THE EFFECT OF SACROILIAC JOINT MANIPULATION ON QUADRICEPS MUSCLE STRENGTH

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by

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DECLARATION

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Technology at the Technikon Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other Technikon or University.

Signature of Candidate: [Signature]
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ABSTRACT

This unblinded, non-randomised pilot study was conducted in order to determine if chiropractic manipulation of the sacroiliac joint could increase the short-term strength of the quadriceps femoris muscle group.

Eighty assymptomatic subjects between the ages of 18 and 40 years participated in the investigation. These subjects were recruited for the study by the use of posters, which were placed in different locations around the Technikon Witwatersrand campus. The participants were placed into two groups of forty patients each. Males were placed into one group, while females were placed in the other. Both groups received manipulation of their sacroiliac joints. Each patient received one treatment.

The inclusion criteria required that the patient had to have motion restriction of one sacroiliac joint, which was determined by chiropractic motion palpation. The objective data was collected by use of an isometric dynamometer. The patient’s quadriceps extension strength was measured using the dynamometer before and after chiropractic manipulative therapy was administered.

The objective results indicated that there was a statistically significant increase in quadriceps extension strength.

In conclusion, chiropractic manipulative therapy does play a role in causing a short-term increase in quadriceps extension strength. This has implications in a rehabilitative setting, as a combination of chiropractic manipulative therapy and muscle strengthening could prove to be more beneficial to the patient being rehabilitated than either treatment in isolation.
DEDICATION

Thank you to my parents for believing in me and for supporting me every step of the way. Without their love, devotion and inspiration I would not be where I am today.

To Nicola, Larren and Jodi:
Without your support and love this work would have never been finished.
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TABLE OF CONTENTS

DECLARATION i
ABSTRACT ii
DEDICATION iii
ACKNOWLEDGEMENTS iv
TABLE OF CONTENTS v
APPENDICES vii
LIST OF FIGURES vii
LIST OF TABLES viii
DEFINITION OF TERMS ix

CHAPTER ONE – INTRODUCTION

1. Introduction 1

CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction 3

2.2 Anatomy 5

2.1.1 The Sacroiliac Joint 5

a) Articular surfaces of the Sacroiliac joint 5
b) Ligaments of the Sacroiliac joint 6
c) Nerve supply of the Sacroiliac joint 9
d) Blood supply of the Sacroiliac joint 10

2.1.2 The Quadriceps Femoris Muscle Group 11

2.1.2.1 Vastus Medialis 12
2.1.2.2 Vastus Lateralis 12
2.1.2.3 Rectus Femoris 13
2.1.2.4 Vastus Intermedius 13
2.1.2.5 Innervation of the Quadriceps Femoris 13
2.1.2.6 Functions of the Quadriceps Femoris 14
2.2 Biomechanical Principles
  2.2.1 Introduction
  2.2.2 Movement of the Sacroiliac Joints

2.3 Effects of Manipulation
  2.3.1 Neurological Effects of Manipulation
  2.3.2 Biomechanical Effects of Manipulation
  2.3.3 Reflexogenic Effects of Manipulation

CHAPTER THREE – METHODOLOGY
  3.1 Study Design
  3.2 Patient Selection
    3.2.1 Patient examination
      3.2.1.1 Motion Palpation of the Sacroiliac Joint
      3.2.1.2 Static Palpation of the Sacroiliac Joint
      3.2.1.3 Orthopaedic Tests
  3.3 Sample Size
  3.4 Treatment Schedule
  3.5 Chiropractic Manipulative Therapy
  3.6 Monitoring
    3.6.1 Objective Measurement

CHAPTER 4 – RESULTS
  4.1 Introduction
  4.2 Quadriceps Strength Measurements

CHAPTER FIVE – DISCUSSION
  5.1 Introduction
  5.2 Quadriceps Strength Measurements
CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion 43
6.2 Recommendations 43

REFERENCES 46

APPENDICES 49
Appendix A: Subject Consent and Information Form 50
Appendix B: Advertisement Poster 52
Appendix C: Contraindications to Manipulative Therapy 53
Appendix D: SOAP Note 55
Appendix E: Lumbar Spine Neurological Examination 56

LIST OF FIGURES
Figure 2-1: Bones and Ligaments of the Pelvis 8
Figure 2-2: Bones and Ligaments of the Pelvis 9
Figure 2-3: Femoral Nerve and Lateral Femoral Cutaneous Nerves 14
Figure 3-1: Erichsen’s Test 27
Figure 3-2: Sacral Compression Test 28
Figure 3-3: Patrick FABER Test 29
Figure 3-4: Thigh-Ilio-Deltoid 31
Figure 4-1: Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups 35
Figure 4-2: Bar Graph comparing the quadriceps strength measurements for the right thigh for both the male and female groups 36
Figure 4-3: Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups combined 37
Figure 4-4: Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups combined

LIST OF TABLES

Table 4-1: Paired T-test for the Changes in Strength Measurements in the left thigh before and after a manipulative thrust was administered for the male and female groups.

Table 4-2: Paired T-test for the Changes in Strength Measurements in the right thigh before and after a manipulative thrust was administered for the male and female groups.

Table 4-3: Paired T-test for the Changes in Strength Measurements in the left thigh before and after a manipulative thrust was administered for the combined male and female groups

Table 4-4: Paired T-test for the Changes in Strength Measurements in the right thigh before and after a manipulative thrust was administered for the combined male and female groups

Table 4-5: Side of Sacroiliac joint fixation as related to side of increased quadriceps strength

Table 4-6: Effects of Sacroiliac joint manipulation on quadriceps strength

Table 4-7: Sacroiliac joint fixation

Table 4-8: Ages of the participants
DEFINITION OF TERMS

CHIROPRACTIC MANIPULATIVE THERAPY

A passive therapeutic manoeuvre in which specifically directed forces are applied to vertebrae and extra-vertebral articulations of the body, with the object of restoring mobility to restricted areas. For the purpose of this study, a short lever manipulation/adjustment is a high velocity thrust directed at an isolated joint, namely a unilateral sacroiliac joint (Gatterman 1990:410).
CHAPTER ONE – INTRODUCTION

There is not a large body of evidence linking manipulation to increased muscle strength, be it a transient or long-term increase in strength (1, 2, 3).

In an attempt to provide some answers to this problem, this unblinded, controlled pilot study investigated the ability to increase short-term muscle strength using chiropractic manipulative therapy. This research aimed to determine the effect of manipulation on quadriceps strength.

Suter, McMorrow, Herzog and Bray (1999: 151-152) state that evidence exists that conservative rehabilitation protocols fail to achieve full recovery of muscle strength and function after joint injuries. They found evidence that manipulation caused a decrease in muscle inhibition and an increase in knee-extensor torques and muscle activation (2).

Wyke (1985:74) describes documented effects of manipulation, which include pain suppression, reflexogenic, neurological, and biomechanical mechanisms (4).

The sacroiliac joint was chosen, because it is the largest joint in the body, and according to Chapman-Smith (1990:1), it is clinically a very important joint with regards to low-back pain, leg pain and dysfunction throughout the rest of the spine (5). Suter et al (2000:76) state that sacroiliac joint dysfunction is commonly associated with anterior knee pain and the associated strength deficits and decreased activation of the knee extensors (3).

