 to 20 seconds with no burning pain or obvious muscle weakness. If burning pain occurs in less than 15 seconds, then the scapula retractors are weak. If the participant relaxes the contraction slightly and then can hold the contraction in a comfortable zone for a longer period of time without burning pain, that is also an indication of weak scapula stabilisers (Magee, 2008). For this test to be valid and to properly objectify scapula muscle weakness, the lateral scapula slide test may be used (Voight and Thomsom, 2000).

3.5 INTERVENTIONS

3.5.1 Spinal Manipulative Therapy

Spinal manipulative therapy (SMT) in this study utilised high velocity low amplitude (HVLA) thrust in line with the techniques outlined by Berman and Peterson (2002). The spinal manipulative techniques below were used based on the presentation of joint dysfunction.

3.5.1.1 Bilateral Hypothenar Transverse (Crossed Bilateral) Manipulation

The participant was instructed to lie in the prone position with his/her face resting in the headpiece with arms resting on the arm rest for comfort (Bergmann and Peterson, 2002). The practitioner stood on one side of the bed in the fencer stance, facing the head of the participant. The practitioner removed tissue slack and established contact on the transverse processes with the hypothenar region (pisiform) of the palms. At tension the practitioner applied an impulse thrust using the arms, trunk and body (Bergmann and Peterson, 2002).

3.5.1.2 Thumb Spinous Push

The participant was instructed to lie in the prone position with his/her face resting in the headpiece with arms resting on the arm rest for comfort (Bergmann and Peterson, 2002). The practitioner stood on either side of the bed in the fencer stance, facing the head of the participant. The distal palmer surface of the practitioners thumb was placed on the lateral surface of the participant's spinous process. The practitioner's indifferent hand supported the upper cervical spine. As the fingers contacted the inferior occiput, the practitioner applied an impulse thrust lateral to medial and with slight posterior to inferior angulation to maintain segment contact (Bergmann and Peterson, 2002).

3.5.1.3 Bilateral Hypothenar Transverse Push

The participant was instructed to lie in the prone position with his/her face resting in the headpiece with arms resting on the arm rest for comfort. The headpiece was then lowered for flexion restrictions and placed in the neutral position for extension restrictions (Bergmann and Peterson, 2002). The practitioner stood at the head of the table, facing caudally. The practitioner removed tissue slack and established contact on the transverse processes with the hypothenar region (pisiform) of the palms. At tension the practitioner applied an impulse thrust through the arms, trunk and body (Bergmann and Peterson, 2002).

3.5.2 Placebo Intervention

An activator instrument was used in this study as a placebo. The participant was instructed to lie in the same position as the if they were receiving a bilateral hypothenar transverse (crossed bilateral) manipulation, the activator was set to zero tension and placed five centimetres above the skin of the joint that was restricted. The activator was then activated resulting in an audible click with no administration of a thrust to the participant.

3.6 BLINDING

Double blinding was used in this study whereby the researcher was blinded to the treatment the participants received, and the participants were blinded to which treatment they were receiving. A research assistant allocated the participant into the groups. The participant was informed not to communicate with the research about the treatment they received. This was done so that the attitude of the researcher towards the treatment was not directly transferred to the participants and to reduce information bias (Schulz and Grimes, 2002).

3.7 RESEARCH PROCEDURE

During the first consultation with the participant the researcher conducted a case history, physical, thoracic and shoulder regional examination which included the orthopaedic test that were used to include or exclude the participant into the study. Once the participant was included into the study, the first set of data measurements was collected by the researcher. Thereafter the research assistant was introduced to the participant at this stage the assistant randomly allocated the participant to a group and the interventions were administered, during which time the researcher was outside the room. When the intervention was completed the research assistant left the room and the researcher then re-entered and collected the second set of data measurements. The participant was required to return to the DUT CDC 48 hours after the initial consultation to complete the third set of measurements.

3.8 CONSORT FLOW DIAGRAM

The CONSORT flow diagram for this research study is represented in Figure 3.1.

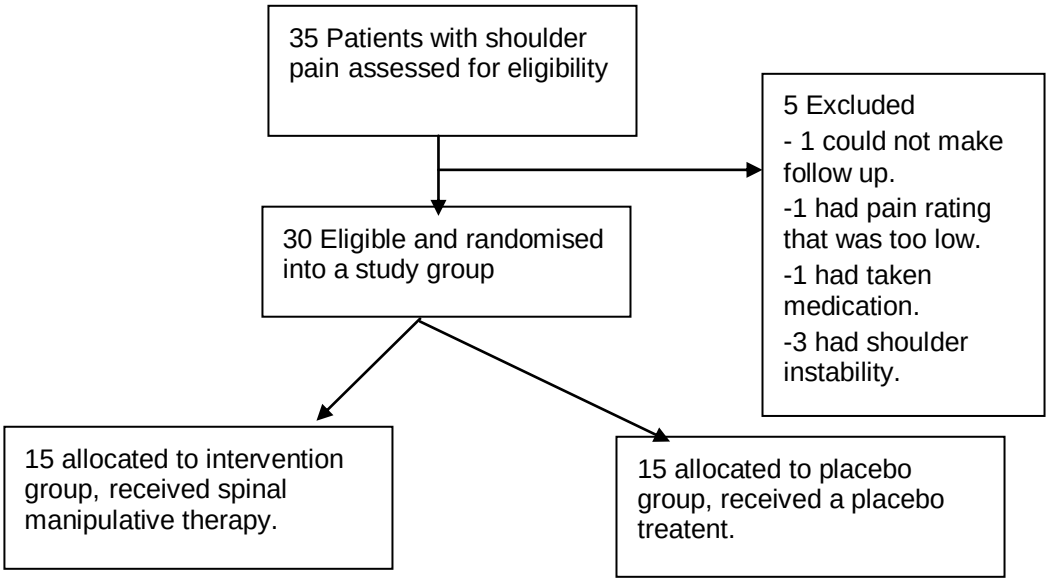


Figure 3.1: CONSORT flow diagram

3.9 DATA ANALYSIS

When the study was complete all data was coded and transferred into an Excel spreadsheet. Data was analysed using SPSS version 21 with a p value < 0.05 considered to be statistically significant. The demographic data was analysed using t-tests for continuous variables and chi square tests for categorical variables. The repeated measures ANOVA test was used to compare changes over the three time points for intra-group comparison and to examine the time by group interaction effect (treatment effect) for the inter-group analyses (email from Esterhuizen on 03/06/2014).

CHAPTER FOUR: RESULTS

4.1 PARTICIPANT CHARACTERISTICS

4.1.1 Gender

There was no statistically significant difference between the groups in terms of gender (p = 1.00; chi squared), with the majority of the participants being male, as seen in Figure 4.1.

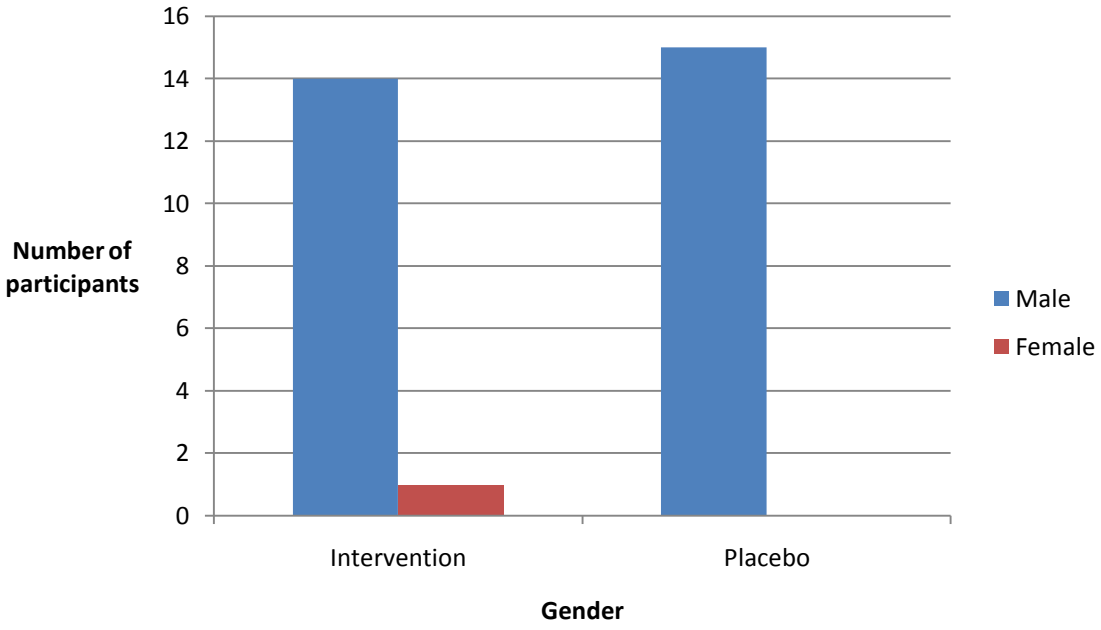


Figure 4.1: The gender distribution between the groups

4.1.2 Race

Figure 4.2 represents the racial distribution between the groups; there was no statistically significant difference between the groups in term of race (p = 0.16; chi squared).

