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A correlation study between quadratus lumborum trigger points and leg length inequality

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

By:

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Dr. C. Yelverton

Johannesburg, 2015
DECLARATION

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

Charissa Swan

On the ______ day of the month of ___________ 2015
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You never disappoint, it has been an honour and a privilege.
DEDICATION

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**Purpose:** The aim of this study was to determine whether or not there was correlation between a leg length inequality and a quadratus lumborum muscle trigger point.

**Method:** One hundred participants were recruited. The examiner performed a prone leg length evaluation, a supine-to-sit test and their legs were measured for a leg length inequality using the real and apparent methods. The researcher took algometer readings of the quadratus lumborum muscles bilaterally.

**Results:** The objective results showed the total of the 59% (n=59) participants that had more sensitive trigger points on the left hand side, 50% (n=6) had no distinguishable leg length inequality, 63.9% (n=23) had a left short leg and 57.7% (n=30) had a left long leg.

From the total of the 41% (n=41) participants that had more sensitive trigger points on the right hand side, 50% (n=6) had no distinguishable leg length inequality, 36.1% (n=13) had a left short leg and 42.3% (n=22) had a left long leg.

The Pearson Chi- Square test indicated that there was no statistically significant correlation (Sig. Value > 0.5) between the apparent measurement and that of the algometer reading.

Therefore the sig value, which was found in this study of 0.67, had no statistical significance. From the total of the 59% (n=59) participants that had more sensitive trigger points on the left hand side, 71.4% (n=5) had no distinguishable leg length inequality, 60.5% (n=23) had a left short leg and 56.4% (n=31) had a left long leg.

From the total of the 41% (n=41) participants that had more sensitive trigger points on the right hand side, 28.6% (n=2) had no distinguishable leg length inequality, 39.5% (n=15) had a left short leg and 43.6% (n=24) had a left long leg.

The Pearson Chi- Square test indicated that there was no statistically significant correlation (Sig. Value > 0.5) between the actual measurement and that of the algometer reading. The statistical analysis shows that the sig value of 0.75 has no statistical significance (Sig. Value > 0.5).

**Conclusion:** The study showed that there was no significant correlation found between the quadratus lumborum muscle trigger points and the leg length inequality. There was
however an increased incidence of active trigger points found in the quadratus lumborum muscle in comparison to the latent trigger points.
DECLARATION

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CHAPTER ONE: INTRODUCTION

1.1 Problem Statement

Studies show that there are a strong correlation between the presence of a leg length inequality and back pain (Grine, 2013). Back pain in the presence of a leg length inequality is usually relieved by correcting the inequality of the lower limbs (Travell and Simons, 1999). The contributing factor of a leg length inequality to abnormal biomechanics in the lumbopelvic area is not thoroughly investigated (Kendall, Bird and Azan, 2014).

Mechanical lower back pain is thought to be a result of some musculoskeletal dysfunction (Kendall, Bird and Azan, 2014). The most common cause of muscular pain is myofascial trigger points and is commonly relieved by correcting asymmetries in the body (Travell and Simons, 1999).

Defrin, Benyamin, Aldubi and Pick (2005), conducted a study on individuals with chronic lower back pain and a leg length inequality of 10mm or less. After the individuals’ shoes were fitted with shoe inserts they started experiencing relief in their lower back pain symptoms. It was concluded that the shoe inserts reduced the functional disability as well as the chronic lower back pain (Defrin, Benyamin, Aldubi and Pick, 2005).

According to Knutson (2005), a heel lift should be utilized in an individual with a leg length inequality to reduce the pelvic torsion caused by the hypertonic quadratus lumborum muscle. Thus if there is a correlation between the presence of a quadratus lumborum trigger point and a leg length inequality it should be taken into account and therefore assist in future treatments of functional and structural leg length inequality.

The purpose of this study was to determine whether or not a practitioner should invest time in treating the quadratus lumborum trigger points when there is a functional or structural leg
length inequality present. Therefore if there was a significant correlation between the leg length inequality and the quadratus lumborum trigger point treatment should in essence also be aimed at the latter.

The gathered literature states that there might be a correlation between a leg length inequality and a quadratus lumborum muscle trigger points, however no controlled study has been done to prove this theory.

1.2 Aims

The aim of this study was to determine whether or not there was a correlation between quadratus lumborum trigger points and a leg length inequality.

1.3 Possible Outcomes

This study could determine whether or not there is a correlation between a leg length inequality and a quadratus lumborum muscle trigger point. A correlation may be established once there is a correspondence of the shorter leg and the side of the trigger point that presents more sensitive, on the pressure algometer, upon stimulation.

It would also determine whether an active or passive trigger point has more of a correlation to the presence of a structural or functional leg length inequality, determined by the sensitivity of the muscle fibres due to the muscle orientation.

Once such a correlation is made, one may assist in determining whether or not myofascial treatment of quadratus lumborum will increase the quality of the treatment protocol.
CHAPTER TWO: LITERATURE REVIEW

The literature review will take an in depth look at the anatomy and functioning of the quadratus lumborum muscle. The different types of trigger points found in the quadratus lumborum muscle as well as the referral patterns and perpetuating factors will be discussed.

The different types of leg length inequality will also be discussed in this chapter and the biomechanical implication it has on the different joints in the lower limb.

The diagnostic criteria and treatment protocol for both leg length inequality and quadratus lumborum trigger points will briefly be looked at.

2.1 The Quadratus Lumborum Muscle

2.1.1 Anatomy and Biomechanics of Quadratus Lumborum

The quadratus lumborum muscle is situated in the posterior abdominal wall as part of a muscular sheet. The muscle is bilateral to the lumbar vertebrae and broadens inferiorly (Moore, Dalley and Agur, 2010). The muscle is irregularly quadrilateral in shape and is broader distally than it is proximally. It originates from the aponeurotic fibres from the iliolumbar ligament and a part of the adjacent iliac crest to then insert into the inferior border of the 12th rib (Drake, Vogl and Mitchell, 2014; Travell and Simons, 1999). The muscle also inserts onto the tips of the transverse processes of the first four lumbar vertebrae via four small tendons at the insertion point (Drake, Vogl and Mitchell, 2014).

A second portion of the quadratus lumborum muscle is occasionally located anteriorly to the preceding. It originates from the superior borders of the transverse processes of the last three or four lumbar vertebrae and then insert onto the inferior border of the 12th rib (Drake, Vogl and Mitchell, 2014).
The quadratus lumborum muscle has three groups of fibres with different orientation, namely the iliocostal fibres, the iliolumbar fibres and the lumbocostal fibres (Travell and Simons, 1999). The iliocostal fibres are nearly vertical in origin whereas the iliolumbar and lumbocostal fibres run diagonally and intersect cross wisely which affects the functions of the three separate fibre groups (Travell and Simons, 1999).

The lateral border of the muscle is formed by the nearly vertical iliocostal fibres and the medial border of the muscle is formed by the iliolumbar and lumbocostal fibres (Travell and Simons, 1999).

These iliocostal fibres slant medially as they run cephalad and turn out laterally at the insertion of the pelvis (Travell and Simons, 1999). The superior attachment of the iliocostal fibres are the medial half of the lower border of the 12th rib and the inferior attachment is the superior border of the posterior aspect of the iliac crest and the adjacent iliolumbar ligament (Travell and Simons, 1999; Kelley, Finnegan and Dommerholt, 2013). The iliocostal fibres are also sometimes referred to as the intermediate layer of the quadratus lumborum muscle (Travell and Simons, 1999).

The iliolumbar fibres attach superiorly to the tips of the first four transverse processes of the lumbar vertebrae and inferiorly to iliac crest and adjacent iliolumbar ligament (Travell and Simons, 1999).

As indicated in figure 2.1 the lumbocostal fibres attach superiorly to the 12th rib and inferiorly to the first four transverse processes of the lumbar vertebrae. The lumbocostal fibres are the most variable fibres of the three groups of fibres and are generally referred to anatomically as anterior to the iliocostal fibres. The diagonal fibres of the lumbocostal group are interdigitated with the iliocostal and iliolumbar fibres, the fibres interdigitates more densely closer to the pelvic and costal attachment sites and also more frequently at the lateral longitudinal fibres (Travell and Simons, 1999).
Figure 2.1: An anterior view of the quadratus lumborum muscle (Travell and Simons, 1999).

It has an indirect attachment to the ilium of the pelvis via the iliolumbar ligament (Moore, Dalley and Agur, 2010). As indicated in figure 2.2 the fibres of the quadratus lumborum muscles are closely interdigitated with the iliolumbar ligament fibres (Travell and Simons, 1999). The inferior attachment of the quadratus lumborum muscle is via aponeurotic tissue to the iliac crest and iliolumbar ligament (Kelley, Finnegan and Dommerholt, 2013).

Anatomical variations may occur in the quadratus lumborum muscle where it attaches to the transverse process of the 5th lumbar vertebra. A second muscle belly can be present anteriorly to the first or main muscle belly where it will then attach to the lower three or four transverse processes of the lumbar vertebrae (Vizniak, 2012). Another variation is when the muscle fibres attach to the transverse process or vertebral body of the 12th thoracic vertebra (Kelley, Finnegan and Dommerholt, 2013).
2.1.2 Function of the Quadratus Lumborum Muscle

The iliolumbar and lumbocostal fibres both control segmental lateral flexion and concave curvature of the lumbar spine while the iliocostal fibres control overall lumbar curvature (Travell and Simons, 1999). Acting unilaterally the quadratus lumborum laterally flexes the spine contralaterally by contracting eccentrically, it also keeps the 12th rib fixed during inhalation (Moore, Dalley and Agur, 2010; Kelley, Finnegan and Dommerholt, 2013).
Bilaterally the quadratus lumborum functions to extend the vertebral column (Kelley, Finnegan and Dommerholt, 2013). One of the main actions of the quadratus lumborum muscles is to prevent elevation of the 12th rib during contraction of the diaphragm during respiratory inspiration (Vizniak, 2012).