The purpose of finding a link between manipulation and increased muscle strength has implications in a rehabilitative setting. For example, if a patient is receiving rehabilitation for a specific condition, and strengthening exercises are part of the prescribed programme, then sacroiliac joint
manipulation can be administered before undertaking the exercise programme, and greater results are likely to be achieved. This is thought to be due to the better efficiency of the involved muscle to contract, which either has a neurological or biomechanical basis, or both.

The following literature review explains the documented effects of chiropractic manipulation. There is an in depth look and explanation into the neurological, biomechanical and reflexogenic effects of manipulative therapy. This information is vital to understand the effect of manipulative therapy on muscle strength.
CHAPTER TWO – LITERATURE REVIEW

2.1 Introduction

Chapman-Smith (1990:1) states that Gray's Anatomy has now reclassified the sacroiliac joint as a true synovial joint and acknowledges that it moves for everyone, not just expectant mothers (5).

During the meeting of the International Federation of Manual Medicine in London during September 1989, medical specialists presented papers affirming the importance of sacroiliac dysfunction in generating back and leg pain, and skilled manipulation in removing it (5).

The sacroiliac joint has been implicated in causing:

- Buttock and leg (sciatic) pain.
- Dysfunction throughout the spine from compensation for pelvic dysfunction.
- Neck pain and headaches may have sacroiliac problems as their primary cause (5).

A study has shown that sacroiliac dysfunction and back pain are surprisingly high in schoolchildren (29.9% of elementary schoolchildren [ages 6-12] and 41.5% of secondary schoolchildren [ages 12-17] tested positive for sacroiliac dysfunction using Gillet's assessment methods) (5).

In a more recent study by Chapman-Smith (1993:1-2), 98% of patients had mechanical dysfunction of the sacroiliac joints as a major cause of their low-back pain. Treatment of these patients by restoration of full sacroiliac joint motion, along with correction of other dysfunctions, led to relief in almost all cases (6).
Suter, McMorland, Herzog and Bray (1999:149) state that after manipulation, subjective improvement in knee extensor strength was reported (2).

According to Colloca, Keller, Gunzburg, Vandeputte and Fuhr (2000:448) the beneficial effects of spinal manipulative therapy are related to mechanical, neurophysiologic and reflexogenic mechanisms. These beneficial effects have been thought to be associated with mechanosensitive afferent stimulation and presynaptic inhibition of nociceptive afferent transmission in the modulation of pain, inhibition of hypertonic muscles, and improvement of functional ability (7).

Dishman and Bulbulian (2000:2519-2525) found that a high-velocity, low amplitude lumbosacral manipulative procedure led to short-term attenuation of α-motoneuronal activity, as quantified by Hoffman reflex amplitude changes (8).

The Hoffman reflex (H-reflex technique) is a tibial nerve reflex. The H-reflex provides a neurophysiologic index of α-motoneuron excitability as a consequence of lumbosacral spinal manipulation, as 1a afferents from the triceps surae muscle activate the α-motoneuron pool of the lumbosacral spine. Therefore, the amplitude of the tibial nerve H-reflex response is reduced if activation of proprioceptive afferents after lumbosacral manipulation inhibits the α-motoneuron pool, and vice versa (8).

Pollard and Ward (1996:137) acknowledge that scientific knowledge of spinal manipulative therapy on muscle strength is absent, resulting in a restrictive basis for therapy and treatment. Muscle function and strength are affected by spinal cord excitability, and they are also effectors of changes to the spinal cord (1).
2.2 Anatomy

2.1.1 THE SACROILIAC JOINT

a) Articular surfaces of the Sacroiliac joint

Moore (1992:251) describes the Sacroiliac articulations as strong synovial joints between the surfaces the sacrum and the ilium. These surfaces have irregular elevations and depressions, which result in a partial interlocking of the bones (9).

Gatterman (1990:111-113) describes the sacrum as the keystone of the pelvic ring (10).

According to Harrison, Harrison and Troyanovich (1997:608), the sacrum is a tilted wedge, with its base orientated anterior and superior. Compression, caused by gravity and body weight, forces the sacrum inferiorly and anteriorly, while the apex moves postero-superior, thus functioning like a keystone, as mentioned earlier. Therefore, the more downward force applied, the more tightly the sacrum fits between the 2 ilia (11).

The articular surfaces of the sacrum are known as the auricular surfaces, and are located on the lateral aspects of the sacrum. At the upper level of the auricular surface, the sacrum is wider posteriorly than anteriorly, while at the lower level of the auricular surface, the anterior aspect is wider than the posterior aspect. This arrangement therefore increases the stability in resisting flexion of the sacrum between the innominates if the joints are compressed (11).

The auricular surfaces are shaped like an inverted L in men, while in women they are smaller and more oblique, creating a C-shaped joint (11).

The sacral auricular surface is covered by hyaline cartilage, which is up to 3 times thicker than the fibro cartilage found on
the iliac surfaces. Recent studies have suggested that hyaline cartilage may also line the iliac surfaces (11).

The surfaces are irregular, but the irregularities that develop are always reciprocal in nature, and therefore, an elevation on the sacrum fits into the depression on the ilium, which greatly increases friction between the bones, limiting movement. These irregularities develop in adolescence, and to a greater degree in men than women (11).

b) Ligaments of the Sacroiliac joint

Moore (1992:251) states that the strong articular capsule is attached close to the articulating surfaces of the ilium and sacrum (9).

The sacrum is suspended between the iliac bones, which are firmly supported by the sacroiliac and interosseous ligaments (9).

Harrison et al (1997:609) describes the ligamentous structure of the sacroiliac joint, and the following ligaments will be discussed:

i) Anterior sacroiliac ligament
ii) Interosseous ligament
iii) Dorsal sacroiliac ligament
iv) Sacrotuberous ligament
v) Sacrospinous ligament
vi) Iliolumbar ligament
vii) Pubic symphysis (11).

i) The anterior sacroiliac ligament is an anterior thickening of the joint capsule. It is very well developed near the arcuate line and the posterior inferior iliac spine.
The ligament opposes translation of the sacrum up or down, and separation of the joint surfaces.

ii) The interosseous sacroiliac ligament is a very large ligament filling irregular spaces posterior and superior to the joint. This is the largest syndesmosis in the body, and is the strongest connection in the sacroiliac region. The ligament strongly resists joint separation and translations in the vertical and antero-posterior directions.

iii) The dorsal sacroiliac ligament covers the interosseous ligament. Together, the dorsal and interosseous ligaments make up the posterior two thirds of the sacroiliac connections. The ligament may branch into a long posterior sacroiliac ligament, which is continuous with the sacrotuberous ligament.

iv) The sacrotuberous ligament functions to oppose sacral rotation (flexion). It is partly blended with the dorsal ligament.

v) The sacrospinous ligament is a thin, triangular ligament. It functions to prevent counter rotation (extension).

vi) The iliolumbar ligaments run from the transverse process of L4 and L5 to the iliac crests, and merges with the interosseous ligament. It functions to limit all motions between the distal lumbar spine and the sacrum. The ligament also prevents a translation of the sacrum out of the pelvic girdle, and separation of the ilia from the sacrum.

vii) The pubic symphysis is composed of three ligaments (the superior pubic, arcuate pubic and the interpubic ligaments). The pubic symphysis is a syndesmosis, and resists shear stresses and joint separations.
Harrison et al (1997:609) further state that the extensive sacroiliac ligamentous system is to limit every possible motion that may occur at the sacroiliac joint. These ligaments (refer to Figures 2-1 and 2-2) must oppose strong forces for long periods of time, and they play a key role in the self-bracing mechanism of the pelvis. This mechanism maintains the integrity of the low back and pelvis during transfer of energy from the spine to the lower extremities (11).