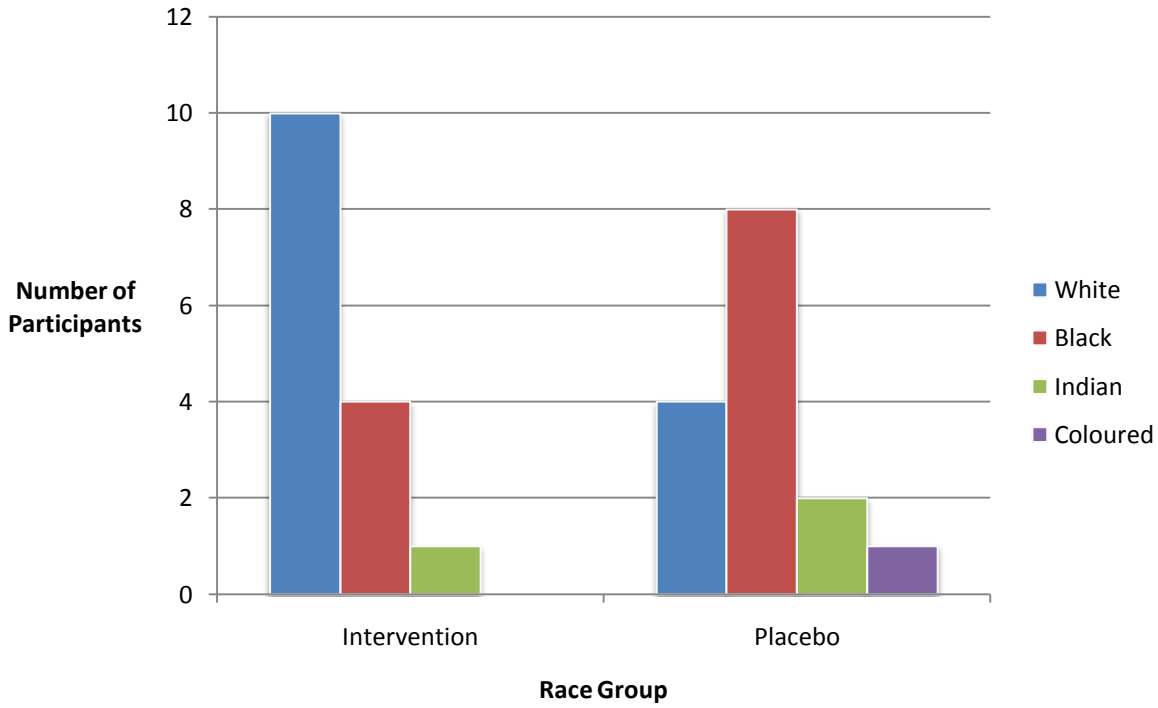


Figure 4.2: The racial distribution between the two groups

4.1.3 Age

There was no statistically significant difference between the two groups in terms of age (p = 0.09; t-test); the mean age for the intervention group was 22.6 years (SD±2.9) and for the placebo group 25.1 years (SD±4.7). The combined mean age of all participants was 23.9 years, with the youngest participant being 19 years and the oldest 32 years.

4.1.4 Height and Weight

Table 4.1 shows that there was no statistically significant difference between the two groups in terms of height and weight.

Table 4.1: The height and weight distribution between the two groups

Variable	Group	Mean	SD	p-value
Height (m)	Intervention	177	7.0	0.30
	Placebo	174.3	6.7	
Weight (kg)	Intervention	82.7	12.8	0.33
	Placebo	87.5	13.7	

4.1.5 Comparison of Symptomatic Shoulders per Group

There were no statistically significant differences between the groups in terms of whether the participants had right or left sided shoulder impingement syndrome (p = 0.07; chi squared).

4.2 SUBJECTIVE MEASURES

4.2.1 Pain Rating

The intervention group showed significant decreases in pain over time, however this was not significantly different from the placebo group, as seen in Table 4.2. There was no clinically significant change observed for the intervention or placebo group with regards to pain.

Table 4.2: Pain rating

Group	**Pre-intervention**			**Post-intervention**			**48 hour follow up**			**p-value**
	Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**Mean**	**SD**	**CI**	
Intervention	6.00	0.76	5.57 to 6.42	4.93	1.83	4.14 to 6.42	4.73	1.91	3.75 to 5.72	0.03**
Placebo	5.87	0.83	5.45 to 6.29	5.60	1.06	4.81 to 6.39	5.33	1.80	4.35 to 6.31	0.08**
p-value	0.65*			0.32*			0.38*			
	0.21**									

* independent t-test
** repeated measures ANOVA

4.2.2 Shoulder Pain and Disability Index

The intervention group showed a statistically significant decrease in disability over time when compared to the placebo group for the SPADI disability score, as seen in Table 4.3. There were no clinically significant changes observed for the intervention or placebo group with regards to SPADI.

Table 4.3: Shoulder pain and disability index scores

Group	SPADI	Pre-intervention			Post-intervention			48 hour follow up			P-value**
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	**Total**	30.56	16.29	20.75 to 40.38	25.65	17.28	15.47 to 35.82	21.39	13.81	13.24 to 29.53	0.01
	Pain	44.40	18.67	34.49 to 54.31	37.07	20.00	26.87 to 47.26	32.53	17.18	23.11 to 41.96	0.03
	Disability	22.00	17.07	11.18 to 32.82	17.40	16.15	6.38 to 28.40	14.42	13.66	5.72 to 23.12	0.001
Placebo	**Total**	41.44	20.57	31.62 to 51.25	39.44	21.00	29.27 to 49.61	35.64	16.85	27.50 to 43.79	0.14
	Pain	53.73	18.79	43.83 to 63.64	49.87	18.52	39.67 to 60.06	45.47	18.45	36.04 to 54.89	0.18
	Disability	33.75	23.37	22.93 to 44.57	32.92	24.62	21.91 to 43.93	29.50	18.83	20.80 to 38.20	0.49
P-value*	**Total**	0.12			0.06			0.02			
	Pain	0.18			0.38			0.06			
	Disability	0.13			0.51			0.02			
P-value**	**Total**	0.32									
	Pain	0.21									
	Disability	0.04									

*independent t tests
**repeated measures ANOVA

4.3 OBJECTIVE MEASURES

4.3.1 Glenohumeral Joint Range of Motion

No significant differences were observed between the groups in terms of glenohumeral joint range of motion, as seen in Table 4.4. Clinically significant changes were observed for abduction for the intervention group and flexion and abduction in the placebo group.

Table 4.4: Glenohumeral joint range of motion measures

Group	ROM	Pre-intervention			Post-intervention			48 hour follow up			p-value**
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	**Flexion**	150.13	16.96	140.20 to 160.07	157.98	16.27	147.23 to 168.73	153.19	26.82	142.45 to 163.90	0.13
	Abduction	123.31	24.97	111.33 to 135.29	138.98	27.29	124.66 to 153.29	142.51	27.50	129.50 to 155.53	0.007
	External rotation	78.62	17.19	67.23 to 90.01	87.04	9.61	77.54 to 96.55	85.56	11.71	76.10 to 95.02	0.03
	Internal rotation	46.09	14.06	38.09 to 53.72	52.96	18.03	44.36 to 61.55	53.11	13.25	47.02 to 59.21	0.001
Placebo	**Flexion**	144.38	20.44	134.44 to 154.31	149.13	23.70	138.38 to 159.88	156.49	10.15	145.76 to 167.22	0.04
	Abduction	113.96	20.06	101.98 to 125.93	123.89	26.85	109.57 to 138.21	127.36	21.33	114.34 to 140.37	0.01
	External rotation	72.16	25.13	60.77 to 83.54	73.98	23.52	64.48 to 83.48	73.91	22.42	64.45 to 83.37	0.93
	Internal rotation	51.93	14.77	44.31 to 59.56	52.44	14.27	43.85 to 61.04	51.22	9.48	45.13 to 57.32	0.92
p-value*	**Flexion**	0.41			0.24			0.66			
	Abduction	0.27			0.14			0.10			
	External rotation	0.42			0.06			0.09			
	Internal rotation	0.28			0.93			0.66			
p-value**	**Flexion**	0.27									
	Abduction	0.56									
	External rotation	0.45									
	Internal rotation	0.07									

*independent t tests
**repeated measures ANOVA

4.3.2 Lateral Scapular Slide Test

Two measurements were obtained from this test, a measurement from the spine of the scapula to the spinous process of either T2/T3 thoracic vertebra, and from the inferior angle of the scapula to the spinous process which was in line with either T7/T8/T9 thoracic vertebra. These measurements were taken bilaterally and at different degrees of abduction. In order to analyse the data the difference between the right and left measurements were calculated and statistically analysed.