The quadratus lumborum also acts as a muscle of inspiration and forced expiration by stabilizing both the 12th rib and the lower attachments of the diaphragm (Kelley, Finnegan and Dommerholt, 2013). According to Drake, Vogl and Mitchell (2014) the quadratus lumborum muscle draws the 12th rib inferiorly and assists with inspiration by fixing the origin of diaphragm (Drake, Vogl and Mitchell, 2014). It is also of the abdominal and lower back stabilizers which forms part of the body’s core muscles (Vizniak, 2012).

When only one muscle is contracted with the spine stationary and fixed, as indicated in figure 2.3, the quadratus lumborum muscle acts on the pelvis and hikes the hip ipsilaterally and when the pelvis is stationary and fixed the spine is laterally flexed ipsilaterally (Kelley, Finnegan and Dommerholt, 2013; Drake, Vogl and Mitchell, 2014). When both muscles on either side contract simultaneously, either from below or above, it causes extension of the trunk (Drake, Vogl and Mitchell, 2014).
2.1.3 Innervation of the Quadratus Lumborum Muscle

The anterior branches of the nerves at the levels of T12 and L1-L4, also known as the lumbar plexus, innervate the quadratus lumborum muscle (Moore, Dalley and Agur, 2010; Vizniak, 2012).

2.1.4 Blood Supply to the Quadratus Lumborum

The blood supply to the quadratus lumborum muscle is the subcostal and lumbar arteries (Vizniak, 2012).

2.2. Trigger Points Involved with the Quadratus Lumborum Muscle

A myofascial trigger point is defined as a hyperirritable area in skeletal muscle that is associated with hypersensitivity on palpation. The local area is painful on compression and could also be associated with characteristic referred pain, referred tenderness, motor dysfunction, and autonomic phenomena (Travell and Simons, 1999).

These myofascial trigger points can either be active or latent. An active myofascial trigger point is always tender, causes a referral pattern on compression and can be accompanied by motor or autonomic phenomenon usually in the pain referral area. It can also mediate a local twitch response when sufficiently stimulated, weakens the muscle and prevents the muscle fibres from complete lengthening (Travell and Simons, 1999).

A latent trigger point can be defined as clinically dormant or inactive. They don’t usually present with spontaneous pain referral patterns and are thus only painful upon palpation. A latent trigger point can however share some of the characteristics of an active trigger point, but it always presents with a taut band that restricts range of motion by increasing the tension in the muscle fibres (Travell and Simons, 1999).
2.2.1 Location of Quadratus Lumborum Trigger Points

There are four trigger points with regards to the quadratus lumborum muscle namely the superficial caudal, deep caudal, superficial cephalad and deep cephalad. The name of the trigger points specifies the anatomical location respectively (Travell and Simons, 1999; Kelley, Finnegan and Dommerholt, 2013).

A) The deep caudal trigger points

The deep trigger points are found more medially as indicated in figure 2.5. The deep caudal trigger point is found at the angle of the iliac crest and the paraspinal muscles (Travell and Simons, 1999). The more deep caudal trigger point refers pain along the inferior gluteal region (Travell and Simons, 1999; Kelley, Finnegan and Dommerholt, 2013).

B) The deep cephalad trigger points

The deep cephalad trigger point can be located in the angle between the 12th rib and the paraspinal muscle (Travell and Simons, 1999). The deep cephalad trigger point mainly refers pain over the sacroiliac joint as indicated in figure 2.5 (Travell and Simons, 1999; Kelley, Finnegan and Dommerholt, 2013).

C) The superficial caudal trigger points

The superficial trigger points, as indicated in figure 2.4, are generally found more lateral to the deep trigger points. The superficial caudal trigger point can be found along the inner crest of the ilium where the iliocostal fibres of the quadratus lumborum muscle attach (Travell and Simons, 1999). The superficial caudal trigger point refers pain over the lower gluteal region and mainly over the greater trochanter and over lateral thigh (Travell and Simmons, 1999; Kelley, Finnegan and Dommerholt, 2013).
D) The superficial cephalad trigger points

The superficial cephalad trigger point can be located inferior to the 12th rib more lateral to the deep cephalad trigger point (Travell and Simons, 1999). The superficial cephalad trigger point mainly refers pain over the sacroiliac joint, the iliac crest, the inferior and anterior portions of the abdomen into the groin, labia and testes as indicated in figure 2.4 (Travell and Simons, 1999; Kelley, Finnegan and Dommerholt, 2013).

Figure 2.4: The location and referral pattern of the superficial cephalad and superficial caudal trigger points of the quadratus lumborum muscle (Travell and Simons, 1999).

These four locations in the muscle cause distinctive referral pain patterns. A complete layout of these patterns has been published.
Bilateral quadratus lumborum trigger points may cause referral pain that extends along the upper sacral region as indicated in figure 2.5. The pain is mainly described as aching and deep. Some instances where reported where patients had referral pain on the anterior aspect of their thighs as well as on their scrotum.

2.2.2 Pathophysiology of Quadratus Lumborum Trigger Points.

The main histopathological mechanism of developing a trigger point is due to repetitive microtrauma or acute trauma to a specific muscle or muscle group (Alvarez and Rockwell,
There are several mechanical and systemic factors that can predispose the quadratus lumborum muscle to develop or activate trigger points. The mechanical factors include a minor hemipelvis, short upper limbs, a soft mattress, sleeping in a hammock for extended periods, constantly leaning over a desk due to lack of elbow support of a chair or due to inappropriate eyeglasses and working over low work surface like a basin. People with weak abdominal muscles generally have bad posture and thus are also predisposed to developing quadratus lumborum trigger points (Travell and Simons, 1999).

A sudden load distribution imbalance for example keeping a wallet in one of the back pockets could cause a load distribution imbalance on the pelvis by elevating one side of the pelvis while in relation lowering the other as seen in figure 2.6 (Travell and Simons, 1999).

Systemic factors that could cause trigger points in the quadratus lumborum muscle includes nutritional deficiencies, metabolic disorders like hypothyroidism, any chronic infection and increased emotional disturbances. Decreased body temperature also predisposes the quadratus lumborum to myofascial trigger point development (Travell and Simons, 1999).
Patients generally complain about lower back stiffness and pain which is consistent and deep aching in nature and might have been present for a couple of months before they seek treatment (Travell and Simons, 1999). The pain is generally worse in the upright position without support or in the weight bearing position either seated or standing and usually requires stabilization of the entire lumbar spine. Small movements of the torso might cause intervals of pain that is sharp or stabbing in nature and is usually completely immobilizing especially restricting forward flexion of the lumbar spine as well as turning or leaning into the opposite direction. Climbing stairs, coughing and sneezing has also been reported to be painful as well as patients being forced to creep on their hands and knees to get out of bed (Travell and Simons, 1999).

Although back pain is generally the main complaint, referral pain to the groin, testis, scrotum and posterior thigh has also been reported. The posterior thigh pain could be due to satellite trigger points from the paraspinal muscles and or from the gluteus minimus (Travell and Simons, 1999).

2.2.3 Treatment of Quadratus Lumborum Trigger Points

According to Hanten, Olson, Butts and Nowicki, (2000) ischemic compression and sustained stretching is effective in treating myofascial trigger points (Hanten, Olson, Butts and Nowicki, 2000).

Pharmacological treatment of myofascial trigger points includes analgesics, muscle relaxant and non-steroidal anti-inflammatory drugs. Other medication also generally prescribed includes antidepressants and neuroleptics (Alvarez and Rockwell, 2002).

Non pharmacological treatment of myofascial trigger points mainly includes a stretch protocol, modalities like massage, ultrasonography, cryotherapy, heat therapy, acupressure, transcutaneous electrical nerve stimulation, dry needling, ethyl chloride spray and stretch
and trigger point injections with saline, steroid or local anaesthetic (Alvarez and Rockwell, 2002).

It is also advised to educate patients on the corrective measurements ie. to assist them in prevention of actions that causes the trigger points in the first place. For example to utilize a chair with proper arm rests, use appropriate visual aids to prevent leaning over the desk to read the fine print, strengthen the core muscles and sleep with a pillow between the legs to prevent quadratus lumborum hypertonicity (Travell and Simons, 1999).

2.3 Leg Length Inequality

A leg length inequality can be defined as a condition where one limb is noticeably shorter than the other. Leg length inequality is classified as functional, structural or environmental. A structural, functional and environmental leg length inequality would have an effect on the quadratus lumborum muscles (Gurney, 2001).

2.3.1 Functional Leg Length Inequality

Functional leg length inequality is defined as biomechanical changes due to muscular tightness or weakness, ligamentous laxity or tightness and/or restrictions in the range of motions in the ankle, knee or hip joint (Kennedy, 2005). When measuring a functional leg length inequality with fixed points it is found that the limbs are equal and only appears to be unequal due to a biomechanical cause (Simpson, 2004). The etiology of a functional leg length inequality involves sacroiliac syndrome; muscle imbalance leading to different tensions on the pelvis and excessive pronation and supination at the ankle joint (Carnes and Vizniak, 2011).

According to McCaw and Bates, (1999) a functional leg length inequality is secondary to a pelvic rotation as a result of joint contractures and or axial malalignments like a functional scoliosis (McCaw and Bates, 1999).

The functional leg length inequality is also known as the unloaded leg length inequality (Knutson, 2005).
Figure 2.7: Illustrates how a leg length inequality could affect the surrounding structures especially the lateral lumbar curvature due to hypertonicity of the quadratus lumborum muscle (Travell and Simons, 1999).