![Image of pelvic bones and ligaments]

**Figure 2-1** Bones and ligaments of the pelvis (Netter 1996: 334)
Figure 2-2 Bones and ligaments of the pelvis (Netter 1996: 335)

c) Nerve supply of the Sacroiliac joint

Chapman-Smith (1993:4-5) states that the sacroiliac joint derives its innervation from two sources:

i) Independent branches of the posterior primary rami that provide specific pathways to the capsule and overlying ligaments.

ii) Non-specific branches coming from muscles overlying the joint (6).
Posteriorly, the lateral branches of the posterior primary ramus from L4 to S3 supply the ligaments and joint capsule. Anteriorly, the innervation is from L2 to S2 (6). There is a wide range of segmental innervation, variable from person to person, and from left side to right side within the same person. This important fact accounts for the variable referred pain pattern seen in sacroiliac joint syndrome (6).

The sacroiliac joint and overlying ligaments have unmyelinated free nerve endings that transmit pain and thermal sensations, and both myelinated and unmyelinated nerve endings provide information on pressure and position. Pain from the sacroiliac joint may be local, or referred distally to an extremity. The referred pain is deep, dull and ill defined in nature and it radiates in the sclerotomal distribution (6).

Magee (1997:15) describes a sclerotome as an area of bone or fascia supplied by a single nerve root. The referral down the extremity is variable (13).

d) Blood supply of the Sacroiliac joint

According to Moore (1992:252/420/265), the arterial supply of the sacroiliac joint is derived from the superior gluteal, iliolumbar and lateral sacral arteries (9).

i) The superior gluteal artery is a short vessel, and is the largest branch of the internal iliac artery. It passes posteriorly between the lumbosacral trunk and the first sacral ventral ramus. The superior gluteal artery leaves the pelvis through the greater sciatic foramen, superior to the piriformis muscle (9).
ii) The iliolumbar artery arises from the posterior division of the internal iliac artery. It runs superolaterally to the iliac fossa. It then passes anterior to the sacroiliac joint (and supplies the anterior aspect of the sacroiliac joint) (9).

iii) The lateral sacral arteries arise from the posterior division of the internal iliac artery, and are divided into a superior and inferior branch on each side. They pass medially, and descend anteriorly to the sacral ventral rami, giving off spinal branches that supply the spinal meninges and sacral nerve roots (9).

2.1.2 THE QUADRACEPS FEMORIS MUSCLE GROUP

Moore (1992:386-387) describes the quadriceps femoris muscle as the largest muscle of the body and the great extensor of the leg. It covers almost all of the anterior surface and sides of the femur (9).

Lieber (1992: 42-43, 49-52) describes the architecture of the quadriceps. The quadriceps muscles are characterised by their relatively high pennation angles (fibre angle relative to the force generating axis), large physiologic cross-sectional areas and short fibres. Functionally, the quadriceps are designed for force production due to their low fibre length/muscle length ratios, and large cross-sectional areas (14).

Guyton and Hall (1996:1059) state that many of the differences in muscle performance between males and females is due to the extra percentage of muscle in the male body, which is due to endocrinial differences. Testosterone, which is secreted by the endocrine gland in males, has a powerful anabolic effect in causing greatly increased
deposition of protein everywhere in the body, especially in the muscles. This will result in increased strength in the male, even in a male who does not participate in sporting activity. Oestrogen, which is a female hormone, increases the deposition of fat. The non-athletic female has about 27% body fat composition in contrast to the non-athletic male who has about 15%. Testosterone also increases aggressiveness in males, which plays a role in males contracting harder and for longer than their female counterparts (15).

The quadriceps femoris is divided into four parts, namely:

- Vastus medialis
- Vastus lateralis
- Rectus femoris
- Vastus intermedius

2.1.2.1 VASTUS MEDIALIS

Anatomical attachments

- The Vastus medialis covers the medial aspect of the thigh.
- It originates from the medial lip of linea aspera and the intertrochanteric line.
- It inserts into the base of the patella (medial side) and the tibial tuberosity via the patella ligament (9).

2.1.2.2 VASTUS LATERALIS

Anatomical attachments

- The Vastus lateralis lies on the lateral side of the thigh.
- It originates from the greater trochantor and the lateral lip of linea aspera.
- It inserts into the base of the patella (lateral side) and the tibial tuberosity via the patella ligament (9).
2.1.2.3 RECTUS FEMORIS

Anatomical attachments

- This muscle covers the anterior aspect of the femur.
- It originates from the anterior superior iliac spine, and its fibres are deep and run straight down the thigh.
- It inserts into the base of the patella and the tibial tuberosity via the patella ligament (9).

2.1.2.4 VASTUS INTERMEDIUS

Anatomical attachments

- This muscle is located between the Vastus medialis and Vastus lateralis.
- It originates from the anterior and lateral surface of the body of the femur.
- It inserts into the base of the patella and the tibial tuberosity via the patella ligament (9).

2.1.2.5 INNERRATION OF THE QUADRICEPS FEMORIS

Moore (1992:387) explains that the femoral nerve innervates the quadriceps femoris group (refer to Figure 2-3). The nerve root levels are the posterior divisions of L2, L3, and L4 (9).
2.1.2.6 FUNCTION OF THE QUADRICEPS FEMORIS

Travell and Simons (1999:257-258) extensively describe the functions of the quadriceps femoris muscle group as follows:

- When the leg and foot are free to move, the four heads of quadriceps femoris muscle act together as prime extensors of the leg at the knee.

*Figure 2-3 Femoral Nerve and Lateral Femoral Cutaneous Nerves (Netter 1996: 506)*
• The rectus femoris either flexes the thigh at the hip, or flexes the pelvis on the thigh, depending on which segment is fixed.
• Participation of the rectus femoris in quadriceps contraction is dependant on the demands at the hip joint.
• The four heads trade off among each other in variable ways during slow increase of knee extension to maximum effort. Balanced tension on the patella between the vastus medialis and vastus lateralis maintains normal positioning and tracking of the patella.
• For upright activities with the foot fixed on a supporting surface, the quadriceps exerts its pull proximally rather than distally.
• The quadriceps frequently undergo lengthening contractions to control or decelerate movement caused by body weight.
• The quadriceps femoris functions to control movements of bending backward, squatting, sitting down from a standing position, and descending stairs, but it is not active during quiet standing.
• During walking, it is active immediately after heel-strike to control knee flexion and at toe-off to stabilise the knee in extension. It is not active during the period that the knee is extending during stance phase.
• The quadriceps femoris has a shortening function during rising from a seated position, and in ascending stairs.
• The quadriceps femoris contracts strongly during the down-stroke of the pedal during cycling (16).