4.3.2.1 Neutral (0 Degrees)

A baseline difference was observed for the spine of scapula measurement. There is a trend of an effect for the intervention group for this measurement where it can be seen that the intervention group had a decrease in this measurement compared to the placebo group where the reading remained almost constant, as seen in Table 4.5.

Table 4.5: Lateral scapula slide test at 0 degrees

Group		**Pre-intervention**			**Post-intervention**			**48 hour follow up**			**p-value****
		Mean	**SD**	**CI**	**Mean**	**SD**	**CI**	**Mean**	**SD**	**CI**	
Intervention	**Spine of the scapula**	1.23	0.75	0.85 to 1.61	0.93	0.59	0.63 to 1.23	0.43	0.53	0.17 to 0.70	0.007
	Inferior angle of the scapula	1.43	0.73	1.06 to 1.80	0.93	0.78	0.54 to 1.33	1.06	0.82	0.65 to 1.48	0.01
Placebo	**Spine of the scapula**	0.67	0.52	0.40 to 0.93	0.63	0.74	0.26 to 1.01	0.66	0.59	0.37 to 0.96	0.99
	Inferior angle of the scapula	1.57	1.33	0.89 to 2.24	0.93	0.96	0.45 to 1.42	1.06	0.88	0.62 to 1.51	0.14
p-value*	**Spine of the scapula**	0.02			0.23			0.26			
	Inferior angle of the scapula	0.74			1			1			
p-value**	**Spine of the scapula**	0.03									
	Inferior angle of the scapula	0.92									

*independent t tests
**repeated measures ANOVA

4.3.2.2 45 Degrees

No significant differences were found when the groups were compared over time, as seen in Table 4.6.

Table 4.6: Lateral scapula slide test at 45 degrees

Group			Pre-intervention			Post-intervention			48 hour follow up			p-value**
			Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	Spine of the scapula		1.10	0.71	0.74 to 1.46	0.87	0.92	0.40 to 1.33	1,00	0.73	0.63 to 1.37	0.77
	Inferior angle of the scapula		1.70	1.31	1.04 to 2.36	1.37	0.88	0.92 to 1.81	1.30	0.67	0.53 to 1.20	0.04
Placebo	Spine of the scapula		1.03	0.72	0.67 to 1.40	0.87	0.79	0.47 to 1.27	0.76	0.68	0.42 to 1.11	0.57
	Inferior angle of the scapula		1.80	1.16	1.21 to 2.39	0.90	0.81	0.49 to 1.31	1.06	0.96	0.58 to 1.55	0.03
p-value*	Spine of the scapula		0.80			1			0.37			
	Inferior angle of the scapula		0.83			0.14			0.51			
p-value**	Spine of the scapula		0.80									
	Inferior angle of the scapula		0.32									

*independent t tests
**repeated measures ANOVA

4.3.2.3 90 Degrees

No significant differences were observed when the groups were compared over time, as seen in Table 4.7.

Table 4.7: Lateral scapula slide test at 90 degrees

Group		Pre-intervention			Post-intervention			48 hour follow up			p-value**
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	Spine of the scapula	1.00	0.78	0.61 to 1.39	0.37	0.52	0.11 to 0.63	0.96	0.64	0.64 to 1.29	0.003
	Inferior angle of the scapula	1.57	0.98	1.07 to 2.06	1.53	1.11	0.97 to 2.09	0.93	0.96	0.45 to 1.42	0.31
Placebo	Spine of the scapula	0.97	0.74	0.59 to 1.34	0.27	0.59	0.03 to 0.57	0.66	0.65	0.34 to 0.99	0.045
	Inferior angle of the scapula	1.80	0.88	1.35 to 2.25	1.10	1.14	0.52 to 1.68	1.06	0.42	0.86 to 1.28	0.046
p-value*	Spine of the scapula	0.91			0.63			0.21			
	Inferior angle of the scapula	0.50			0.30			0.63			
p-value**	Spine of the scapula	0.72									
	Inferior angle of the scapula	0.33									

*independent t tests
**repeated measures ANOVA

4.3.2.4 120 Degrees

Table 4.8 shows that there were no significant difference observed between the groups when compared over time.

Table 4.8: Lateral scapula slide test at 120 degrees

Group		Pre-intervention			Post-intervention			48 hour follow up			p-value**
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	Spine of the scapula	1.03	0.97	0.54 to 1.53	0.96	0.77	0.58 to 1.35	0.56	0.50	0.32 to 0.82	0.24
	Inferior angle of the scapula	0.77	0.62	1.03 to 2.17	1.00	0.85	0.57 to 1.43	0.73	0.70	0.38 to 1.09	0.02
Placebo	Spine of the scapula	1.60	1.12	0.45 to 1.08	0.43	0.50	0.18 to 0.68	0.56	0.50	0.32 to 0.82	0.37
	Inferior angle of the scapula	1.73	1.16	1.14 to 2.32	1.00	0.76	0.62 to 1.38	1.10	0.81	0.69 to 1.51	0.05
p-value*	Spine of the scapula	0.38			0.03			1			
	Inferior angle of the scapula	0.75			1			0.19			
p-value**	Spine of the scapula	0.26									
	Inferior angle of the scapula	0.69									

*independent t tests
**repeated measures ANOVA

4.3.2.5 150 Degrees

Table 4.9 shows that there were no significant differences observed between the groups when compared over time.

Table 4.9: Lateral scapula slide test at 150 degrees

Group		Pre-intervention			Post-intervention			48 hour follow up			p-value**
		Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	Spine of the scapula	0.87	0.81	0.46 to 1.28	1.06	0.68	0.72 to 1.41	0.46	0.61	0.16 to 0.78	0.11
	Inferior angle of the scapula	1.77	0.90	1.31 to 2.22	1.33	1.10	0.78 to 1.89	0.83	0.70	0.48 to 1.19	0.03
Placebo	Spine of the scapula	0.50	0.63	0.18 to 0.82	0.73	0.56	0.45 to 1.02	0.70	0.56	0.42 to 0.98	0.53
	Inferior angle of the scapula	1.20	0.92	0.73 to 1.67	1.26	0.70	0.91 to 1.62	1.26	1.03	0.74 to 1.79	0.96
p-value*	Spine of the scapula	0.18			0.15			0.29			
	Inferior angle of the scapula	0.10			0.84			0.19			
p-value**	Spine of the scapula	0.17									
	Inferior angle of the scapula	0.11									

*independent t tests
**repeated measures ANOVA

4.3.3 Scapula Isometric Pinch Test

There were no significant differences seen between the groups over time for the scapula isometric pinch test as seen in Table 4.10.

Table 4.10: Scapula isometric pinch test

Group	Pre-intervention			Post-intervention			48 hour follow up			p-value
	Mean	SD	CI	Mean	SD	CI	Mean	SD	CI	
Intervention	8.44	4.31	5.80 to 11.09	8.16	4.31	6.12 to 10.20	8.57	5.54	6.20 to 10.93	0.88*
Placebo	7.83	5.61	5.18 to 10.48	5.79	3.34	3.75 to 7.83	6.46	3.05	4.10 to 8.83	0.21*
p-value	0.74**			0.10**			0.21**			
	0.55*									

*repeated measures ANOVA
**independent t-test

CHAPTER FIVE: DISCUSSION

5.1 PARTICIPANT CHARACTERISTICS

5.1.1 Age, Gender and Ethnicity

The age of the participants (18-35 years) was a controlled variable in this study, in an attempt to minimise the chance of accepting participants with stage three primary shoulder impingement syndrome (SIS) which often occurs after the age of 35 years (Ferro et al., 2003). With increasing age there is also a greater likelihood of degeneration of the acromioclavicular joint (Bonsell et al., 2000) with osteophyte formation and potential rotator cuff rupture (Hattam and Smeatham, 2010). Studies similar to this study (Bang and Deyle, 2000; Strunce et al., 2007; Boyles et al., 2009) had a broader age range unlike this study, which may be a threat to the external validity of these results.