Functional leg length inequality could also be caused by a functional scoliosis as depicted in figure 2.7. The tight quadratus lumborum muscle is suspected to affect the pelvis at the sacroiliac joint and in turn affect the quality of the leg length. The only way to determine whether or not the quadratus lumborum muscle had an effect on the leg length inequality was to eliminate the quadratus lumborum trigger point and ensure the muscle returns to its original length (Travell and Simons, 1999).
2.3.2 Structural Leg Length Inequality

A structural leg length inequality is caused by an anatomical change. It could be due to a physical shortening or lengthening of either the tibia or femur due to several conditions including congenital or developmental factors it could also be due to post-polio, or post-operative conditions (Kennedy, 2005). It can also be caused by a compensatory scoliosis (Travell and Simons, 1999).

A structural leg length inequality is also known as an anatomical leg length inequality, because just as the name suggests, the leg length inequality is caused by the anatomy rather than the actual functioning of the structures thus there will be a inequality if there an actual length difference in the bony structure. A structural leg length inequality is generally compensated for by a functional compensatory mechanism on the side of the longer leg, it is usually pronation of the foot at the ankle joint (McCaw and Bates, 1991). As indicated by figure 2.8 an equal leg length results in a level pelvis and straight spine, however a structural leg length inequality might lead to a functional compensatory mechanism of the lumbar spine as indicated in figure 2.9. There is also the possibility of a distorted pelvis with no effect to the equality of the leg length when compared, but a resultant functional compensation of the lumbar spine as illustrated in figure 2.10. The other possibility as illustrated in figure 2.11 could be a possible angulation in the lumbar spine with no effect to the pelvis or the equality of the leg length when compared to one another (Travell and Simons, 1999).

The anterior superior iliac spine and the posterior superior iliac spine are both elevated on the side of the longer leg, which means there is less pelvic torsion that is seen with a functional leg length inequality, causing the posterior superior iliac spine to be high on the side of the shorter leg and the anterior superior iliac spine to be even higher on the side of the longer leg (McCaw and Bates, 1991).
2.3.3 Environmental Leg Length Inequality

This type of leg length inequality is more suited to road runners. The concavity of the road designed for drainage of excess water imposes a difference in height between the left leg and the right leg (McCaw and Bates, 1991).

The drainage slopes designed and implemented on roads causes a height difference between the runner’s two limbs whilst running (McCaw and Bates, 1991). Road runners run against traffic which means that they run on the right side of the road causing their right leg to run on a lower surface than their left leg, causing the average road runner to have a
left short leg and a right long leg (Bradley and Castellano, 2011). Based on the previous information, it can be postulated that the same biomechanical changes that occur with a functional leg length inequality should also be considered to potentially occur with an environmental leg length inequality due to the non structural nature of the inequality.

2.4 Signs and Symptoms of a Leg Length Inequality

The signs and symptoms of a leg length inequality are mainly due to the biomechanical changes in the body. It has been hypothesized that scoliosis, functional or structural, can cause the non-specific lower back pain that individuals with a leg length inequality complain of. The signs and symptoms that are caused by altered biomechanics include an altered gait or a limp, decreased spinal range of motion, asymmetrical extremity range of motion, knee pain, iliotibialband syndrome, pronation syndrome, plantar fasciitis and asymmetrical myotome grading in the lower limbs (Carnes and Vizniak, 2011).

Positive signs that a clinician would be able to pick up on examination include; a positive Alliś, a positive Derifield-Thompson test; a difference in the iliac crest heights, a supine or prone leg length difference and a difference in numeric values when measured with the tape measurement technique (Carnes and Vizniak, 2011).

2.5 Diagnosing a Leg Length Inequality

There are different types of tests and techniques to asses and diagnose a leg length inequality, with the gold standard being a radiographic study (Shneider, Homonai, Moreland and Delitto, 2007). Other techniques with less radiation exposure include the prone leg length assessment, the supine leg length assessment, the sit-to-supine assessment, the Derifield-Thompson technique and the Activator Methods Chiropractic Technique (AMCT) to mention a few (Thomas, 1991: Fuhr and Menke, 2002; Magee, 1992).

Recent studies show that the tape measurement method is in fact as reliable as the gold standard method which is a computed tomography scanogram in measuring leg length inequality (Jamaluddin, Sulaiman, Kamarul, Juhara, Ezane and Nordin, 2011).
In a clinical setting a practitioner would usually observe and compare bony and soft tissue landmarks to determine if there is a possible leg length inequality and or scoliosis. These bony and soft tissue landmarks include the earlobes, shoulder levels, anterior superior iliac spine, posterior superior iliac spine, superior border of the patella, medial or lateral malleoli (Vizniak, 2012).

Figure 2.12 indicates the difference in levels of the anterior superior iliac spines with the presence of a leg length inequality.

Figure 2.12: Illustrating the level marker practitioners utilize to visually assess a patient for a LLI (Travell and Simons, 1999).
Most of the leg length assessment techniques will be explained in detail in chapter three including the supine and prone leg length assessment, the supine-to-sit assessment and the real and apparent tape measurement technique.

2.6 Biomechanical Implication

A structural and functional leg length inequality has different biomechanical implications at different joints in the lower extremity.

2.6.1 The Spine

It has been hypothesized that a leg length inequality can induce a functional scoliosis, meaning it caused mainly by muscle imbalances in the area of the curvature. In a scoliotic spine it is found that the annulus fibrosis of the intervertebral disc on the concave side of the curvature is compressed while the annulus fibrosis fibres of the intervertebral disc on the convex side of the curvature is in tension. The compressed fibres of the annulus fibrosis can protrude out of the intervertebral space on to the intervertebral foramen and compress the dorsal sensory nerve root (McCaw and Bates, 1991).

Gibson, Papaioannou and Kenwright (1983) conducted a study on lateral flexion of the lumbar spine in participants 10 years after acquiring a structural leg length inequality, caused by a femoral fracture after they have reached skeletal maturity found that besides the compensatory lumbar scoliosis they had symmetrical lateral flexion of the lumbar spine (Gibson, Papaioannou and Kenwright, 1983).

Another study was conducted by Papaioannou, Stokes and Kenwright (1982) on individuals with a significant acquired leg length inequality (30mm) prior to skeletal maturity, however the study was only conducted after the individuals reached skeletal maturity. They found that there was significant asymmetry of lateral flexion in the lumbar spine even after placing a heel lift under the short leg in attempt to level the pelvis, indicating that the body compensated on a permanent basis to structural changes in the spine and or pelvis (Papioannou, Stokes and Kenwright, 1982).
Figure 2.13 illustrates the compensatory mechanisms in the spine specifically due to the presence of a leg length inequality. Eventually the lumbar spine and both the thoracic and cervical spine compensates for a leg length inequality if left untreated.

Figure 2.13: Illustrates all the compensatory patterns the body could follow due to a leg length inequality (Travell and Simons, 1999).

2.6.2 Sacroiliac Joint

A leg length inequality has implications on the sacroiliac, hip, knee and ankle joint causing possible long term complications. The sacroiliac joint is mainly affected by a leg length inequality due to rotation of the inominates in the sagittal and or frontal plane, this is also referred to as pelvic torsion (Knutson, 2005).

Walsh, Connolly, Jenkinson, OBrien (2000) found that the most general compensatory mechanism for a leg length inequality up to 22mm was pelvic torsion (Walsh, Connolly, Jenkinson, OBrien, 2000). In a standing position in an individual without a leg length inequality the weight of the torso on the pelvis induces a force vector through the hip joint caudally to the feet, however with a leg length inequality the ground force that is now placed onto the hip through the pelvis will induce a torsion or rotation of the pelvis (Knutson, 2005). According to McCaw and Bates (1991) the posterior superior iliac spine is high on
the side of the shorter leg, however the anterior superior iliac spine is even higher on the side of the longer leg. This is proposed to be due to the pelvic torsion (McCaw and Bates, 1991).

### 2.6.3 The Hip Joint

A leg length inequality of more than 20mm affects the biomechanical functioning of the hip joint by changing the load distribution on the hip joints individually; the short leg is affected more than the longer leg (Wretenberg, Hugo, Brostrom, 2008). Wretenberg, Hugo and Brostrom (2008) conducted a study on a leg length inequality after a complete hip arthroplasty and found that the load distribution was increased on the shorter leg, however they also found that the load pattern was altered on the side of the longer leg, this increased the internal rotation of the hip and led to increased torsion on the stem implant. There was also an increase in abduction reported to the side of the shorter leg due to the increase in height which also led to an increase on stress on the stem implant.

### 2.6.4 The Knee Joint

Walsh, Connolly, Jenkinson and O'Brien (2000) conducted a study on seven normal individuals where they fitted heel raises. They found that the individuals developed alterations in their kinematic chains to compensate for the leg length inequality. The individuals who were fitted with larger degrees of discrepancy started developing flexion of the knee at the side of the longer leg.

### 2.6.5 The Ankle Joint

Individuals with a leg length inequality might subconsciously pronate the foot at the ankle joint of the longer leg, to functionally shorten this longer leg, in an attempt to level out the leg length inequality. The feet on an individual with a leg length inequality are also affected biomechanically and are found to be externally rotated on the side of the shorter leg, the heel of the foot assumes a valgus position causing the longitudinal arch of the foot to collapse (McCaw and Bates, 1991). According to Liu, Fabry, Molenaes, Lammens and
Moens, (1998) individuals with a leg length inequality supinates at the subtalar joint causing a stiffer more rigid foot that experiences more impact on the lower limb during ambulation.