2.2 Biomechanical Principles

2.2.1 INTRODUCTION
Levangie and Norkin (2001:150) explain that stability of the sacroiliac joints is extremely important, because these joints must support a large portion of body weight. In normal erect posture, the
weight of the head, arms and trunk is transmitted through the fifth lumbar vertebra and lumbosacral disc to the first sacral segment (17).

2.2.2 MOVEMENT OF THE SACROILIAC JOINTS
Levangie et al (2001:146-150) describe nutation and counternutation as the following movements:
Nutation is the commonly used term to refer to movement of the sacral promontory of the sacrum anteriorly and inferiorly, while the coccyx moves posteriorly in relation to the ilium.
Counternutation refers to the opposite movement in which the anterior tip of the sacral promontory moves posteriorly and superiorly, while the coccyx moves anteriorly in relation to the ilium.
The change in position of the sacrum during nutation and counternutation affects the diameter of the pelvic brim and pelvic outlet. During nutation, the anteroposterior (A-P) diameter of the pelvic brim is reduced and the A-P diameter of the pelvic outlet is increased. During counternutation, the opposite occurs (17).

The force of body weight on the sacrum creates a nutation torque on the sacrum, while the ground reaction force creates a posterior torsion on the ilia. The counter torques of nutation and counternutation of the sacrum and posterior torsion of the ilia are prevented by ligamentous tension and the fibrous expansions from the adjacent muscles that reinforce the capsule (17).

The sacroiliac joints are linked to the symphysis pubis in a closed kinematic chain, which forms an atypical three joint complex. Motion occurring at the symphysis pubis is accompanied by motion at the sacroiliac joints and vice versa.
The three joint complex is functionally closely linked to the hip joints, and is therefore affected by, and affects movements of the
trunk and lower extremities. For example, weight shifting from one leg to the other is accompanied by motion at the sacroiliac joints. Hip flexion in the supine position tilts the ilia posteriorly in relation to the sacrum. This pelvic motion causes nutation at the sacroiliac joints, which increases the diameter of the pelvic outlet, which is relevant during the process of giving birth (17).

It is important to note that the pelvis of the female is wider to accommodate childbirth. This means that females have an increased Q angle (quadriceps angle) at the knee. According to Levangie et al (2001:360), the Q angle is the angle formed between a line connecting the Anterior Superior Iliac Spine to the midpoint of the patella, and a line connecting the tibial tubercle and the midpoint of the patella. In females, the increased Q angle is due to the wider pelvis, increased femoral antversion and relative knee valgus. This results in excessive lateral forces on the patella, which causes a deficiency in the lever system of the quadriceps (17).

Don Tigny (1985:36) states that the sacroiliac joint has a large and important role in ambulation. Ambulation can be considered as a controlled fall with a forward inclination of the trunk to initiate and continue forward movement, while the legs move forward alternatively to maintain balance. A braking force is created on initial heel-strike. Between the inertia of the upper trunk and the deceleration on the innominates, there is a margin of shear. The sacroiliac joints function to absorb the shearing forces (18). The inertial movement of the trunk must always exceed the deceleration movement of the legs, or forward motion will cease. The braking force created on initial contact is partially absorbed at the foot on heel-strike and at the knee just before terminal extension (18). Therefore, the role of quadriceps contraction on the sacroiliac joint...
is that of flexion or extension of the sacroiliac joint, because it crosses the hip and knee joint and attaches to the anterior aspect of the ilium. Just before heel strike of the right leg for example, the right quadriceps is contracting to extend the right knee, and the right sacroiliac joint is pulled into flexion from an extended position. Counter-rotation of the upper trunk rotates the sacrum slightly posteriorly, which serves to lessen the deceleration moment on the sacroiliac joint. Therefore on contact of the right foot, the left shoulder is brought forward (18).

2.3 Effects of Manipulation

2.3.1 NEUROLOGICAL EFFECTS OF MANIPULATION

Colloca et al (200:448) describes neurophysiologic studies that theorise that spinal manipulative therapy stimulates and modulates the somatosensory system and consequently evokes neuromuscular reflexes. These studies therefore suggest that joint manipulation has both direct and indirect clinical benefits (7).

Pickar and Wheeler (2001:2-10) postulate that spinal manipulation affects impulse-based neural activity by altering the inflow of sensory information to the spinal cord. Mechanical forces introduced into the vertebral column may stimulate or inhibit receptive nerve endings in paraspinal tissues (including skin muscles, tendons, ligaments, joints and the intervertebral disc). Thus, spinal manipulation may remove an aberrant sensory input, or possibly add a new input. The manipulation-induced changes in sensory input are thought to affect central neural integration within motor, nociceptive, and/or autonomic neuronal pools and thereby elicit changes in afferent somatomotor and visceromotor activity (19).
Pollard and Ward (1996:137/8) suggest that neural integrity is vital to muscle function, though some claims exist that suggest that manipulation modulates neural activity. L3 is seen as the main segmental supply to the quadriceps muscle. The L3 nerve roots pass out of the central canal of the spinal column through the intervertebral foramina formed by the L3 and L4 vertebrae before joining the lumbar plexus on their respective sides (1).

Pollard further states that inflammation in a spinal segment causes a state of sustained hyperexcitability in the spinal cord. This hyperactivity can disrupt normal muscle function, which is similar to the concept of facilitation. Alterations at the segmental levels can bring about both short-term and relatively permanent changes in neural characteristics of the cord and can also result in changes to peripheral structures. The alterations that occur within the spinal cord manifest themselves as changes in spinal excitability independent of influences from higher centres. These processes occur at cellular level within the neurones of the spinal cord, and last varying times, having the potential to alter the functional capacity of the individual. The processes are referred to as habituation, sensitisation and fixation.

- Habitation is the progressive decrease in spinal excitability in response to a constant, repeated stimulus.
- Sensitisation is the opposite of habituation and occurs to a stronger stimulus. When sensitisation occurs repeatedly, it may result in long-term sensitisation, which may last a few hours.
- Fixation is a form of alteration of spinal excitability where sustained stimulation at a high intensity sees a prolonged increase in spinal activity. Fixation described here is analogous to the facilitated segment as described by
chiropractors and treated by them using manipulative techniques. When injury occurs, it is hypothesised that inputs from nociceptors to the spinal cord will produce habituation in the spinal circuits. Once afferent activity reaches a certain level or intensity, sensitisation occurs, and the interneuron pool produces more and more output. This results in the brain, muscles, and structures associated with that segment become activated. If inflammation occurs, the increased sensory input to the segment may produce fixation or facilitation to occur. Normal movements greatly increase the input to the affected spinal centres. This is because movement occurring in association with decreased threshold of the nociceptors will cause the nociceptors in the joints and surrounding soft tissue of the injured to be stimulated much more readily. This cycle of hyperexcitability has the possibility of causing disruption to normal body function and health, which includes muscle function (1).

Pollard and Ward (1996:139) further state that removal of motion restrictions in an articulation is generally thought to have an effect by reducing stresses in the joint, the joint capsule, ligaments, and surrounding musculature, therefore reducing reactive proprioceptive, nociceptive and mechanical stimuli bombardment from these structures to the associated spinal segments. This bombardment of the associated spinal segments has been implicated as an initial cause or contributing factor to the vertebral subluxation complex (1).