In terms of gender, it has been reported that there is a greater prevalence of shoulder complaints among women than men (Greving et al 2012). This does not compare to the gender distribution in this study as there were more male than female participants. During the recruitment process several participants became aware of the study through their rugby clubs, this could have skewed the gender distribution of this study.

There has been no documented evidence to show that certain ethnic backgrounds are associated with impingement syndrome; as seen in this study, a variety of ethnic groups participated. The least represented ethnic group was Indian. The eThekwini municipality of Durban is home to a large Indian population, however they were under represented in this study.

5.1.2 Height and Weight

Height and weight have not been identified as factors in SIS, although increased height may lead to height embarrassment (Magee, 2002) which could result in a poor

posture. A slouched posture may lead to an anteriorly tilted scapula, this alteration in scapula position may narrow the subacromial space and result in shoulder impingement (Bullock, Foster and Wright, 2005), which may lead to an increase in shoulder pain (Lewis, Green and Wright, 2005) and a decrease in glenohumeral range of motion (Bullock, Foster and Wright, 2005; Lewis, Green and Wright, 2005). There was no difference between the groups in terms of height and weight therefore this effect on the outcome may be regarded as negligible.

5.1.3 Symptomatic Shoulder per Group

There was an even distribution of left and right symptomatic shoulders in both groups. When performing the lateral scapulae slide test the distance between two points on the scapulae and the spine were measured bilaterally. With hand dominance there may have been an inherent difference in the participants. This study did not correlate the symptomatic shoulders with hand dominance. The study inclusion criteria did not specify that the participants had to have either left or right shoulder impingement, which may have affected the results.

5.2 DISCUSSION OF THE RESULTS

Boyles et al (2009), Strunce et al (2007) and Muth et al (2012) found that thoracic spinal and rib manipulative therapy decreased shoulder pain. Similar findings were found in this study with a significant change overtime being observed in the intervention group. Although the change was not clinically significant (Finch, 2002 & Kahl and Cleland, 2005), indicating that although there was improvement the benefit to the participant was not sufficient to result in clinical change. In this study the intervention group was compared to a placebo group which was lacking in the above studies. This comparison yielded no significant differences between the intervention and placebo group. This result may question the use of thoracic spinal and rib manipulative therapy in the treatment of shoulder impingement syndrome. However there was a trend that the intervention group reported a faster improvement in pain which may have been more appreciable had the study utilised a larger sample size. Both the SPADI and a NRS were utilised to obtain changes in pain reported by the participants and both found no significant changes, indicating that it was not by

chance that no effect was detected. This finding lends little support to the theory of regional interdependence.

In terms of disability, the intervention group showed a significant improvement, which supports the findings of Boyles et al (2009). This finding may indicate that thoracic spinal and rib manipulative therapy may have more impact on the ability of the patient to utilise their arm as opposed to decreasing pain in the shoulder. This warrants further investigation. It has been proposed that thoracic spinal manipulation (TSM) restores mechanical mobility (Gatterman, 2005 & Bergmann and Peterson, 2002) and results in excitation of the joint receptors (Leach, 1994, Pickar, 2002, Potter et al, 2005), which subsequently normalises arthrogenic reflexes (Bernard and Cassidy, 1991 & Tullberg et al, 1998), and alters the transmission of nocioceptive information (Sueki and Chaconas, 2011).

The participants in this study did not have thoracic spinal pain but the mechanical changes and their neurological consequences that occurred following TSM may have influenced their perception of shoulder disability. This would provide support for the theory of regional interdependence (Wainner, 2007) and support authors who suggest the inclusion of TSM in patients with shoulder disability (Strunce et al, 2007 & Walser et al, 2007 & Boyles et al, 2009 & Muth et al, 2012).

TSM may alter the mechanical position of the scapular or alter the function of the scapular stabilising muscles (Boyles et al, 2009 & Sueki and Chaconas, 2011). The results of this study do not support this. This study found no significant changes in the lateral scapular slide test or the scapular pinch test. Indicating that following TSM there was no improvement in the scapular stabilising muscles, and no change in position of the scapula. Similarly, Muth et al (2012) found only a small change in scapular up ward rotation following TSM, with no alteration in scapular kinematics. These findings are contradictory to Cleland et al (2004) who found that following TSM there was a significant increase in lower trapezius muscle strength when compared to a placebo group, indicating that further research is warranted. In administering the lateral scapular stabilisation test, some participants experienced difficulty holding their arm in the various abduction positions especially those at the extreme ROM's, which could possibly have influenced the validity of these results. Similarly, some participants reported difficulty in completing the post intervention SPADI, due to the

short time interval between receiving the intervention and then having to re-answer the questionnaire. This may have influenced the validity of these results.

In terms of glenohumeral range of motion (ROM) Strunce et al (2007) found significant improvements in shoulder flexion, abduction and rotation following TSM. The current study does not support these findings as no significant differences were observed between the intervention and placebo groups. Although clinically significant differences in glenohumeral ROM were observed as these occurred in both groups the effect may be due to placebo, the passing of time or increased confidence of the participants in performing the measures. This result provides little support for the theory of regional interdependence.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 CONCLUSION

The purpose of this study was to determine the short term effect of thoracic spine and rib manipulation compared to a placebo treatment for shoulder impingement syndrome. The results showed that thoracic spine and rib manipulation was more effective in decreasing disability than placebo, with no treatment effect observed in terms of pain, scapula stabilisation or glenohumeral range of motion (ROM), but trends favouring the intervention group were observed. Therefore the alternative hypothesis was unable to be rejected that the intervention group would be more effective in decreasing disability than the placebo group. The null hypothesis was unable to be rejected for pain, scapula stabilisation and glenohumeral ROM. This study provides limited to no support for the treatment of shoulder impingement syndrome with thoracic spine and rib manipulation.

6.2 RECOMMENDATIONS

A study with a larger sample size, using a more scientifically ridged methodology especially with regards to the measurement tools should be undertaken. A sample which is restricted to the inclusion of only left or right sided shoulder impingement syndrome participants should be conducted to determine if the trends observed in this study are valid. A study should include a pain rating during glenohumeral range of motion to determine the participant's pain during shoulder motion. Thoracic range of motion can be included to measure the thoracic motion compared to the shoulder motion and pain.

The addition of two other groups consisting of a group receiving glenohumeral manipulation and another one with a combination of glenohumeral and thoracic spine and rib manipulations would strengthen the study.

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APPENDIXES

Appendix A: Letter of Information and Consent

LETTER OF INFORMATION

Dear Participant: Welcome to my research project. Thank you for taking the time to consider participating in my study.

Title of the Research Study: The short term effectiveness of Thoracic Spinal Manipulation on Secondary Shoulder Impingement Syndrome.

Principal Investigator/s/researcher: Ryan Booyens

Co-Investigator/s/supervisor/s: Dr. L. O'Connor (M.Tech: Chiropractic)

Brief Introduction and Purpose of the Study: The shoulder joints is one of the most commonly injured joint in the body, often this is due to it being the most moveable joint in the body. A common condition affecting the shoulder is shoulder impingement syndrome, where the tendons of the muscles supporting the shoulder get "caught" in the shoulder joint and as a result inflammation occurs. There are several reasons for this to happen, one reason is that the muscles that stabilise the shoulder blade become weak and as a result there is increased strain of the anterior aspect of the shoulder. As these muscles attach to the spine if the spine is not working correctly often it can lead to the muscles not working correctly. Several studies have investigated treatment applied to the thoracic spine (spinal manipulative therapy) and its effect on shoulder impingement syndrome, these studies showed favourable results. This study aims to compare thoracic spinal manipulation to a placebo treatment in the management of secondary shoulder impingement syndrome.
The study is designed as a single blinded, placebo-controlled, comparative clinical trial, in which thirty patients will be randomly allocated into two groups. One group will receive thoracic spine manipulation and the other an activator adjustment instrument set at zero tension (placebo group). Both groups will have one treatment and then a follow up for data collection 48 hours after the initial treatment. There is a 50% chance that you may fall into the placebo group.
Inclusion:

1. You are required to be between the age of 18 and 35.
2. Diagnosed with secondary shoulder impingement syndrome
3. If you are taking medication (e.g. Ibuprofen, Paracetamol) you will be asked to discontinue the medication for three days at minimum before I will be able to allow you onto the study. This is because the medication interferes with the readings that I need to take for my research.
4. You will be asked to read, agree to and sign this letter.