2.7 Treatment of a Leg Length Inequality

A functional and environmental leg length inequality can easily be treated with an alternative treatment protocol including; lumbar adjustments, sacroiliac adjustments, spinal mobilizations, myofascial release, stretching of hypertonic musculature in the area and manage lower extremity biomechanical dysfunction (Carnes and Vizniak, 2011). Treatment should be aimed at levelling the pelvis and restoring function (McCarthy and MacEwen, 2001).

In the case where the leg length inequality is more than 6mm a heel lift or orthotic might be considered to treat the leg length inequality (Carnes and Vizniak, 2011).

A structural leg length inequality is considered more serious and a permanent foot orthotic should be used to prevent any further biomechanical compromise to body. Surgical treatment could be considered depending on the cause of the leg length inequality (Gurney, 2002).

2.8 Conclusion

A hypertonic quadratus lumborum muscle has therefore been postulated to have a great effect on the forces causing pelvic torsion and could affect the biomechanical functioning of the body as a whole. Therefore quadratus lumborum trigger points may have a correlation to a functional or structural leg length inequality and should be considered when treating a leg length inequality.

A leg length inequality as well as a hemipelvis might be perpetuating factors of a quadratus lumborum myofascial trigger points due to the fact that it changes an individual’s biomechanical functioning (Travell and Simons, 1999). According to Travell and Simons (1999) a quadratus lumborum muscle trigger point can be perpetuated by a leg length inequality of as little as 3mm. Superimposition of an individual with a pelvic torsion due to a
leg length inequality causing possible quadratus lumborum hypertonicity and the body’s ability to adapt might cause muscular bracing and pain as a response (Knutson, 2005).

According to Indahl, Kaigle, Reikeras and Holm (1999) stimulating the joint capsule of the sacroiliac joints in pigs could cause reflexive muscular responses depending on whether it is on the dorsal or ventral aspect of the joint. They found that stimulation of these low threshold nerve endings in the sacroiliac joint tissue may cause a reflex activation of the gluteal and paraspinal muscle that become hypertonic and painful over a period of time, they also found that stimulating the ventral area of the sacroiliac joint tissue caused a reflexive activation of quadratus lumborum muscle that could possibly be a positive feedback cycle.

This feedback cycle could determine whether quadratus lumborum hypertonicity causes lumbar curvature and possible pelvic torsion which in turn stimulates the nerve endings in the sacroiliac tissue, causing more hypertonicity of the quadratus lumborum muscle followed by more lumbar curvature and pelvic torsion (Indahl, Kaigle, Reikeras and Holm, 1999).

The importance of measuring leg length inequality is that it gives a practitioner a better clinical picture of the patient’s biomechanical functioning as well as the source of the problem if it starts affecting ambulation. It also enables the practitioner to efficiently diagnose and treat the patient if they suspect any possible underlying spinal anatomical abnormality that could cause a leg length inequality for example wedging of a vertebral body, increased spurring and excessive disc degeneration to mention a few (Carnes and Vizniak, 2011).

If the cause is due to a quadratus lumborum trigger point it would make the practitioner’s treatment protocol more effective by addressing the trigger point in the quadratus lumborum. A leg length inequality can lead to degenerative arthritis of the lumbar spine as well as the lower extremity due to compensation patterns during ambulation (Sabharwal and Kumar, 2008).
3.1 Introduction

This chapter serves to describe and explain the manner in which research study was conducted and carried out.

3.2 Evaluation Approach

There was only one evaluation session and no follow up consultation in this study. The evaluation was mainly blinded by ensuring that the examiner performed the prone leg length evaluation, the supine-to-sit test and the measuring of the leg length inequality. The participants did not receive any treatment and was briefly assessed on their medical history.

The visit included:

- This study only required one consultation where the participant completed the information form (Appendix A) as well as the consent form (Appendix B).
- A qualified Chiropractic practitioner, with experience of more than five years in private practice, did all the assessments except for the algometer reading which was performed last to keep the study blinded and prevented the researcher from any bias opinions.
- Each participant was assessed in the exact sequence as stated below.
- The examiner then assessed the levels of the left and right anterior as well as the posterior superior iliac spines and records on the information sheet (Appendix C).
- The prone leg length evaluation was performed next by the examiner and also recorded the side of the shorter leg.
- The Supine-to-sit test was then performed by the examiner and the values were recorded accordingly.
- During the prone evaluation and the supine-to-sit test the patient’s feet were covered with a towel to ensure that the study remained blinded.
After the measurements were taken and recorded the researcher took the readings on both sides of the participant's quadratus lumborum muscles with the algometer and then recorded the readings on a separate form (Appendix D).

- No treatment was thus given to the participants.

### 3.3 Study design

This study was a blinded correlation study and the flow of each evaluation session is explained in figure 3.1.

Potential candidates were recruited and evaluated for valid participants.

Participants were asked to complete and sign the information and consent form.

The examiner performed the following tests without the researcher being present:

- Prone Leg Length Evaluation
- Supine-To-Sit Test
- Tape Measurement

The researcher took the algometer readings after the examiner performed all of the tests. The participant's feet were covered with a towel so that the study remained blinded.

*Figure 3.1: Flow diagram of study protocol.*
3.4 Sample Selection and Criteria

A hundred participants were recruited on a voluntary basis from the University of Johannesburg. The advertisement (Appendix E) was placed in around the Chiropractic Day Clinic and on the Doornfontein campus of the University of Johannesburg. Participants were also recruited via word of mouth amongst students on campus.

Participants that presented to the Chiropractic Day Clinic between the ages of 18 and 40 years of age were considered possible candidates for this research study. Participants had to read the information form (Appendix A) and sign the consent form (Appendix B).

Each participant was briefly screened to ensure that they met the inclusion and exclusion criteria before further examination took place.

3.5 Inclusion Criteria

Participants were included if they met the following criteria:

- Either male or female between the ages of 18 and 40 years

- Had to have a leg length inequality as measured by: Prone leg-length evaluation, Supine-to-sit test or actual and apparent tape measurement readings.

- BMI: Was between 19 – 24 (Bickley and Szilagyi, 2009). An elevated BMI could affect the participant’s sensitivity towards the pressure algometer. Thus in order to prevent the participant from experiencing pain sensation prior to the stimulation upon the actual trigger point the BMI should remain between 19 - 24. The amount of pressure needed to get to the actual trigger point will also be increased resulting in possible false readings on the algometer. An increase in BMI could also have a negative effect on the reliability of the leg length evaluations performed due to the difficulty in palpating the bony landmarks.

- An active or latent quadratus lumborum trigger point as defined by the participant’s clinical presentation. Active trigger points are always tender, cause a referral
pattern on compression and can be accompanied by a motor or autonomic phenomenon usually in the pain referral area. Latent trigger points are defined as clinically dormant or inactive (Travell and Simons, 1999). The presence and nature of the trigger point was determined upon palpation of the quadratus lumborum muscle.

3.6 Exclusion Criteria

Participants were excluded according to the following criteria:

- Any previous surgery of the spine. Surgery of the spine could cause participants to have decreased or increased sensation over the lumbopelvic area. It could also cause the participants to have an antalgic listing.

- An antalgic listing. An antalgic listing could cause the participant to be excessively sensitive over the quadratus lumborum muscle giving false readings on the pressure algometer measurements. An antalgic list could also give false readings on the leg length measurements.

- Pregnant Women. Due to the distended abdomen in pregnant individuals the tape measurement readings from the umbilicus to the malleolus may affect the accuracy of the measurements.

3.7 Subjective Data

No subjective data was obtained in this research study.
3.8 Objective Data

3.8.1 Algometer

As illustrated in figure 3.2 the algometer was used on the quadratus lumborum muscle to determine the pain threshold measurements in order to accurately locate trigger points and to quantify their sensitivity (Rachlin, 1994). An algometer is found to be a valid as well as a reliable instrument that measures sensitivity to pain caused by pressure (Kinser, Sands and Stone, 2009). The pressure of the algometer caused a referral pattern in the participant if the trigger point was active.

The participants were asked to expose their lower back and to lie in a prone position. The quadratus lumborum muscle was palpated and evaluated for trigger points. The participants were instructed to indicate to the examiner when the pressure of the algometer elicited initial pain on the trigger point of the quadratus lumborum muscle. Then the algometer was placed over the trigger point and a gradual increase in pressure was applied via the algometer, the participant indicated that he/she experienced initial pain and a value was then recorded.

The pressure algometer is proven to have high reliability in measuring the pressure pain threshold in patients with myofascial pain (Park, Kim, Park, Kim, Jang, 2011).
3.8.2 Prone Leg –Length Evaluation

The Prone Leg –Length Evaluation (Schneider, Homonai, Moreland and Delitto, 2007) was utilized to determine the side of the leg length inequality as illustrated in figure 3.3.

Participants were asked to remove their shoes and lie in a prone position with both knees extended, the examiner was then asked to determine the side of the short leg. The participant’s knees were then flexed and the examiner had to determine whether there was a change in the leg length (Schneider, Homonai, Moreland and Delitto, 2007). The shorter side was then recorded on the information sheet (Appendix C).

The prone leg length assessment has good interexaminer reliability when determining the side of the short or longer leg however it does not show good reliability when determining the amount of difference between the short leg and the longer leg (Schneider, Homonai, Moreland, Delitto, 2007).
3.8.3 Supine –to –Sit Test

The supine-to-sit test was performed to evaluate whether or not the participant had a functional leg length inequality as illustrated in figures 2.4 and 2.5.