If spinal cord excitability were the cause of altered physiological processes (muscle function and strength), then reducing or removing the hyperexcitability would reduce or correct the
aberrant physiological processes affecting muscle function and strength. According to chiropractic literature, manipulation reduces spinal cord excitability. Therefore, the effects of manipulation should be to reduce or correct the aberrant physiological processes that are occurring which would allow muscle function to normalise (1).

Pickar and Wheeler (2001:2-10) have described a hypothetical mechanism for the neurological effects of spinal manipulation:

- Spinal manipulation increases joint mobility by producing a barrage of impulses in muscle spindle afferents, decreasing the activity of facilitated $\gamma$-motoneurons (19).
- $\gamma$-motoneuron discharge is elevated to muscles of vertebral segments in need of spinal manipulation. This impairs joint mobility by allowing the myotatic stretch reflex to detect very small changes in muscle length (19).
- The impulses from muscle spindle afferents in response to the spinal manipulation reduce the gain of the $\gamma$ loop through an undetermined neural pathway (19).
- This resets the $\gamma$ bias by producing a high frequency discharge in the muscle spindle and golgi tendon organ afferent (19).
- Muscle spindles and golgi tendon organs therefore respond to spinal manipulative-like loads. The chiropractic motion restriction is thought to affect reflex neural activity. Stimulation of muscle spindles from a given limb muscle evokes a monosynaptic excitatory potential in all $\alpha$-motoneurons to the same muscle (19).

The vertebral subluxation complex is a structural dysrelationship, typically between contiguous vertebrae, and is thought to affect reflex neural activity (19).
Therefore, when normal movement is induced through spinal manipulative therapy, stimulation of the α-motoneuron pool, muscle spindles and the golgi tendon organs occur, which is more than the preload. This relates to the spinal manipulative therapy increasing the discharge of muscle proprioceptors (19, 8).

2.3.2 BIOMECHANICAL EFFECTS OF MANIPULATION

Pickar and Wheeler (2001:2) describe how the mechanical force introduced into the vertebral column during a spinal manipulation alters segmental biomechanics by releasing trapped meniscoids, releasing adhesions and reducing distortion of the annulus fibrosis. The mechanical changes are thought to restore zygapophyseal joint mobility and joint play. This also applies to the sacroiliac joint (19).

According to Keller and Colloca (2000:593) spinal manipulation improves the functional ability of trunk muscles (20).

According to Schafer and Faye (1990:2) fixation is defined as a mobility hindrance mechanism. It is therefore any physical, functional or psychic mechanism that produces a loss of segmental mobility within a joints’ normal physiologic range of motion (21).

Haldeman (2000:113) proposes that the fixation is an aberrant biomechanical relationship within the spine. These aberrant relations in the spine are assumed to stimulate receptors in spinal and paraspinal tissues such as muscle, ligaments, facets and the sacroiliac joints. The impulses generated by stimulation of spinal structures activate neural reflex centres within the spinal cord’s higher centres that in turn, cause somatovisceral responses in sympathetic and parasympathetic nerves, or somato-somatic responses resulting in muscle spasm. This muscle spasm can lead
to weakness and dysfunction of the muscle. Therefore, a fixation can lead to a state of muscle weakness or inhibition (2, 3, 22).

2.3.3 REFLEXOGENIC EFFECTS OF MANIPULATION

Wyke (1985:74) describes the reflexogenic effects of manipulation. Following manipulation, articular mechanoreceptors exert reciprocally coordinated reflexogenic influences on muscle tone, and on the excitability of stretch reflexes in all striated muscles. It is this mechanism that gives rise to reflex changes in muscle tone (involving both facilitation and inhibition of motor unit activity) (4). Furthermore, Dishman et al (2000:2519), Pickar et al (2001:5), Budgel (2000:194) and Suter et al (1999:151, 2000:76) state that the reflexogenic effects of manipulation are to stimulate the α-motoneuronal pool, muscle spindles and Golgi tendon organs. This leads to decreased muscle inhibition as a direct result of increasing stimulation of the muscle proprioceptors (2, 3, 8, 19, 23).

Haldeman (2000:113) further states that there are multiple sensory receptors in muscle, ligaments, facets, paraspinal skin, the meninges and outer fibres of the intervertebral disc. These receptors are responsive to mechanical (position, motion and tissue distortion), inflammatory (nociceptive), and temperature changes. Each spinal structure has its own neural receptors with different characteristics and sensitivities. Stimulation of these receptors has been shown to activate central reflex pathways and specific somato-somatic reflexes (22).
CHAPTER THREE – METHODOLOGY

3.1 Study Design

The purpose of this investigation was to determine if there was a link between chiropractic adjustment of the sacroiliac joint and an increase in strength of the quadriceps muscle.

There were two groups, one male group of forty, and one female group of forty. The groups were not combined, and subjects were placed into each group by their gender.

Both the male and female group of patients were treated with sacroiliac manipulation of a motion-restricted sacroiliac joint.

Each research patient attended one consultation.

The objective measurement consisted of a leg extension dynamometer, which measured the patients’ strength in kilograms. The measurements were recorded before and after chiropractic manipulation was applied to the motion restricted sacroiliac joint. Three pre-manipulative measurements were recorded in 1-minute intervals, which were followed by 3 post-manipulative measurements, which were recorded in 1-minute intervals. This method of testing is consistent with that used by Pollard and Ward (1996).

Each patient in the investigation was required to sign the subject information and consent form (Appendix A), which described what the procedure of testing was.
Objective data collected during the treatment period was statistically analysed to ascertain any improvement in strength and any differences between groups.

3.2 Patient Selection

Patients were recruited by means of an advertisement poster placed throughout the Technikon Witwatersrand, Doornfontein Campus (refer to Appendix B).

3.2.1 PATIENT EXAMINATION
The only requirement for these patients was a sacroiliac motion restriction, as determined by motion palpation.

3.2.1.1 Motion Palpation of the Sacroiliac Joint
Motion palpation of the sacroiliac joint is described by Schafer and Faye (1990:260). The sacroiliac joint was palpated in the standing position, and is known as The Standing Flexed-Knee-Raising Test (21).

- To screen iliac flexion and extension on the sacrum, the examiner's thumbs were placed on the patient's Posterior Superior Iliac Spines (PSISs), and the patient was asked to raise the right knee up and down, as if taking a high step. The right PSIS would be felt to arc posteriorly and inferiorly. After about 20° of leg raise, the patient's left PSIS dropped backward and downward. Any motion other than this indicated a sacroiliac joint motion restriction or fixation. The test was also repeated using the left leg (21).

- To specifically test which sacroiliac joint was restricted, the left thumb was placed on the sacral base of the patient, and the right thumb on the right PSIS. The patient then raised the
right knee to their chest. Separation of the thumbs was a normal finding. The sacral base would normally arc 1 cm posteriorly, and the PSIS would move backward and downward. If there was none of the above movement, then a right-sided flexion restriction was noted. The left knee was then raised (with the same thumb contacts) and the thumbs would normally approximate each other. If this did not occur, a right-sided extension restriction was noted. Both of the tests were repeated for the left sacroiliac joint (21).