Exclusion:

1. To safeguard you as the patient, you will be screened for contraindications to manipulation.
2. If you have been part of another research trial you will not be permitted to take part in this study until a three month wash-out period has taken place. Similarly if you have attended the DUT Chiropractic Day Clinic for treatment you will not be permitted into this study until a 2 week wash out period has taken place.

After the telephonic conversation, an appointment will be made for you at the clinic. When you arrive for this appointment you will be given this letter of information and informed consent to read. Should you agree to participate in the study, you will be asked to sign this letter of information and informed consent. You will then undergo a case history, physical and regional examinations to confirm your eligibility to participate in the study. Once accepted into the study you will be expected to have 2 visits

within 48 hours. The initial visit will take approximately 2 hours and the following visit will take no longer than 20 minutes.

Risks or Discomforts to the Participant: You may feel transient stiffness or discomfort after the treatment this should resolve within 24-48 hours. Should the symptoms persist please report this to me.

Reason/s why the Participant May Be Withdrawn from the Study: Non-compliance, illness, adverse reactions, etc. There will be no adverse consequences for the participant should they choose to withdraw.

Remuneration: You may feel transient stiffness or discomfort after the treatment this should resolve within 24-48 hours. Should the symptoms persist please report this to me.

Costs of the Study: There will be no cost to participants to take part in the study

Confidentiality: All personal information will remain confidential by the use of a coding system for the analysis and reporting of information. Your participation in the study is voluntary and you may withdraw from the study at any time.

Research-related Injury: The D.U.T Clinic Protocol will be followed and the injury would also need to be reported to the Institutional Research Ethics committee, so please ensure that you advise me of any such problems.

Persons to Contact in the Event of Any Problems or Queries: Please contact the researcher: Ryan Booyens (tel no. 072 344 0786), my supervisor: Dr O'Connor (tel no. 031 373 2923) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

General:
Potential participants must be assured that participation is voluntary and the approximate number of participants to be included should be disclosed. A copy of the information letter should be issued to participants. The information letter and consent form must be translated and provided in the primary spoken language of the research population e.g. isiZulu.

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, _____ (name of researcher), about the nature, conduct, benefits and risks of this study - Research Ethics Clearance Number: _____,
- I have also received, read and understood the above written information (Participant Letter of Information) regarding the study.
- I am aware that the results of the study, including personal details regarding my sex, age, date of birth, initials and diagnosis will be anonymously processed into a study report.
- In view of the requirements of research, I agree that the data collected during this study can be processed in a computerised system by the researcher.
- I may, at any stage, without prejudice, withdraw my consent and participation in the study.
- I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in the study.
- I understand that significant new findings developed during the course of this research which may relate to my participation will be made available to me.

_____	_____	_____	_____
Full Name of Participant	**Date**	**Time**	**Signature / Right Thumbprint**

I, _____ (name of researcher) herewith confirm that the above participant has been fully informed about the nature, conduct and risks of the above study.

_____	_____	_____
Full Name of Researcher	**Date**	**Signature**
_____	_____	_____
Full Name of Witness (If applicable)	**Date**	**Signature**
_____	_____	_____
Full Name of Legal Guardian (If applicable)	**Date**	**Signature**

DURBAN UNIVERSITY OF TECHNOLOGY
CHIROPRACTIC DAY CLINIC

Patient: Date:

File #: __ Age:

Sex: _ Occupation:

Intern: Signature:

FOR CLINICIANS USE ONLY:
Initial visit
Clinician: Signature :

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT:	Signature:	Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

Conditions met in Visit No:	Signed into PTT:	Date:

Case Summary signed off:	Date:

Intern's Case History:

1. **Source of History:**

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

3. **Present Illness:**

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

4. **Other Complaints:**

5. **Past Medical History:**

< General Health Status

< Childhood Illnesses

< Adult Illnesses

< Psychiatric Illnesses

< Accidents/Injuries

< Surgery

< Hospitalizations

6. Current health status and life-style:

< Allergies

< Immunizations

< Screening Tests incl. x-rays

< Environmental Hazards (Home, School, Work)

< Exercise and Leisure

< Sleep Patterns

< Diet

< Current Medication
Analgesics/week:
< Tobacco

< Alcohol

< Social Drugs

7. Immediate Family Medical History:

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

8. Psychosocial history:

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

9. Review of Systems:

< General

< Skin

< Head

< Eyes

< Ears

< Nose/Sinuses

< Mouth/Throat

< Neck

< Breasts

< Respiratory

< Cardiac

< Gastro-intestinal

< Urinary

< Genital

< Vascular

< Musculoskeletal

< Neurologic

< Haematologic

< Endocrine

< Psychiatric

Appendix C: PHYSICAL EXAMINATION, SENIOR

Patient Name : _____ **File no :** _____ **Date :** _____

Student : **Signature :**

VITALS:				
Pulse rate:			Respiratory rate:	
Blood pressure:	R	L	Medication if hypertensive:	
Temperature:			Height:	
Weight:	Any recent change? Y / N		If Yes: How much gain/loss	Over what period

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

SYSTEM SPECIFIC EXAMINATION:
CARDIOVASCULAR EXAMINATION
RESPIRATORY EXAMINATION
ABDOMINAL EXAMINATION
NEUROLOGICAL EXAMINATION
COMMENTS

Clinician: **Signature :**

Appendix D: SHOULDER REGIONAL EXAMINATION

Patient: …… File No: …….. Date: …….

Intern: ……Signature: ……

Clinician: ……Signature: ……...

Observation

Posture		S-C Joints	
Skin		Clavicles	
Swelling		A-C Joints	
Shoulder levels		Scapulae	
Comments			

Palpation

S-C Joint:		SCM:	Scalenes:
Sternum:		Ribs and costal cartridge:	
Clavicle:		Coracoid process:	
A-C Joint:		Acromion:	
Greater Tuberosity:			
Lesser Tuberosity:			
Intertubercular (bicipital groove):			
Trapezius:		Deltoid:	
Biceps:		Triceps:	
Supraspinatus insertion:			
Musculotendinous portion of supraspinatus:			
Axilla:	Lymph nodes:		
	Brachial artery:		
	Serratus anterior (medial wall):		
	Pectoralis major (anterior wall):		
	Lattisimus dorsi (posterior wall):		
Scapula	Borders:	Spine:	
	Supraspinous fossa:		
	Infraspinous fossa:		

Cervico-thoracic spine:

Active Movements (note ROM and pain)

Elevation through abduction (170-180°):	
Painful arc with abduction:	
Elevation through forward flexion (160-180°):	
Elevation through scapula plane (170-180°):	
Lateral rotation (80-90°):	Medial rotation (60-100°):
Extension (50-60°):	Adduction (50-75°):
Horizontal adduction/abduction (130°):	
Circumduction (200°):	
Apley's Scratch:	

Passive movements (note end-feel, ROM and pain)

Elevation through abduction (bone to bone or tissue stretch)……
Elevation through forward flexion (tissue stretch)……
Lateral rotation (tissue stretch)……
Medial rotation (tissue stretch)……
Extension (tissue stretch)…….
Adduction (tissue approximation) ……..
Horizontal adduction (tissue stretch or approximation)……...
Horizontal abduction (tissue stretch)……
Quadrant Test……...

Resisted Isometric Movements (note strength and pain)

Flexion		Medial rotation	
Extension		Lateral Rotation	
Adduction		Elbow flexion	
Abduction		Elbow extension	

Joint Play Movements (and motion palpation)

SC Joint	Supero-inferior (shrug shoulder with arm at side):
	Horizontal add/abduction (arm abducted 90°):
AC Joint	A-P Shear:
	Supero-inferior shear:
Scapula	Normal scapulo-humeral rhythm?:
	General mobility of scapula:

Glenohumeral Joint

Lateral movement of humeral _____

head

Inferior movement of humeral head (Caudalglide)(50°)

Anterior movement of humeral head (P-A glide)(25°)

Posterior shear of humeral head (A-P glide) **>50%** At 10° flexion

At 90° flexion

Backward glide of humeral head in abduction

Long-axis distraction of humeral head in abduction

Downward and backward (S-I → A-P)

Outward and backward (med-lat → A-P

External rotation of humeral head

Internal rotation of humeral head

Instability Tests

1. Anterior Instability Tests

	R			L		
	Pos	Neg	n/a	Pos	Neg	n/a
Anterior drawer Test						
Rowe Test						
Fulcrum Test						
Apprehension (crank) Test						
Clunk Test (tear of labrum)						
Rockwood Test						

2. Posterior Instability Tests

	Pos	Neg	n/a	Pos	Neg	n/a
Posterior Apprehension Test						
Norwood Stress Test						
Push-pull Test						
Jerk Test						