The supine-to-sit test was performed with the participant initially supine and legs extended. The examiner then observed the level of the legs in relation to one another. The participant was then asked to sit up, the examiner again observed the level of the legs and whether or not one of the legs moved up, in other words towards the hip. If one of the legs moved proximally in relation to the other leg it was indicative of a functional leg length inequality, due to a pelvic torsion causing a pelvic dysfunction (Magee, 1992). Thus when the leg was longer when the participant was supine and shorter when the patient was seated, the pelvic dysfunction was on the affected side and therefore the functional leg length inequality will be on the affected side.
Figure 3.4: Illustrates the first part of the supine-to-sit test.

Figure 3.5: Illustrates the second part of the supine-to-sit test.
3.8.4 Measuring Leg Length

Real leg length measurements

The real leg length measurements were taken from the anterior superior iliac spine to the medial malleolus to determine the difference in length between the two legs (Gioia and Braatz, 1986).

The participants were asked to lie in a supine position and to expose their anterior superior iliac spine. The examiner used a standard measuring tape and started from the anterior superior iliac spine aligning the tape along the participant’s anteromedial thigh following...
through over the patella and then the anteromedial aspect of the lower part of the leg and ending at the distal aspect of the medial malleolus (Bretas, Nogueira, Carneiro, Souza, Simao, 2009); (Beattie, Isaacson, Riddle, Rhothstein, 1990). Both lower limbs were measured and the values were recorded.

**Apparent measurements**

The apparent readings were measured from the umbilicus to the medial malleolus (Sabharwal and Kumar, 2008).

The participants were asked to lie in a supine position and to expose their umbilicus. The examiner used a standard measuring tape and started from the participant's umbilicus aligning the tape along the participant's medial aspect of the thigh following through over the medial aspect of the knee and then the medial aspect of the lower part of the leg and ending at the distal aspect of the medial malleolus (Sabharwal and Kumar, 2008).

There is a high interobserver reliability of the true and apparent measurements when compared to radiographic methods however it is advised to use the mean value of the two separate measured values when utilizing the tape measurement method in assessing leg length inequality (Sabharwal and Kumar, 2008).

All the above mentioned readings were only taken once on each participant.

**3.9 Data Analysis**

The data was collected by the examiner and the researcher during the trials. The data was analysed by a statistician at STATKON. Descriptive data analysis was used in this study to correlate the variables (The apparent leg length measurements to the algometer readings). Depending on the sample size and whether there was an equal distribution the parametric test would be used. If the distribution was profoundly unequal, which is likely due to the blinded aspect of this study, the non-parametric test would be utilized. To correlate the relation of leg length inequality to the quadratus lumborum trigger point the Chi-square test was used. Furthermore a T-test was utilized to determine whether the predicator variable
(Side of leg length) correlated to the outcome variable (Algometer reading). Lastly the Kruskal Wallis test was used to determine a correlation between the independent variable and the dependant variable to measure whether the algometer reading was equal or different depending on whether the trigger point was active or latent.

3.10 Ethical Considerations

All participants that wished to partake in this particular study were requested to read, understand and sign the information and consent form specific to this study.

The information and consent form outlined the names of the researcher, purpose of the study and benefits and risks of partaking in the study, participant assessment and treatment procedure.

The information and consent form was also explain that the participants privacy would be protected as only the doctor, patient and clinician would be in the treatment room and that anonymity would be ensured as the patient information would be converted into data and therefore cannot be traced back to the individual. The form would also state that standard doctor/patient confidentiality would be adhered to at all times when compiling the research dissertation. The participants were informed that their participation is on a voluntary basis and that they were free to withdraw from the study at any stage. Should the participant have had any further questions, those would be explained by the researcher; whose contact details were made available. The participants were then required to sign the information and consent form, signifying that they understood all that was required of them for this particular study. Results of the study would be made available on request.

With regards to this particular study, there were no risks involved. Slight discomfort might have been experienced by the pressure of the algometer on active quadratus lumborum trigger points when the measurements were taken.

Participants were referred to the appropriate health care practitioner when necessary.
CHAPTER FOUR: THE RESULTS

4.1 Introduction

In this chapter the results obtained in the clinical trials will be discussed. The objective findings will also be discussed.

The study determined whether or not there was a significant statistical correlation between the short leg of a leg length inequality and the increased sensitivity of the quadratus lumborum trigger point on the ipsilateral side.

4.2 Statistical Analysis of Data

Descriptive data analysis was used in this study to correlate the variables (The apparent leg length measurements to the algometer readings). Due to the sample size and the blinded aspect of the study, there was an unequal distribution and thus the non-parametric test was used.

The relation of leg length inequality to the quadratus lumborum trigger point was correlated by utilizing the Pearson Chi-square test.

Level of confidence is 0.05, thus a sig. value. of below 0.05 indicates a correlation between the two variables.

4.3 Demographics

The study group consisted of hundred participants (N=100). There was only one group and all of the participants underwent objective analysis.
With reference to table 4.1 and table 4.2 the age of the participants ranged between 18 and 39 years of age with the average being 24.43 years. The group of participants consisted of 66 females and 34 male subjects.

4.4 Frequency Representation

4.4.1 Anterior Superior Iliac Spine Level

Table 4.3: The frequencies of the anterior superior iliac spine level correlated to the side.
In Table 4.3 the frequencies of the anterior superior iliac spine levels correlated to the side that was found to be higher, are represented. 65% of the participants had a higher level of the anterior superior iliac spine on the left hand side, 29% of the participants had a higher level of the right hand side and 6% of the participants had no distinguishable differences between the two sides.

### 4.4.2 Posterior Superior Iliac Spine Level correlated to the side.

**Table 4.4: The frequencies of the posterior superior iliac spine level correlated to the side.**

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHS higher &amp; RHS lower</td>
<td>47</td>
<td>47.0</td>
<td>47.0</td>
<td>47.0</td>
</tr>
<tr>
<td>RHS higher &amp; LHS lower</td>
<td>43</td>
<td>43.0</td>
<td>43.0</td>
<td>90.0</td>
</tr>
<tr>
<td>No distinguishable difference between sides</td>
<td>10</td>
<td>10.0</td>
<td>10.0</td>
<td>100.0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

As indicated in Table 4.4 the frequencies of the levels of the posterior superior iliac spine correlated to the side that was found to be higher, are represented. 47% of the participants presented with a higher posterior superior iliac spine on the left hand side, while 43% presented with a higher posterior superior iliac spine on the right hand side, with 10% of the participants with no distinguishable differences between the two sides.
4.4.3 Prone Leg Length Evaluation

Table 4.5: The frequencies of the prone leg length evaluation correlated to the side.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHS Short</td>
<td>36</td>
<td>36.0</td>
<td>36.0</td>
<td>36.0</td>
</tr>
<tr>
<td>RHS Short</td>
<td>60</td>
<td>60.0</td>
<td>60.0</td>
<td>96.0</td>
</tr>
<tr>
<td>No Distinguishable</td>
<td>4</td>
<td>4.0</td>
<td>4.0</td>
<td>100.0</td>
</tr>
<tr>
<td>difference between</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

In table 4.5 the prone leg length evaluation frequencies correlated to the side that was found to be shorter, are represented. 36% of the participants presented with a shorter leg on the left hand side compared to the right hand side, 60% presented with a shorter leg on the right hand side compared to the left hand side and 4% of the participants with no distinguishable differences between the two sides.

4.4.4 Supine-To-Sit Test

Table 4.6: The frequencies of the supine part of the supine-to-sit test correlated to the side.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHS longer &amp; RHS</td>
<td>59</td>
<td>59.0</td>
<td>59.0</td>
<td>59.0</td>
</tr>
<tr>
<td>shorter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>RHS longer &amp; LHS</td>
<td>29</td>
<td>29.0</td>
<td>29.0</td>
<td>88.0</td>
</tr>
<tr>
<td>shorter</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Distinguishable</td>
<td>12</td>
<td>12.0</td>
<td>12.0</td>
<td>100.0</td>
</tr>
<tr>
<td>difference between</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>sides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>100</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

As indicated in table 4.6 the frequencies of the supine part of the supine-to-sit orthopaedic test correlated to the side that was found to be longer, are represented. 59% of the participants had a longer leg on the left hand side compared to the right, 29% had a longer
leg on the right hand side compared to the left and 12% of the total participants had no distinguishable differences between the two sides.

Table 4.7: The frequencies of the seated part of the supine-to-sit test correlated to the side.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>LHS longer &amp; RHS shorter</td>
<td>37</td>
<td>37.0</td>
<td>37.0</td>
<td>37.0</td>
</tr>
<tr>
<td>RHS longer &amp; LHS shorter</td>
<td>32</td>
<td>32.0</td>
<td>32.0</td>
<td>69.0</td>
</tr>
<tr>
<td>No Distinguishable difference between sides</td>
<td>31</td>
<td>31.0</td>
<td>31.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

In table 4.7 the frequencies of the seated part of the supine-to-sit orthopaedic test correlated to the side that was found to be longer, are represented. 37% of the participants had a longer leg on the left hand side compared to the right, 32% had a longer leg on the right hand side compared to the left and 31% of the total participants had no distinguishable differences between the two sides.

4.4.5 Myofascial trigger points

Table 4.8: The frequencies of activity of quadratus lumborum myofascial trigger points.

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
<th>Valid Percent</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active</td>
<td>42</td>
<td>42.0</td>
<td>42.0</td>
<td>42.0</td>
</tr>
<tr>
<td>Latent</td>
<td>58</td>
<td>58.0</td>
<td>58.0</td>
<td>100.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
<td>100.0</td>
<td></td>
</tr>
</tbody>
</table>

In table 4.8 the frequencies of the quadratus lumborum myofascial trigger points’ activity are represented. It was determined that 42% of the participants’ myofascial trigger points
were active and 58% were latent.