3.2.1.2 Static Palpation of the Sacroiliac Joint
According to States (1985:28), static palpation compared the levels of the PSIs to each other. The test was performed with the patient prone, and the thumbs were placed on both PSIs, and the levels of the thumb were compared. The lower PSIS, which was also more prominent, was deemed to be the side of sacroiliac fixation. (24).

Patients did not have to be symptomatic with regards to sacroiliac pain.

3.2.1.3 Orthopaedic Tests
Suter, McMorland, Herzog and Bray (2000:78) recommended 3 orthopaedic tests, which were used to determine if the patient was symptomatic with regards to sacroiliac joint pain:

i. Erichsen’s test.

ii. Sacral Compression test.

iii. Patrick FABER test. (2).

Magee (1997:443, 447, 473) describes the tests as follows:

i. Erichsen’s test

The patient lies prone. The examiner flexes the patient’s knee to 90° and extends the hip (refer to figure 3-1). Pain
localised to the sacroiliac joints is a positive test, and indicates some form of sacroiliac joint pathology (motion restriction, anterior ligament damage) (13).

Figure 3-1 Erichsen's test (Magee 1997:447)

ii. Sacral Compression test

The patient lies prone on a firm surface, and the examiner contacts the base of their hand at the apex of the patient's sacrum (refer to Figure 3-2). Downward pressure is then
applied, and a positive is pain over the joint and indicates a sacroiliac joint problem (13).

Figure 3-2 Sacral Compression test (Magee 1997:443)

iii. Patrick FABER test

The patient lies supine, and the examiner places the patient's test leg, so that the foot of the test leg is on top of the knee of the opposite leg. The examiner then lowers the test leg in abduction toward the examining table (refer to Figure 3-3). A negative test is indicated by the test leg being parallel with the opposite leg, or falling past it to the table. A positive test occurs when the test leg remains above the
opposite straight leg. A positive test indicates that the sacroiliac joint has a problem (13).

Figure 3-3 Patrick FABER test (Magee 1997:473)

Additionally the following criteria were also observed:

1. Patients had to be between the ages of 18-40 years old.
2. Patients had to be healthy individuals with no history of previous trauma or injury.
Those participants with proven eligibility that exhibited no contraindications to manipulative therapy (refer to Appendix C) were allowed to participate in the study. Each patient received a subject consent and information sheet (refer to Appendix A) that explained the details and nature of the research study. Each participant was afforded the opportunity to ask any questions or voice any concerns they had regarding the investigation. Once the patient was satisfied as to the nature of the research, informed consent was given.

3.3 Sample Size

Eighty patients were incorporated into the research. The 80 patients were divided into two groups, with 40 patients in each group. The patients were placed into each group by virtue of their gender. The research was non-randomised in nature. Both groups received manipulative therapy to the motion-restricted sacroiliac joint.

3.4 Treatment Schedule

Each research patient attended one consultation. The Patrick FABER, Erichsen's and Sacral Compression tests were performed (refer to Appendix D), as well as a full lumbar neurological examination (refer to Appendix E).

3.5 Chiropractic Manipulative Therapy

Standard chiropractic manipulative techniques, more specifically known as Diversified Technique (States 1985:119) were used for the correction of joint complex dysfunction. This was indicated by specific orthopaedic, neurological and chiropractic assessment, which included the assessment of static and motion palpation to detect the fixated sacroiliac joint (24).
States (1985:119) describe the Diversified technique which was used. The technique is called Thigh-Ilio-Deltoid (refer to Figure 3-4), and it was directed to sacroiliac joint motion restrictions.

![Image of Thigh-Ilio-Deltoid]

**Figure 3-4 Thigh-Ilio-Deltoid (Kirk et al 1985:119)**

i. Thigh-Ilio-Deltoid

- Patient Position

  Side-lying with restricted side up. The lower shoulder is anterior with the hand under the head. The upper shoulder is posterior with the forearm resting on the lateral thoracic wall. The lower thigh and leg are straight, while the upper thigh and leg are flexed with the dorsum of the foot in the popliteal space of the lower limb. The pelvis is brought towards the edge of the table, and the pelvis is positioned so the upper Anterior Superior Iliac Spine (ASIS) is anterior to the lower ASIS.
• Doctor Position
  Stand in a fencer’s stance facing the head. Take a lateral thigh-to-thigh contact, with the caudal foot off the floor.

• Contact Hand
  The caudal hand is used to take a pisiform contact medial and inferior to the PSIS. The elbow is flexed, with the forearm at right angles to the contact hand.

• Indifferent Hand
  The cephalad hand is used to take a palmar contact on the anterior aspect of the upper shoulder.

• Thrust
  The indifferent hand stabilises the patient, while the contact hand drives the PSIS anterior, with a slight torque (ulnar deviation) and simultaneous body drop.

  It should be noted that the manipulative procedure was only applied to the fixated sacroiliac joint (24).

3.6 Monitoring

3.6.1 OBJECTIVE MEASUREMENT

Objective measurement consisted of an isometric dynamometer reading of quadriceps extension strength. A previous study has established a high level of both intra- and inter-examiner reliability for the dynamometer (Dainty, Mior and Bereznick 1998:109-116) (25). The dynamometer was secured to the wall on one side, while the other side was attached around the patient’s leg by a Velcro ankle strap. When the patient extended the leg (contracting the quadriceps), the scale measured the extension strength in kilograms.
3.7 Statistical Analysis

A Two-Sample T-test was used to compare the changes in strength measurements for both groups. The Two-Sample t-test was used to statistically analyse the results by comparing the means of two columns.
CHAPTER FOUR – RESULTS

4.1 Introduction

The objective data for this study consisted of quadriceps strength measurements, measured in kilograms using an isometric dynamometer, which Dainty et al (1998) found to be a valid and accurate instrument (25). The measurements were taken before and after manipulative therapy was applied.

The statistically analysed means of the objective data were used to plot bar graphs indicating the objective changes in strength. A Two-Sample T-test was used to compare the changes in strength measurements for both groups. The Two-Sample t-test was used to statistically analyse the results by comparing the means of two columns. Therefore, the means of the pre manipulative and post manipulative readings were compared and statistically analysed.

The Two-Sample T-test, thus accurately assessed any statistically significant differences in the changes before and after manipulation was administered.

In analysing the Isometric Dynamometer readings, two values were focused on. The P-value determined the significance of the statistics (P < 0.05 = statistically significant), and the mean difference determined whether or not any change in the quadriceps strength was achieved as a response to the treatment. A positive mean difference indicated that after the treatment, an increase in quadriceps strength occurred. Therefore, a positive mean difference value indicated that the treatment was beneficial, and a negative value indicated that the treatment was ineffective in increasing quadriceps strength.
Note: That in this study a 95% confidence interval was used to determine any statistical significance after conducting the Two-Sample t-test.

4.2 Quadriceps strength measurements

![Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups](image)

Figure 4-1 Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups.