3. Inferior and Multi-directional instability tests

	Pos	Neg	n/a	Pos	Neg	n/a
Inferior Shoulder Instability Test						
Feagin Test (antero-inferior instability)						

A-C Joint Stress Test:

S-C Joint Stress Test:

Tests for Muscle or Tendon Pathology

1.	Speed's Test (bicipital tendonitis)	
2.	Gilchrest Sign (bicipital tendonitis)	

3.	Supraspinatus Test (supraspinatus tendonitis)	
4.	Hawkins-Kennedy Impingement Test (supraspinatus tendonitis)	
5.	Drop –arm Test (rotator cuff tear)	
6.	Impingement Test	
7.	Pectoralis Major Contracture Test	
8.	Ludington's Test (rupture of long head of biceps)	

Tests for neurological function

Brachial Plexus Tension Test			Radial Nerve										
			Median Nerve										
Tinel's Sign (Scalene triangle)													
Dermatones	C4		C5		C6		C7		C8		T1		T2	
Reflexes	Biceps(C5/6)						Triceps (C7/8)						

Thoracic Outlet Syndrome Tests

Adson's Test		Halstead's Test	
Costoclavicular Test		Eden's Test (cervical rib)	
Hyperabduction Test		Roos Test	
Allen's Test			

Appendix E: THORACIC SPINE REGIONAL EXAMINATION

Patient:_____File:_____ Date:_____

Intern:_____Signature:_____

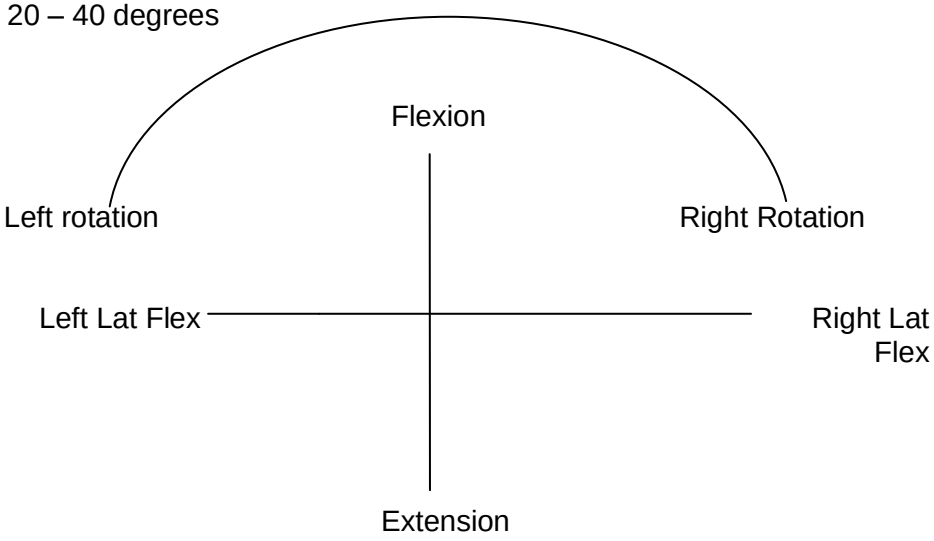
Clinician: _____Signature:_____

STANDING:

Posture (incl. L/S & C/S)
Muscle tone
Skyline view – Scoliosis
Spinous Percussion
Breathing (quality, rate, rhythm, effort)
Deep Inspiration
Scars
Chest deformity
(pigeon, funnel, barrel)

RANGE OF MOTION:

Forward Flexion	20 – 45 degrees (15cm from floor)
Extention	25 – 45 degrees
L/R Rotation	35 – 50 degrees
L/R Lat Flex	20 – 40 degrees



RESISTED ISOMETRIC MOVEMENTS: (in neutral)

Forward Flexion	Extension
L/R Rotation	L/R Lateral Flexion

SEATED:

Palpate Auxillary Lymph Nodes
Palpate Ant/Post Chest Wall
Costo vertebral Expansion (3 – 7cm diff. at 4th intercostal space)
Slump Test (Dural Stretch Test)

SUPINE:

Rib Motion (Costo Chondral joints) SLR

Soto Hall Test (#, Sprains) Palpate abdomen

PRONE:

Passive Scapular Approximation

Facet Joint Challenge

Vertebral Pressure (P-A central unilateral, transverse)

Active myofascial trigger points:

	Latent	Active	Radiation Pattern		Latent	Active	Radiation Pattern
Rhomboid Major				Rhomboid Minor			
Lower Trapezius				Spinalis Thoracic			
Serratus Posterior				Serratus Superior			
Pectoralis Major				Pectoralis Minor			
Quadratus Lumborum							

COMMENTS:_____

NEUROLOGICAL EXAMINATION:

DERMATOMES												
	T 1	T 2	T 3	T 4	T 5	T 6	T 7	T 8	T 9	T 10	T 11	T 12
Left												
Right												

Basic LOWER LIMB neuro:

Myotomes	
Dermatomes	
Reflexes	

KEMP'S TEST:

MOTION PALPATION:

			Right	Left
Thoracic Spine				
Ribs	Calliper (Costo-transverse joints)			
	Bucket Handle	Opening		
		Closing		
Lumbar Spine				
Cervical Spine				

BASIC EXAM	History	ROM	Neuro/Ortho
LUMBAR			
CERVICAL			

Appendix F: SOAPE Note

Patient Name:	***File #:***	***Page:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale*** ***(Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

0: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature:***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: ***P:***

E:

Special attention to: ***Next appointment:***

Date: ***Visit:*** ***Intern:***
Attending Clinician: ***Signature***

S: ***Numerical Pain Rating Scale (Patient)*** ***Intern Rating*** ***A:***
Least 0 1 2 3 4 5 6 7 8 9 10 Worst

O: ***P:***

E:

Special attention to: ***Next appointment:***

SPADI (SHOULDER)

Name _____ Date_____

PAIN SCALE	
How severe is your pain:	
1. At its worst.	No pain 0 1 2 3 4 5 6 7 8 9 10 Worst Pain Imaginable
2. When lying on involved side.	No pain 0 1 2 3 4 5 6 7 8 9 10 Worst Pain Imaginable
3. Reaching for something on a high shelf.	No pain 0 1 2 3 4 5 6 7 8 9 10 Worst Pain Imaginable
4. Touching the back of your neck.	No pain 0 1 2 3 4 5 6 7 8 9 10 Worst Pain Imaginable
5. Pushing with the involved arm.	No pain 0 1 2 3 4 5 6 7 8 9 10 Worst Pain Imaginable
DISABILITY SCALE	
How much difficulty did you have:	
1. Washing your hair.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
2. Washing your back.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
3. Putting on an undershirt or pullover sweater.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
4. Putting on a shirt that buttons down the front.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
5. Putting on your pants.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
6. Placing an object on a high shelf.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
7. Carrying a heavy object of 10 pounds.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help
8. Removing something from your back pocket.	No difficulty 0 1 2 3 4 5 6 7 8 9 10 So difficult required help

DEVELOPED BY Roach 1991 [1];

Reference List

1. Roach KE, Budiman-Mak E, Songsiridej N, Lertratanakul Y. Development of a shoulder pain and disability index. Arthritis Care Res. 4[4], 143-149. 1991.

Trapezius Stretch

- Place ear on shoulder (as far as possible).
- Apply mild tension with opposite hand.
- To increase the stretch, grip side of chair with the other hand.
- Hold for 30 seconds, 3 times. Do both sides.
- Apply stretch twice per a day (Vizniak, 2010).

Levator Scapulae stretch

- Look diagonally at shoulder.
- Apply mild tension with opposite hand.
- To increase the stretch place the other hand behind back and drop shoulder.
- Hold for 30 seconds, 3 time. Do both sides
- Apply stretch twice per a day (Vizniak, 2010).

Push ups plus

- On all fours.
- Drop spine between scapula and squeeze shoulder blades together.
- Then raise the spine between the shoulder blades.
- Hold for 10 seconds.
- Do exercise 10 times (liebenson, 2007).

References:

Vizniak, N. 2010. *Quick Reference evidence based muscle manual*. Professional Health Systems inc: Canada.

Liebenson, C. 2007. *Rehabilitation of the spine – A practitioners manual.* Lippincott Williams & Wilkins. Baltimore, USA.

DO YOU SUFFER FROM SHOULDER PAIN?

ARE YOU BETWEEN THE AGES OF 18-35?

Research is currently being conducted at the Durban University of Technology Chiropractic Day Clinic

FREE TREATMENT

Available to those who qualify to take part in this study
Contact Ryan Booyens on 072 344 0786
Or the chiropractic day clinic on 031 373 2205
To see if you qualify for this study.