4.5 Statistical Analysis of Frequencies

4.5.1 Actual Measurements of Leg Length Inequality

Table 4.9: The tabulation of the actual measurement of the leg length inequality

<table>
<thead>
<tr>
<th></th>
<th>Actual Measurement of the leg length on the LHS (cm)</th>
<th>Actual Measurement of the leg length on the RHS (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>92.89</td>
<td>92.79</td>
</tr>
<tr>
<td>Median</td>
<td>92.25</td>
<td>92.25</td>
</tr>
<tr>
<td>Mode</td>
<td>92.00</td>
<td>91.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>81.50</td>
<td>82.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>108.50</td>
<td>108.00</td>
</tr>
</tbody>
</table>

In table 4.9 the frequencies of the actual measurements of the leg length inequalities are represented. The mean value for the actual tape measurement on the left hand side was 92.89cm, the minimum value for the length of a left leg was 81.50cm and the maximum length was 108.50cm.

The mean value for the actual tape measurement on the right hand side was 92.79cm, the minimum value for the length of a left leg was 82.00cm and the maximum length was 108.00cm.
4.5.2 Apparent Measurements of Leg Length Inequality

Table 4.10: The tabulation of the apparent measurement of the leg length inequality statistics

<table>
<thead>
<tr>
<th></th>
<th>Apparent Measurement of the leg length on the LHS (cm)</th>
<th>Apparent Measurement of the leg length on the RHS (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>99.02</td>
<td>98.91</td>
</tr>
<tr>
<td>Median</td>
<td>97.75</td>
<td>98.25</td>
</tr>
<tr>
<td>Mode</td>
<td>97.00</td>
<td>95.00</td>
</tr>
<tr>
<td>Minimum</td>
<td>84.50</td>
<td>85.00</td>
</tr>
<tr>
<td>Maximum</td>
<td>115.00</td>
<td>116.00</td>
</tr>
</tbody>
</table>

Table 4.10 represents the frequencies on the apparent measurements of the leg length inequalities. The mean value for the apparent tape measurement on the left hand side was 99.02cm, the minimum value for the length of a left leg was 84.50cm and the maximum length was 115.00cm.

The mean value for the apparent tape measurement on the right hand side was 98.91cm, the minimum value for the length of a left leg was 85.00cm and the maximum length was 116.00cm.
4.5.3 Algometer Measurements

Table 4.11: The tabulation of the algometer measurement on the quadratus lumborum muscle trigger points

<table>
<thead>
<tr>
<th></th>
<th>Algometer reading on the LHS (Kg/cm²)</th>
<th>Algometer reading on the RHS (Kg/cm²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Mean</td>
<td>3.07</td>
<td>3.14</td>
</tr>
<tr>
<td>Median</td>
<td>3.00</td>
<td>3.20</td>
</tr>
<tr>
<td>Mode</td>
<td>3.70</td>
<td>2.70</td>
</tr>
<tr>
<td>Minimum</td>
<td>1.60</td>
<td>1.70</td>
</tr>
<tr>
<td>Maximum</td>
<td>4.50</td>
<td>4.60</td>
</tr>
</tbody>
</table>

Table 4.11 represents the frequencies on the algometer measurements on the quadratus lumborum muscle. The mean value for the algometer readings on the left hand side of the quadratus lumborum muscle was 3.07Kg/cm², the minimum value for left side was 1.60Kg/cm² and the maximum value was 4.50Kg/cm².

The mean value for the algometer readings on the right hand side of the quadratus lumborum muscle was 3.14Kg/cm², the minimum value for left side was 1.70Kg/cm² and the maximum value was 4.60Kg/cm².

4.6 Frequencies and Percentages

4.6.1 Actual measurements of the leg length inequalities

Table 4.12: The frequencies and percentages of the actual measurements of the leg length inequality

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left and right equal</td>
<td>7</td>
<td>7.0</td>
</tr>
<tr>
<td>Left shorter</td>
<td>38</td>
<td>38.0</td>
</tr>
<tr>
<td>Left longer</td>
<td>55</td>
<td>55.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>
Table 4.12 summarizes the frequencies and percentages of the leg length inequalities. The percentage of participants that had a left and right equal measurement as measured by the actual measurement technique was 7%. The percentage of participants that had a left shorter leg was 38% and the percentage of participants that had a left longer leg was 55%.

4.6.2 Apparent Measurements of the Leg Length Inequalities

Table 4.13: The frequencies and percentages of the apparent measurements of the leg length inequality

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left and right equal</td>
<td>12</td>
<td>12.0</td>
</tr>
<tr>
<td>Left shorter</td>
<td>36</td>
<td>36.0</td>
</tr>
<tr>
<td>Left longer</td>
<td>52</td>
<td>52.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4.13 summarizes the frequencies and percentages of the leg length inequalities. The percentage of participants that had a left and right equal measurement as measured by the actual measurement technique was 12%. The percentage of participants that had a left shorter leg was 36% and the percentage of participants that had a left longer leg was 52%.

4.6.3 Algometer Measurements of the Quadratus Lumborum Muscle

Table 4.14: The frequencies and percentages of the algometer readings on the quadratus lumborum muscles

<table>
<thead>
<tr>
<th></th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left more sensitive</td>
<td>59</td>
<td>59.0</td>
</tr>
<tr>
<td>Left less sensitive</td>
<td>41</td>
<td>41.0</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Table 4.14 summarizes the
frequency and percentages of which side had more sensitive algometer readings. Majority of the participants (n=59) had a more sensitive reading on the left hand side and the remaining 41 participants had a less sensitive reading on the left hand side.

4.7 Correlation between Leg Length Inequality and Quadratus Lumborum Muscle

Table 4.15: The algometer measurements of left to right relationship cross tabulated with the actual measure of left to right relationship

<table>
<thead>
<tr>
<th>Algomter measure of left to right relationship</th>
<th>Actual measure of left to right relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td>Left more sensitive</td>
<td>% within actual measure of left to right relationship</td>
</tr>
<tr>
<td></td>
<td>Left and right equal</td>
</tr>
<tr>
<td></td>
<td>5</td>
</tr>
<tr>
<td>Right more sensitive</td>
<td>% within actual measure of left to right relationship</td>
</tr>
<tr>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>7</td>
</tr>
</tbody>
</table>

Table 4.15 cross tabulated the algometer measurements with the actual measurements of the leg length. It was determined that 59% of the participants had lower readings on the left hand side which meant that the trigger points were more sensitive on the left hand side. The readings were higher on the remaining 41% of the participants left hand sides, meaning that the trigger points were less sensitive.
From the total of the 59% (n=59) participants that had more sensitive trigger points on the left hand side, 71.4% (n=5) had no distinguishable leg length inequality, 60.5% (n=23) had a left short leg and 56.4% (n=31) had a left long leg.

From the total of the 41% (n=41) participants that had more sensitive trigger points on the right hand side, 28.6% (n=2) had no distinguishable leg length inequality, 39.5% (n=15) had a left short leg and 43.6% (n=24) had a left long leg.

Table 4.16: The Pearson Chi-Square Tests on the algometer measurements of left to right relationship cross tabulated with the actual measure of left to right relationship

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
<th>Df</th>
<th>Asymp. Sig.(2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.642</td>
<td>2</td>
<td>.726</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.661</td>
<td>2</td>
<td>.719</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.565</td>
<td>1</td>
<td>.452</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Pearson Chi-Square test indicated in table 4.16, shows that there was no statistically significant correlation (Sig. Value > 0.05) between the actual measurement and that of the algometer reading.

The statistical analysis shows that the sig value of 0.75 has no statistical significance (Sig. Value > 0.05).

Table 4.17: The Algometer measurements of left to right relationship cross tabulated
with the apparent measure of left to right relationship

Table 4.17 cross tabulated the algometer measurements with the apparent measurements of the leg length. It was determined that 59% (n= 59) of the participants had lower readings on the left hand side which meant that the trigger points were more sensitive on the left hand side. The readings were higher on the remaining 41% (n=41) of the participants' left hand sides, meaning that the trigger points were less sensitive.

From the total of the 59% (n=59) participants that had more sensitive trigger points on the left hand side, 50% (n=6) had no distinguishable leg length inequality, 63.9% (n=23) had a left short leg and 57.7% (n= 30) had a left long leg.

From the total of the 41% (n=41) participants that had more sensitive trigger points on the right hand side, 50% (n=6) had no distinguishable leg length inequality, 36.1% (n=13) had a left short leg and 42.3% (n=22) had a left long leg.

<table>
<thead>
<tr>
<th>Algometer measure of left to right relationship</th>
<th>Left more sensitive</th>
<th>Count % within apparent measure of left to right relationship</th>
<th>Apparent measure of left to right relationship</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left shorter</td>
<td>Longer</td>
</tr>
<tr>
<td>Left more sensitive</td>
<td>6</td>
<td>23</td>
<td>30</td>
</tr>
<tr>
<td>Right more sensitive</td>
<td>6</td>
<td>13</td>
<td>22</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td>36</td>
<td>52</td>
</tr>
</tbody>
</table>
Table 4.18: The Pearson Chi-Square Tests on the algometer measurements of left to right relationship cross tabulated with the apparent measure of left to right relationship

<table>
<thead>
<tr>
<th>Test</th>
<th>Value</th>
<th>Df</th>
<th>Asymp. Sig. (2-sided)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Chi-Square</td>
<td>.794</td>
<td>2</td>
<td>.672</td>
</tr>
<tr>
<td>Likelihood Ratio</td>
<td>.793</td>
<td>2</td>
<td>.673</td>
</tr>
<tr>
<td>Linear-by-Linear Association</td>
<td>.014</td>
<td>1</td>
<td>.907</td>
</tr>
<tr>
<td>N of Valid Cases</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The Pearson Chi-Square test indicated in table 4.18, shows that there was no statistically significant correlation (Sig. Value > 0.05) between the apparent measurement and that of the algometer reading.