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>Standard Difference</th>
<th>T</th>
<th>Prob&lt;</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>40</td>
<td>4.672</td>
<td>5.565</td>
<td>5.310</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>40</td>
<td>2.385</td>
<td>3.674</td>
<td>4.105</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-1 Paired T-test for the changes in strength measurements in the left thigh before and after a manipulative thrust was administered for the male and female groups.
Figure 4-2 Bar Graph comparing the quadriceps strength measurements for the right thigh for both the male and female groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>Standard Difference</th>
<th>T</th>
<th>Prob &lt;</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Males</td>
<td>40</td>
<td>5.162</td>
<td>6.927</td>
<td>4.713</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
<tr>
<td>Females</td>
<td>40</td>
<td>2.888</td>
<td>5.015</td>
<td>3.641</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-2 Paired T-test for the changes in strength measurements in the right thigh before and after a manipulative thrust was administered for the male and female groups

Figures 4-1 and 4.2 indicate an improvement in the quadriceps strength of both the male and female groups. The Two–Sample t-test proved that the difference in the mean values (P < 0.001) before and after an adjustment was applied was greater than would be expected by chance and thus there was a statistically significant difference in quadriceps strength for both the male and female groups (refer to Figures 4-1 and 4-2).

It is of interest to note that there was an overall increase in quadriceps strength in males from 49.12 kg to 53.792 kg for the left thigh. This was
indicated by the positive mean difference of 4.672 on the left, with a T value of 5.310, and a standard deviation of 5.565. There was an overall increase from 44.490 kg to 49.652 kg for the right thigh. This was indicated by the positive mean difference of 5.162 on the right, with a T value of 4.713, and a standard deviation of 6.927 (refer to Tables 4-1 and 4-2).

In the female group, there was an overall increase in quadriceps strength from 28.197 kg to 30.583 kg for the left thigh. This was indicated by the positive mean difference of 2.385 on the left, with a T value of 4.105, and a standard deviation of 3.674. There was an overall increase from 24.765 kg to 27.653 kg for the right thigh. This was indicated by the positive mean difference of 2.888 on the right, with a T value of 3.641, and a standard deviation of 5.015 (refer to Tables 4-1 and 4-2).

Figure 4-3 Bar Graph comparing the quadriceps strength measurements for the left thigh for both the male and female groups combined.
<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>Standard Difference</th>
<th>T</th>
<th>Prob&lt;</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>80</td>
<td>3.529</td>
<td>4.825</td>
<td>6.541</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-3 Paired T-test for the changes in strength measurements in the left thigh before and after a manipulative thrust was administered for the combined male and female groups.

Figure 4-4 Bar Graph comparing the quadriceps strength measurements for the right thigh for both the male and female groups combined.

<table>
<thead>
<tr>
<th>Group</th>
<th>Subjects</th>
<th>Mean Difference</th>
<th>Standard Difference</th>
<th>T</th>
<th>Prob&lt;</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined</td>
<td>80</td>
<td>4.025</td>
<td>6.117</td>
<td>5.855</td>
<td>P&lt;0.0001</td>
<td></td>
</tr>
</tbody>
</table>

Table 4-4 Paired T-test for the changes in strength measurements in the right thigh before and after a manipulative thrust was administered for the combined male and female groups.

Figures 4-3 and 4-4 indicate an improvement in quadriceps strength of both the male and female groups combined. The Two-Sample t-test proved that the difference in the mean values (P < 0.001) before and after
an adjustment was applied was greater than would be expected by chance, and thus there was a statistically significant difference in quadriceps strength for the male and female groups combined (refer to figures 4-3 and 4-4).

The combined groups readings for the left thigh indicate that there was an overall increase in quadriceps strength in both males and females from 38.659 kg to 42.188 kg. This was indicated by the positive mean difference of 3.529 on the left, with a T value of 6.541, and a standard deviation of 4.825 (refer to Tables 4-3 and 4-4).

The combined groups readings for the right thigh indicate that there was an overall increase in quadriceps strength in both males and females from 34.627 kg to 38.652 kg. This was indicated by the positive mean difference of 4.025 on the right, with a T value of 5.855, and a standard deviation of 6.117 (refer to Tables 4-3 and 4-4).

There was a slightly higher correlation of increased quadriceps strength contra-lateral to the side of sacroiliac joint motion restriction. Fifty three percent of patients treated (43 out of 80) presented in this manner (refer to table 4-5).

Eighty five percent of the patients treated (68 out of 80) had an increase in quadriceps strength (refer to table 4-6).

<table>
<thead>
<tr>
<th>Contra-lateral to fixation</th>
<th>Ipsilateral to fixation</th>
</tr>
</thead>
<tbody>
<tr>
<td>43 out of 80 (53%)</td>
<td>37 out of 80 (47%)</td>
</tr>
</tbody>
</table>

*Table 4-5 Side of Sacroiliac joint fixation as related to side of increased quadriceps strength*

<table>
<thead>
<tr>
<th>Increase in strength</th>
<th>Decrease in strength</th>
</tr>
</thead>
<tbody>
<tr>
<td>68 out of 80 (85%)</td>
<td>12 out of 80 (15%)</td>
</tr>
</tbody>
</table>

*Table 4-6 Effects of Sacroiliac joint manipulation on quadriceps strength*
Fifty five percent of patients treated (44 out of 80) had a right-sided sacroiliac joint fixation, while 45 percent of patients had a left-sided sacroiliac joint fixation (refer to table 4-7).

<table>
<thead>
<tr>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>44 out of 80 (55%)</td>
<td>36 out of 80 (45%)</td>
</tr>
</tbody>
</table>

Table 4-7 Sacroiliac joint fixation

The ages and demographics of the patients possibly played a role in the results, as the percentage of patients below the age of 30 was 78%.

<table>
<thead>
<tr>
<th>18–25 years</th>
<th>25–30 years</th>
<th>30–35 years</th>
<th>35–40 years</th>
<th>Average age</th>
</tr>
</thead>
<tbody>
<tr>
<td>36 (45%)</td>
<td>26 (33%)</td>
<td>10 (12%)</td>
<td>8 (10%)</td>
<td>26 years</td>
</tr>
</tbody>
</table>

Table 4-8 Ages of the participants
CHAPTER FIVE – DISCUSSION

5.1 Introduction

The results of this study will be discussed with reference to the previous chapter and to the hypotheses proposed in chapter one.

5.2 Quadriceps strength measurements

Both groups’ received spinal manipulative therapy directed at the motion restricted sacroiliac joint only. Both group’s quadriceps strength did show a statistically significant improvement (refer to Tables 4-1 and 4-2).

It is interesting to note that in the male group, the mean difference was 4.672 (left) and 5.162 (right), while the mean difference in the female group was 2.385 (left) and 2.888 (right). Thus, the quadriceps strength increased greatly in the male group, and to a lesser degree in the female group. Guyton et al (1996:1059) propose that this difference may be due to the lack of testosterone in the female hormonal make-up, and the negative effects of oestrogen, as described in the literature review. Conversely, testosterone increases male performance by 25 – 33%, therefore being one possible explanation for the differences observed.

Another possible explanation could be the orientation of the female pelvis, which is designed for childbirth. Thus the lever system may not work as efficiently as in males. According to Levangie et al (2001:360) females have an increased Q-angle, which decreases the efficiency of quadriceps contraction and power. This is due to the increased lateral stress the quadriceps exert on the patella, so the stability of the quadriceps lever system is somewhat lacking (17).
A possible explanation for both groups' statistically significant improvement in quadriceps strength, is that the adjustment may have increased quadriceps strength by normalising the lever system of the pelvis. Levangie et al. (2001:98) postulate that restoring normalised mechanics of the pelvis may have an effect on any muscle acting about the pelvis (quadriceps crosses the pelvis by virtue of rectus femoris attaching to the anterior inferior iliac spine). The effects they describe are mainly to do with more efficient muscle contraction (17).