Appendix J: Letter of Permission for Advertising

To whom it may concern

I am a student registered for my Master's in Chiropractic at the Durban University of Technology. My study is investigating the short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome.

In order to conduct my study I will need 30 participants who are between the ages of 18 and 35 years, and have shoulder impingement syndrome (or pain on the anterior aspect of their shoulder). Should the respondent be suitable for the study they will then receive either spinal manipulative therapy or a placebo treatment. It is a once off assessment that will be done at the Chiropractic Day Clinic at the Durban University of Technology.

I would like to request to place an advert at your establishment to advertise my study and potentially recruit participants. Should a person be interested in participating in the study they will then be able to contact me directly as my phone number is on the advert.

I am hoping for your kind consideration.

Sincerely yours,

Ryan Booyens

Permission given by (print name) _____ to place an advert at the

following location _____.

Signature: _____

Date: _____

Appendix K: Letter of Permission to use CDC for Research

To whom it my concern

I am a student of Chiropractic at the Durban University of Technology am conducting a study entitled: "The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome."

In this connection, I would like to ask permission to use the Chiropractic Day Clinic to conduct the above research.
I am hoping for your kind consideration.

Sincerely yours
Ryan Booyens

Noted By (print name) _____

Signature _____

Approved By (print name) _____

Signature _____

KUNGABE IHLOMBE LAKHO LIBUHLUNGU?

KUNGABE UPHAKATHI KWEMINYAKA 18-35?

Kunocwaningo olwenziwayo e-Durban University of Technology Chiropractic Klinikhi

UNGATHOLA UKWELASHWA

Kulabo abanayo imibandela edingakalayo kulolucwaningo

Thintana no Ryan Booyens kulenombolo 072 344 0786

Noma i-chiropractic klinikhi kulenombolo 031 373 2205

Ukuthola ukuthi ungaba yini ingxenye yalolucwaningo.

Appendix M: isi-Zulu Letter of Information and Consent

INCWANDI YESAZISO

Mhlanganyeli othandekayo:
Siyakwemukela kumsebenzi wami wocwaningo. Ngiyabonga ukuthi uthole isikhathi sokuthi uzibande kanye nami kulomsebenzi wami.

Title of the Research Study:
The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome.

Umcubunguli omkhulu/umcwaningi: uRyan Booyens
Umcubunguli wesibili/umphathi: Udokotela L. O'Connor (M.Tech: Chiropractic)

Ukwethulwa kafishane nenjongo yalomsebenzi:
Indawo lapho kuhlangana khona ihlombe namathambo kujwayeleke ukuthi kube yindawo elimala njalo emzimbeni, lokhu kwenziwa ukuthi lendawo enyakaza kakhulu emzimbeni. Isimo esijwayelekile esihlasela ihlombe yilapho imisipha yezicubu ezivikela ihlombe zibambeka lapho kuhlangana khona ihlombe nengxenye yomzimba bese kuyavuvukala (shoulder impingement syndrome). Ziningi izizathu ezingenza lokhu, Esinye isizathu izicubu eziqinisa isiphanga ziphelelwa amandla bese kuba khona ukudonseka kwenyama yangaphandle yehlombe. Lezi zicubu zixhumane nomgogodla, uma umgogodla ungasebenzi kahle kuzokwenza ukuthi lezi zicubu zingasebenzi kahle. Ucwaningo olwahlukene olwenziwe luhlole ukwelapha okwenziwa emgogodleni (spinal manipulative therapy) nezimbambo kanye nomthela wazo ehlombe (shoulder impingement syndrome). Lolucwaningo lukhombise umphumela omuhle. Injongo yalolu cwaningo ukubonisa umphumela wekunyakazisa umgogodla (thoracic spinal manipulation) ekulapheni ihlombe (shoulder impingement syndrome).

Lolucwaningo lwenziwe ukuze luqhathanise nezinye izindlela ezingasetshenziswa ukwelapha (comparative clinical trial). Uzokwethwa ufakwe eqenjini elilodwa kwamabili akhona. Kunamathuba angamashumi amahlanu okuthi ungangena eqenjini i-placebo. Amaqembu womabili azothola ukwelashwa kanye bese kulandelelwa kuqoqwe imiphumela yokwelashwa ngemva kwamahora angamashumi amane nesishiyagalombili. Uyacelwa ukuthi ungakhulumi nomcubunguli ngalokhu kwelashwa.

Uma ufuna ukulungenela lolu cwaningo kumele ube neminyaka ephakathi kuka- 18 no 35, futhi ube umuntu ophethwe ihlombe (shoulder impingement syndrome) futhi uvumile ukuthi ezosayina lencwadi yesaziso neyokuthi uyavuma. Uma ungumuntu odla amaphilisi noma umuthi (njenge-buprofen, paracetamol) uzocelwa ukuthi ungaqhubeki nemithi yakho izinsuku ezintathu ngaphambi kokuba ngikuvumele ukuthi ungene kulolucwaningo.

Uma ufuna ukuqhubeka nalolucwaningo, kuzobhekwa umlando wakho emzimbeni kanye nokuhlolwa impilo ukuze kube nesiqinisekiso sokuthi ungakhona yini ukungenela lolucwaningo ngaphandle kwenkinga. Uma sewuvumelekile, uzocelwa ukuthi ubonane nomcwaningi izihlandle ezimbili esikhathini esingamahora angamashumi amane nesishiyagolombili. Uma sewuzoqala ukwelashwa, uzothatha amahora amabili kuphela ekuqaleni bese uma sewuphinda okwesibili kuzokuthatha imizuzu engamashumi amabili kuphela. Abantu abangaphumelelanga ukuqhubeka nalolucwaningo ngenxa yezinto ezithile ezibe nenkinga bazobe sebethunyelwa kudokotela ozobasiza.

Izinto ezingenzeka emzimbeni walowo ongenele lolucwaningo:
Uzozizwa umzimba kungathi uqinile noma uzwe umzimba wakho ungakhululekile ngemuva kokuzixilonga, kodwa lokhu kungaba yinto nje yemizuzu engasukela kumizuzu engamashumi amabili nane kuya kumizuzu engamashumi amane nesishiyagalombili. Uma lesi simo siqhubeka kumele ungazise.

Izizathu ezingenza ukuthi umuntu ozimisele ukungenela lolucwaningo anqatshelwa ukuqhubeka nalo yilokhu:
Uma ungalandeleli uhlelo osuke usuliqalile lwalolucwaningo uzosulwa kuloluhlelo. Uma unquma ukuthi ungezi wonke amalanga okufanele uze ngawo kuloluhlelo angeke ujeziselwe lokho.

Kungabe lumalini lolucwaningo:
Bonke abantu abalungenele loluhlelo angeke bakhokhe lutho, lumahhala.

Okuyimfihlo:
Konke okumayelana nawe kuzoba yimfihlo, kuyovalelwa ngandlela thize yobuchwepheshe kuse kuhlolwe lolulwazi. Awuphoqiwe ukugenela loluhlelo, ungayeka noma nini uma ungasafuni ukuqhubeka.

Ingozi engenzeka ngokwenza loluhlelo:
Imigaqo siseko yasekliniki yase-D.U.T iyolandelelwa futhi uma kube khona ingozi eyenzekile kumele wazise ikomiti le-Institutional Research Ethics, uyacelwa ukuthi ungazise uma kwenzeka inkinga enjalo.

Ngobani ongabazisa uma kwenzeka izinkinga noma kukhona ofuna ukukubuza:
Ngicela uthintane nomcwaningi: uRyan Booyens (ucingo: 0723440786), umphathi wami wocwaningo: Udokotela O'Connor (ucingo: 031 373 2923) noma umphathi wehovisi le-Institutional Research Ethics (ucingo: 031 373 2900) Izikhalazo zingayiswa ku-DVC: TIP, Prof F. Otieno ku-031 373 2382 noma ku: dvctip@dut.ac.za

Othembekileyo wakho,

_____
umcwaningi: uRyan Booyens

_____
Umphathi wocwaningo: Udokotela L. O'Connor

IMVUME

Isitatimende esifungelwe sokuvumela ukungenela lolucwaningo:

- Ngiyavuma ukuthi ungazisile umcwaningi, _____ (igama lomcwaningi), ngendlela, ukuziphatha, ubuhle kanye nobungozi balolucwaningo - Research Ethics Clearance Number: _____,
- Ngitholile futhi, ngafunda, ngazwisisa ngalombiko ongenhla obhaliwe (Participant Letter of Information) mayelana nalolu cwaningo.
- Ngiqinisekile ukuthi imiphumela yalolucwaningo, kanye nombiko omayelana nobulili bami, iminyaka, usuku lokuzalwa, amagama ami nesifo esitholakele emzimbeni wami iyokwenziwa ngokungasebenzisi igama lomuntu othile otholwe enalesi sifo sibe umbiko walolucwaningo.
- Mayelana nemigomo yocwaningo, ngiyavuma ukuthi konke okuqoqiwe ngami ngalolucwaningo kuzobhalwa ngendlela yobuchwepheshe kwikhompuyutha ngumcwaningi.
- Kungenzeka noma nini ngingabe ngisaqhubeka nalolu cwaningo ngaphandle kokuboshwa okuthize, ngingazibandakanyi kulolu cwaningo.
- Ngizinikile isikhathi sokwazi, ngabuza nemibuzo ngalolucwaningo (ngendlela yami futhi nangokukhululeka ngaphandle kwengcindezi) futhi ngazinikela ngaze ngazilungiselela ukuthi ngilungenele lolucwaningo.
- Ngiyethemba ukuthi okusha okutholakele mayelana nocwaningo okuzokhombisa imiphumela yokungenela kwami kulolu cwaningo ngiyokwaziswa ngakho.