The statistical analysis shows that the sig value of 0.67 has no statistical significance.
Figure 4.1: Scattered graph on the correlation between the algometer reading on the left hand side and the actual measurement on the left hand side.

The scattered graph 4.1 does not indicate a strong correlation between the algometer readings on the left hand side and the actual measurements on the left hand side. The mean value of the correlation between the algometer readings on the left hand side and the actual measurements on the left hand side is 0.22 and is larger than 0.05, thus does not show any correlation to one another.
Figure 4.2: Scattered graph depicting the correlation between the algometer reading on the left hand side and the apparent measurement on the left hand side.

The scattered graph 4.2 does not indicate a strong correlation between the algometer readings on the left hand side and the apparent measurements on the left hand side. The mean value of the correlation between the algometer readings on the left hand side and the apparent measurements on the left hand side is 0.26 and is larger than 0.05, thus does not show any correlation to one another.
Figure 4.3: Scattered graph depicting the correlation between the algometer reading on the right hand side and the actual measurement on the right hand side.

The scattered graph 4.3 does not indicate a strong correlation between the algometer readings on the right hand side and the actual measurements on the right hand side. The mean value of the correlation between the algometer readings on the right hand side and the actual measurements on the right hand side is 0.18 and is larger than 0.05, thus does
not show any correlation to one another.

Figure 4.4: Scattered graph depicting the correlation between the algometer reading on the right hand side and the apparent measurement on the right hand side.

The scattered graph 4.4 does not indicate a strong correlation between the algometer readings on the right hand side and the apparent measurements on the right hand side. The mean value of the correlation between the algometer readings on the right hand side
and the apparent measurements on the right hand side is 0.25 and is larger than 0.05, thus does not show any correlation to one another.

CHAPTER FIVE: DISCUSSION

5.1 Introduction

Chapter five will discuss the statistical analysis presented in chapter four and how it correlates with the aim of this study highlighted in chapter one. The outcomes are discussed by means of the biomechanical and histopathological changes that occur with a leg length inequality.

5.2 Demographic Analysis

This study consisted of a 100 participants between the ages of 18 and 40. This group of participants consisted of 66 females and 34 males. Each participant had a leg length inequality as measured by any of the test included in the assessment protocol.

According to Vecchiet (2002), myofascial trigger points that presents as active trigger points are mainly present in individuals under the age of fifty years. This is thought to be due to the particular age group which are more active and thus might sustain more overuse injuries and micro trauma to the muscle fibres. Therefore participants used in this study were between the ages of 18 and 40 years.

According to Sturesson, Uden and Vleeming (2000), the average rotation within the sacroiliac joint is only about 2.5 degrees, whereas the average translation is only 0.7mm. Studies have shown that the range of motion in the sacroiliac joint is small and decrease with age. Motion predominantly occurs around the X-axis and some translation on the Z-axis (Cassidy and Mierau, 1992). Thus participants used in this study were between the ages of 18 and 40, to avoid any decrease in range of motion in the sacroiliac joint while performing orthopaedic tests that rely on nutation/counter-nutation of the sacroiliac joint.
5.3 Objective Data

5.3.1 Algometer Readings

In Chapter 4 (table 4.13) it was determined that 59% of the participants had lower readings on the left hand side which meant that the trigger points were more sensitive ie. more active on the left hand side. The readings were higher on the remaining 41% of the participants’ right hand sides, meaning that the trigger points are less active.

In table 4.9 of Chapter 4 the frequencies of the myofascial trigger points were discussed and it was determined that 42% of the participants’ myofascial trigger points were active and 58% were latent.

Table 4.11 represented the frequencies on the algometer measurements on the quadratus lumborum muscle and illustrated that the mean value for the algometer readings on the left hand side of the quadratus lumborum muscle was 3.07Kg/cm2, the minimum value for left side was 1.60Kg/cm2 and the maximum value was 4.50Kg/cm2. The mean value for the algometer readings on the right hand side of the quadratus lumborum muscle was 3.14Kg/cm2, the minimum value for left side was 1.70Kg/cm2 and the maximum value was 4.60Kg/cm2.

The algometer was used on the quadratus lumborum muscle to determine the pain threshold measurements in order to accurately locate trigger points and to quantify their sensitivity (Rachlin, 1994). An algometer is found to be a valid as well as a reliable instrument that measures sensitivity to pain caused by pressure (Kinser, Sands and Stone, 2009).

The increase incidence of latent trigger points could be due to multiple initiating factors including histopathological mechanisms and imbalances in load distribution. However these are factors for the individuals that participated in the study.
The main histopathological mechanism of developing a trigger point is due to repetitive microtrauma or acute trauma to a specific muscle or muscle group (Alvarez and Rockwell, 2002). There are several mechanical and systemic factors that can predispose the quadratus lumborum muscle to develop or activate trigger points. The mechanical factors include a minor hemipelvis, short upper limbs, a soft mattress, sleeping in a hammock for extended periods, constantly leaning over a desk due to lack of elbow support of a chair or due to inappropriate eyeglasses and working over low work surface like a basin (Travell and Simons, 1999). People with weak abdominal muscles generally have bad posture and thus are also predisposed to developing quadratus lumborum trigger points (Travell and Simons, 1999). Even though the above mentioned initiating factors are valid and very common, it does not mean that this was in fact the cause of the development of quadratus lumborum trigger points of every single participant.

Systemic factors that could cause trigger points in the quadratus lumborum muscle includes nutritional deficiencies, metabolic disorder like hypothyroidism, any chronic infection and increased emotional disturbances. Decreased body temperature also predisposes the quadratus lumborum to myofascial trigger point development (Travell and Simons, 1999).

Latent trigger points might be present in a number of asymptomatic skeletal muscles however they might be activated by a number of perpetuating factors and result in active trigger points. These active trigger points can be inactivated by means of treatment, but might not completely resolve or disappear. According to Celik and Mutlu (2013) these inactivated trigger points are converted back into latent trigger points after treatment. This might explain the findings in this particular study, which found that the majority of participants had latent myofascial trigger points as appose to active trigger points.

The drainage slopes designed and implemented on roads causes a height difference between the runner’s two limbs whilst running (McCaw and Bates, 1991). This means that the road is designed in a concave manner which leaves the runner with a height difference in terms of the placement of the feet, which in turn leads to a leg length difference. Road runners run against traffic which means that they run on the right side of the road causing
their right leg to run on a lower surface than their left leg, causing the average road runner to have a left short leg and a right long leg (Bradley and Castellano, 2011).

The daily activity, including whether or not each participant was a runner or not, was not formally documented, thus the above mentioned could be a possible explanation to the findings in this study which found that the majority of participants had a more sensitive reading on the left quadratus lumborum muscle versus the right. When only one muscle is contracted with the spine stationary and fixed, the quadratus lumborum muscle acts on the pelvis and hikes the hip ipsilaterally and when the pelvis is stationary and fixed the spine is laterally flexed ipsilaterally (Kelley, Finnegan and Dommerholt, 2013; Drake, Vogl and Mitchell, 2014). Thus tightening and shortening of the quadratus lumborum muscle can occur due to the constant hiking of the pelvis on the left hand side, this could possibly result in a higher level of the anterior superior iliac spine and leading to possible trigger points on the left hand side.

Another biomechanical change in the pelvis and spine could be due to a sudden load distribution imbalance for example keeping a wallet in one of the back pockets could cause a load distribution imbalance on the pelvis by elevating one side of the pelvis while in relation lowering the other (Travell and Simons, 1999).

The sensitivity on the left hand side of the quadratus lumborum muscle could be due to everyday routine causing biomechanical changes within the body. The first example of biomechanical change could be due to a functional leg length inequality caused by road running. The concavity of the road designed for drainage of excess water imposes a difference in height between the left leg and the right leg (McCaw and Bates, 1991). This could explain the findings in chapter three where the majority of participants presented with a more sensitive reading on the left hand side, which means that the myofascial trigger points on the left has a lower pain threshold.

A study was conducted by Vohra, Jaiswal and Pawar (2014) on effectiveness of strain counterstrain technique on quadratus lumborum trigger points in low back pain. They found that 40 out of the 50 participants had myofascial trigger points in their quadratus lumborum muscles. The amount of trigger points, active or latent, found in this study is similar to that of the study conducted by Vohra, Jaiswal and Pawar (2014).
5.3.2 Posterior Superior Iliac Spine Levels

In chapter 4 (table 4.5) the frequencies of the levels of the posterior superior iliac spine are discussed and it was determined that 47% of the participants presented with a higher posterior superior iliac spine on the left hand side while 43% presented with a higher posterior superior iliac spine on the right hand side. 10% of the participants had no changes in the levels of posterior superior iliac spine.

When comparing table 4.4 and table 4.5, there was no correlation between the side of the participants' level of anterior superior iliac spine and posterior superior iliac spine. A possible explanation could be due to the pelvic torsion. The sacroiliac joint is mainly affected by a leg length inequality due to rotation of the inominates in the sagittal and or frontal plane, this is also referred to as pelvic torsion (Knutson, 2005). In other words if there was a higher anterior superior iliac spine on the left hand side yet there was a lower level of the posterior superior iliac spine on the left it could be due torsion or counter-nutation of the sacroiliac joint. If there was a higher level of both the anterior and posterior superior iliac spine on the left it could be proposed that there was an increase in hiking of that inominate.

The participants in this study that presented with both the anterior superior iliac spine and the posterior superior iliac spine levels higher on the left hand side than on the right could be due to the complete hiking of the hip with minimal torsion of the actual sacroiliac joint.