Another explanation could be that there could have been a neurological basis for the statistically significant improvement in quadriceps strength, because of the diverse innervation of the sacroiliac joint (L4-S3 posteriorly and L2-S2 anteriorly). The quadriceps femoris is innervated by the femoral nerve (nerve root levels L2-L4), which is consistent with the findings of Pollard et al. (1996) (1).

In their study, Pollard et al. (1996) showed that manipulation applied to the L3/L4 motion segment resulted in a significant short-term increase in quadriceps strength (1).

Suter et al. (1999, 2000) reported that after manipulation, a decrease in quadriceps inhibition and an increase in knee extensor torques occurred. They reported a 7.5% increase in quadriceps strength in the 2000 study (3).

Similar findings can be reported in this investigation, where the increase in quadriceps strength was reported to be extremely significant.

There is still debate about the exact mechanisms as to why there was an increase in quadriceps strength, but there is a neurological and biomechanical basis to manipulation (1, 3, 17).
CHAPTER SIX – CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

Both groups received chiropractic spinal manipulative therapy directed specifically at the sacroiliac joint. These groups showed statistically significant improvements with regard to the objective measurement (quadriceps extension strength) that was recorded. This indicates that the manipulative therapy had excellent immediate benefits and was effective in improving quadriceps extension strength.

It therefore cannot be denied that the use of standard chiropractic manipulative techniques is an effective way to increase quadriceps extension strength for the short-term.

Because of the results, a different approach to the rehabilitation could be advocated. A manipulative thrust could be administered prior to the strengthening programme, and there is the possibility of greater strength gains being achieved.

In conclusion, the short-term quadriceps strength may be increased with a specific manipulative thrust to the motion-restricted sacroiliac joint.

6.2 Recommendations

Validation and improvement of these initial results may be achieved through the following recommendations:
6.2.1 The inclusion of a long-term treatment period to assess the long-term effects of spinal manipulative therapy with regards to quadriceps strength.

6.2.2 Utilising three groups, where one group receives spinal manipulative therapy to the lumbosacral region, one group receives spinal manipulative therapy to the cervical region, and the last group receives spinal manipulative therapy to the cervical, thoracic and lumbosacral regions. This could help to determine if treatment of the full spine could have a benefit in improving quadriceps strength.

6.2.3 Include a myofascial component to the treatment, which plays a large role in joint and muscle dysfunction. Treatment of the motion restricted articulations in combination with myofascial trigger point therapy could increase the ability of the muscle to contract, improving efficiency and power.

6.2.4 The inclusion of a control group, where spinal manipulative therapy is provided to one group, and ultrasound over the buttock, for example, is applied to the control to differentiate placebo effects.

6.2.5 The use of restraints to ensure proper patient positioning and accurate results when the patient is being tested.

6.2.6 The Cybex method of testing could also be used, which is also a very accurate method of strength measurement.

6.2.7 The inclusion of a much larger sample group may provide significant information to help determine the extent to which quadriceps strength increases in a larger sample population.
6.2.8 Testing a sample of the population symptomatic with regards to back pain.

6.2.9 A double blind, randomised process to recruit and place patients into groups could be used.

6.2.10 Patients recruited from a specific sporting activity could be used, to increase the validity of the objective measurements. This is because they would all have a similar baseline level of fitness and strength.
REFERENCES


APPENDICES

Appendix A – Subject consent and information form

Appendix B – Advertisement poster

Appendix C – Contraindications to manipulative therapy

Appendix D – SOAP Note

Appendix E – Lumbar Spine Neurological Examination
Appendix A: Subject Consent and Information Form

THE EFFECT OF SACROILIAC JOINT MANIPULATION ON QUADRICEPS MUSCLE STRENGTH.

Dear Participant

The purpose of this study is to determine the effect of sacroiliac joint manipulation on quadriceps strength. This will involve the application of a manipulative thrust, which will be performed on your sacroiliac joint. This joint is a very large articulation, involving three bones (the paired ilia, and the sacrum).

You will be placed into one of two groups of forty, with one group consisting of males, and the other consisting of females.

The possible benefits are that normal motion will be restored to the sacroiliac joint, and that may result in more efficient muscle function.

You may experience some post-treatment discomfort, which is a normal occurrence in some patients, but it should only last a day or two.

Participation in the study is voluntary and you are free to refuse to participate or to withdraw your consent and to discontinue participation at any time. Such refusal or discontinuance will not effect your regular treatments or medical care in any way. A signed copy of this consent form will be made available to you.

I have fully explained the procedures, identifying those, which are investigational, and have explained their purpose. I have asked whether any questions have arisen regarding the procedures and have answered these questions to the best of my ability.
Date: ________________________    Researcher: ______________

I have been fully informed as to the procedures to be followed, including those which are investigational and have been given a description of the attendant discomforts, risks, and benefits to be expected and the appropriate alternate procedures. In signing this consent form I agree to this method of treatment and I understand that I am free to withdraw my consent and discontinue my participation in this study at any time. I also understand that if I have any questions at any time, they will be answered.

Date: ________________________    Patient: ________________________

or Guardian/Next of Kin: ____________________________________________
FREE CHIROPRACTIC TREATMENT

Would you like to participate in a chiropractic research study?

All treatment is **free**, and is conducted in the Supervised Technikon Witwatersrand Chiropractic Day Clinic, by a 5th year chiropractic intern.

*If interested, call Greg on*

082 – 687 – 3536
Appendix C: Contraindications to Manipulative Therapy

If the case history or regional examination lumbosacral area revealed any one of the following contraindications to lumbosacral spine manipulative therapy the patient was subsequently excluded from the study (Gatterman 1990).

1. **Vascular Complications**
   1.1 Atherosclerosis of major blood vessels.
   1.2 Abdominal Aortic Aneurysm

2. **Tumours**
   2.1 Lung
   2.2 Thyroid
   2.3 Prostate
   2.4 Breast
   2.5 Bone

3. **Bone Infections**
   3.1 Tuberculosis
   3.2 Osteomyelitis

4. **Traumatic**
   4.1 Fractures
   4.2 Joint instability or hypermobility
   4.3 Severe sprains or strains
   4.4 Unstable spondylolisthesis

5. **Arthritic Conditions**
   5.1 Rheumatoid Arthritis
   5.2 Ankylosing spondylitis
   5.3 Psoriatic Arthritis
   5.4 Unstable or late stage osteoarthritis
   5.5 Uncoarthritis

6. **Metabolic Disorders**
   6.1 Clotting disorders
6.2 Osteopaenia

7. Psychological Considerations
   7.1 Malingering
   7.2 Hystera
   7.3 Hypochondriasis
   7.4 Pain intolerance

8. Neurologic Complications
   8.1 Disc lesions
   8.2 Space-occupying lesions
# Appendix E: SOAP Note

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## Appendix E: Lumbar Spine Neurological Examination

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