_____ _____ _____ _____

Igama eligcwele longenele ucwaningo **Usuku** **Isikhathi Sayina/Ngesokudla Isithupha (Thumbprint)**

Mina, _____(igama lomcwaningi) ngiyavuma ukuthi lona ongenhla ongenele lolu cwaningo utsheliwe kabanzi ngendlela, ukuziphatha kanye nebungozi balolucwaningo.

_____ _____ _____

Igama eliphelele lomcwaningi **Usuku** **Sayina**

_____ _____ _____

Igama eliphelele likafakazi (uma ekhona) **Usuku** **Sayina**

_____

Igama eliphelele lomvikeli osemthethweni (uma ekhona)

_____ _____

Usuku **Sayina**

Appendix N: Permission to use DUT Chiropractic Day Clinic

MEMORANDUM

To : Prof Puckree
Chair : RHDC

Prof Adam
Chair : IREC

From : Dr Charmaine Korporaal
Clinic Director : Chiropractic Day Clinic : Chiropractic and Somatology

Date : 27.07.2013

Re : Request for permission to use the Chiropractic Day Clinic for research purposes

---

Permission is hereby granted to :

Mr Ryan Booyens (Student Number: 20804041)

Research title : The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome.

It is requested that Mr Booyens submit a copy of his RHDC / IREC approved proposal to the Clinic Administrators before he starts with his research in order that any special procedures with regards to his research can be implemented prior to the commencement of him seeing patients.

Thank you for your time.

Kind regards

[redacted]

Dr Charmaine Korporaal

Clinic Director : Chiropractic Day Clinic : Chiropractic and Somatology

Cc: Mrs Pat van den Berg : Chiropractic Day Clinic

Dr L O'Connor : Research co-ordinator and research supervisor

Appendix O: Institutional Research Ethic Committee approval

Institutional Research Ethics Committee
Faculty of Health Sciences
Room M5-49, Monteith School Site
Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban South Africa 4001

Tel: 031 373 2900
Fax: 031 373 2577
Email: lavanyad@dut.ac.za
http://www.dut.ac.za/research/ethics_committees_research_ethics

www.dut.ac.za

14 August 2013

IREC Reference Number: **REC 40/13**

Mr R P Booyens
78 Langenhoven Street
Parkrand
Boksburg
1459

Dear Mr Booyens

The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome

I am pleased to inform you that Full Approval has been granted to your proposal REC 40/13.

The Proposal has been allocated the following Ethical Clearance number IREC 040/13. Please use this number in all communication with this office.

Approval has been granted for a period of one year, before the expiry of which you are required to apply for safety monitoring and annual recertification. Please use the Safety Monitoring and Annual Recertification Report form which can be found in the Standard Operating Procedures (SOP's) of the IREC. This form must be submitted to the IREC at least 3 months before the ethics approval for the study expires.

Any adverse events (serious or minor) which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.
Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC

NHREC

South African Human Research Electronic Application System

Appendix P: South African Clinical Trials Registration

TRIAL APPLICATION

Application ID:	3516	DOH Number	DOH-27-0813-4516	Page:	1/2

Applicant Details	
Organisation :	Durban University of Technology
Applicant Type :	Academic Investigator
Contact Name :	Laura O'Connor
Address :	Durban University of Technology
Telephone :	Chiropractic department
Fax :	11 Ritson rd
E-mail :	Berea
Responsible Contact person (for public)	4000
Telephone :	0313732923 0865324207
Research contact person	lauraw@dut.ac.za Laura
Telephone :	O'Connor
	0313732923
	Ryan Booyens
	0723440786

Trial Application Details	
Issue Date :	2013/08/22
Sponsors :	Durban University of Technology
Primary Sponsor :	Durban University of Technology
FundingType :	Not Funded
Research Site Names :	Chiropractic Clinic, Durban University of Technology
Primary Research Site Name :	Chiropractic Clinic, Durban University of Technology
Total National Budget for Trial :	R 5167.95
Protocol / Grant Reference Number	REC40/13

Study Descriptive Information		
Brief Title of Study :	The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome Single Site	
Full Title of Study :	The short term efficacy of thoracic spinal manipulation on shoulder impingement syndrome	
Anticipated Start Date :	2013/08/22	
Anticipated End Date :	2014/02/02	
Target Sample Size :	30	
Study Phase :	Other	
Study Scope :	Single Site	
Study Type :	Interventional	
Disease Type Heading :	Muscle, Bone and Cartilage Diseases	
Disease Type Condition	Musculoskletal Abnormalities	
Intervention Name (Generic)	Spinal manipulative therapy	
Intervention Duration	No.	Type
	6	Months

NHREC

South African Human Research Electronic Application System

TRIAL APPLICATION

Application ID:	3516	DOH Number	DOH-27-0813-4516	Page:	2/2

Interventional	
Intervention Type :	Procedure
Purpose :	Treatment
Allocation :	Randomised
Masking :	Single Blind
Control :	Placebo
Assignment :	Parallel
Endpoints :	Efficacy

Study Descriptive Information	
Recruitment Status as at Date:	2013/08/19
Recruitment Status :	Recruiting
Gender :	Both
Ethnicity :	All
Age :	From 18 Years To 40 Years
Qualifying Disease Condition for Inclusion :	Diagnosed with shoulder impingement syndrome using the following criteria: • Anterior and/or lateral shoulder pain during overhead activity • Orthopaedic testing:Both the impingement test and empty can test must be positive and at least one of the following must be positive: Hawkins-Kennedy impingement test, apprehension test and/or relocation test
Major Exclusion Criteria :	1. Contra-indications to thoracic spinal and rib manipulation such as neurological deficits, instability, unstable spondylolisthesis, arthritis, fractures, Potts disease, malignancy of the spine, dislocation of the vertebra. This will be determined by the case history and physical examination. 2. Primary complaint of neck pain and cervical radiculopathy, positiveresult on a cervical distraction test or Spurling test 3. Any patient receiving treatment for shoulder impingement syndrome within the last week. 4. Neurological deficit of the Dorsal Scapular nerve (C4-C5) determined by an inability to perform the Scapular isometric pinch test 5. Positive internal rotation resistance strength test to exclude those participants with internal impingement syndrome 6. Those participants who present with shoulder instability as determined through orthopaedic testing (e.g. anterior instability test, posterior drawers and feagin test) will be excluded, to ensure that the cause of secondary impingement is from weakness of the scapulothoracic muscles and not glenohumeral instability. 7. Severe postural thoracic abnormalities such as gibbus, severe increase in the thoracic kyphosis and severe scoliosis.
Key Primary Outcome :	Pain and disability
Key Secondary Outcomes :	Shoulder range of motion, scapulohumeral rhthym and scapular stabilisation test

Committees			
Ethics Committee :	Approval Status	Ethics Number	Ethics Date
Durban University of Technology Institutional Research Ethics Committee	Approved	REC40/13	2013/08/14

Appendix Q: Data Collection Sheet

PATIENT NAME _____ CODE_____

1) **Inclinometer R.O.M.**

	1	2	3	Average
Flexion				
Abduction				
External Rotation				
Internal Rotation				

2) **Lateral Scapular Slide Test**

	Spine of Scapula	Inferior Angle of Scapulae
0 Degrees		
45 Degrees		
90 Degrees		
120 Degrees		
150 Degrees		

3) **Scapular Isometric Pinch Test**

Time	
Burning	
Compensation	
Other	
Normal (> 20 seconds)	