Rotation of the sacroiliac joint occurs along the longitudinal axis and causes the level of the posterior superior iliac spine to change. During anterior rotation of the sacroiliac spine the posterior superior iliac spine moves medially and superiorly. During posterior rotation the posterior superior iliac spine moves laterally and inferiorly (Cramer and Darby, 1995). The amount of potential movement of the posterior iliac spine is not stated and it should be determined whether or not it is significant enough to pick up on palpation of the two levels. Rotary movements will only occur at the sacroiliac joint if there are sufficient forces applied to separate the surfaces (Gatterman, 2004).

Vertical loads like weight bearing while standing cause downward motion of the sacrum
and results in rotation. This is due to weight placement on the anterior superior aspect of the sacrum (Magee, 1997).

During standing the ideal centre of gravity lies anterior to the second sacral vertebrae, however the centre of gravity is considered to be conceptual and changes with movement or position. Thus this ideal centre of gravity is found when the pelvis is symmetrical and both sides have equal movement (Swanson, 2011). This means that when the pelvis is not symmetrical and the movement is not equal that the posterior tilt might be more exaggerated on side and cause a difference in the levels of the posterior superior iliac spine.

5.3.3 Anterior Superior Iliac Spine Levels

In chapter 4 (table 4.4) the frequencies of the anterior superior iliac spine levels are discussed and it has been determined that 65% of the participants had a higher level of the anterior superior iliac spine on the left hand side. It was also determined that 29% of the participants had a higher level of the right hand side. This leaves 6% of the participants that had no abnormalities detected.

Walsh, Connoly, Jenkinson, OBrien (2000) found that the most general compensatory mechanism for a leg length inequality up to 22mm was pelvic torsion (Walsh, Connolly, Jenkinson, OBrien, 2000). Therefore there might be differences within the levels of the anterior superior iliac spine when comparing the two sides in the presences of a leg length inequality which was found in this study when the left and right anterior superior iliac spine levels were compared with one another.

The anterior superior iliac spine will have similar changes within the levels as with the posterior superior iliac spine. This includes the explanation on running and vertical loads applied.

Not all the participants were runners and thus another possible explanation could be due to an individual’s biomechanical changes while sitting. Some individual’s sit with their
dominant leg crossed over the non-dominant leg, causing a nutation movement of the sacrum on the inominate. During nutation the sacrum rotates so that the promontory moves anteriorly and superiorly, consequently the inominate rotates posteriorly and superiorly as to create torsion in the sacroiliac joint. This causes a higher level of the anterior superior iliac spine (Levangie and Norkin 2001).

5.3.4 Prone Leg Length Evaluation

In chapter 4 (table 4.6) the prone leg length evaluation frequencies are discussed and it was determined that 36% of the participants presented with a shorter leg on the left hand side, compared to the right hand side and 60% presented with a shorter leg on the right hand side, compared to the left hand side. 4% of the participants had no changes in the leg length compared to the sides.

These findings could be due to the fact that individuals in general develop and use a dominant side more than the non-dominant side. Thus every part of an individual’s routine will increase muscular forces on the dominant side. It was found that lateral asymmetry is mainly found in the upper extremity however the dominant leg is usually in the lower limb with the strongest tibia and is usually found on the opposite side of the dominant arm. It was also found that the left leg, regardless of the dominancy of the upper limb, was mainly the weight bearing limb and thus determined as the dominant leg (Carpes, Mota and Faria, 2010).

Driving a car also makes a big impact on an individual’s biomechanical changes, the left lower limb mainly controls the clutch pedal, which when driving a manual car is only occasionally used. The right lower limb however needs to control the gas pedal at all times as well as the brake pedal, thus causing an increase in shearing forces on the sacroiliac joint as well as different forces on the lower lumbar muscles. Lumbosacral angle and sacral tilt is significantly decreased when comparing seated to standing measurements (De Carvalho, Soave, Callaghan, 2010). Therefore another proposed mechanism could be that a number of participants where drivers of motor vehicles and could thus explain the findings in this study, however this does not conclude that all participants were in fact
drivers and only leaves the above mentioned as a possibility.

5.3.5 Supine-to-Sit Test

In chapter 4 (table 4.7) the frequencies of the supine part of the supine-to-sit orthopaedic test is discussed. It was determined that 59% of the participants had a longer leg on the left hand side, compared to the right and 29% had a longer leg on the right hand side compared to the left. In this test it was determined that 12% of the total participants had no change in leg length compared to the sides.

In table 4.8 the frequencies of the seated part of the supine-to-sit orthopaedic test was presented. It was determined that 37% of the participants had a longer leg on the left hand side, compared to the right and 32% had a longer leg on the right hand side compared to the left. In this test it was determined that 31% of the total participants had no change in leg length compared to the sides.

The supine-to-sit test was performed to evaluate whether or not the participant had a functional leg length inequality. If one of the legs moved proximally in relation to the other leg it was indicative of a functional leg length inequality due to a pelvic torsion causing a pelvic dysfunction. Hence when the leg was longer when the patient was supine and shorter when the patient was seated the pelvic dysfunction was on the affected side therefore the functional leg length inequality will be on the affected side (Magee, 1992). This test indicated that a possible explanation could be that a majority of participants had a functional leg length inequality on the left side which does correlated with the tape measurement findings, discussed later in this chapter.

Movement of the sacrum in relation to the inominates is generally referred to as nutation and counter nutation. Nutation can be defined as anterior and inferior movement of the sacral promontory, with posterior movement of coccyx relative to the inominates. Counter nutation can be defined as movement opposite to nutation and occurs with posterior and superior movement of sacral promontory, with anterior movement of the coccyx relative to the inominate (Levangie and Norkin 2001; Kapandji, 1974). The supine-to-sit test is exactly nutation and counteration of the sacroiliac joint and a dysfunction in the sacroiliac joint might affect the outcome of the test itself. However in this study the presence or side of
dysfunction was not determined and therefore might be a possible factor affecting the positive findings in this test.

5.3.6 Actual and Apparent Measurements

The percentage of participants that had a left and right equal measurement as measured by the actual measurement technique was 12%. The percentage of participants that had a left shorter leg was 36% and the percentage of participants that had a left longer leg was 52%.

Recent studies show that the tape measurement method is as reliable as the gold standard method which is a computed tomography scanogram in measuring leg length inequality (Jamaluddin, Sulaiman, Kamarul, Juhara, Ezane and Nordin, 2011).

According to Woerman and Binder-Macleod (1984) 60-70% of the adult population presented with a leg length inequality which correlates to the results found in this study.

The percentage of participants that had a left and right equal measurement as measured by the actual measurement technique was 7%. The percentage of participants that had a left shorter leg was 38% and the percentage of participants that had a left longer leg was 55%.

The percentages of the actual and apparent measurements are very closely related to one another, the measurements that do not correlate with the other tests performed may be due to human error.

Although the actual and apparent tape measurement technique is valid and reliable, the difference in leg length might not be significant enough to correlate with the increased sensitivity of the quadratus lumborum trigger points.
5.3.7 Correlations

The Pearson Chi-Square test indicated that there was no statistically significant correlation (Sig. Value > 0.5) between the apparent measurement and that of the algometer reading.

A leg length inequality as well as a hemipelvis might be perpetuating factors of a quadratus lumborum myofascial trigger points due to the fact that it changes an individual’s biomechanical functioning (Travell and Simons, 1999). According to Travell and Simons (1999) a quadratus lumborum muscle trigger point can be perpetuated by a leg length inequality of as little as 3mm (Travell and Simons, 1999). Superimposition of an individual with a pelvic torsion due to a leg length inequality causing possible quadratus lumborum hypertonicity and the body’s ability to adapt might cause muscular bracing and pain as a response (Knutson, 2005). Therefore quadratus lumborum trigger points could have a correlation to a functional or structural leg length inequality and should be considered when treating a leg length inequality, it could also implicate the biomechanical functioning of the body as a whole.

According to Indahl, Kaigle, Reikeras and Holm (1999) stimulating the joint capsule of the sacroiliac joints in pigs could cause reflexive muscular responses depending on whether it is on the dorsal or ventral aspect of the joint. They found that stimulation of these low threshold nerve endings in the sacroiliac joint tissue may cause a reflex activation of the gluteal and paraspinal muscle that become hypertonic and painful over a period of time, they also found that stimulating the ventral area of the sacroiliac joint tissue caused a reflexive activation of quadratus lumborum muscle that could possibly be a positive feedback cycle (Indahl, Kaigle, Reikeras and Holm, 1999).

This feedback cycle could determine whether quadratus lumborum hypertonicity causes lumbar curvature and possible pelvic torsion which in turn stimulates the nerve endings in the sacroiliac tissue, causing more hypertonicity of the quadratus lumbarum muscle followed by more lumbar curvature and pelvic torsion (Indahl, Kaigle, Reikeras and Holm, 1999).

According to Travell Simons, (1999) a leg length inequality of about 3mm might perpetuate
quadratus lumborum trigger points it was also stated that a leg length inequality of about 6mm are more likely to do so (Travell and Simons, 1999). The participants in this study had leg length inequalities between 0.5 cm and 1 cm however it did show a significant correlation to the quadratus lumborum trigger points.

The lack of correlation might be because the leg length inequality might be caused due to pelvic torsion which is not stated as one of the functions of the quadratus lumborum muscle. Superimposition of an individual with a pelvic torsion due to a leg length inequality causing possible quadratus lumborum hypertonicity and the body’s ability to adapt might cause muscular bracing and pain as a response (Knutson, 2005).

It should be kept in mind that the range of motion is of the sacroiliac joint is so small, more or less two degrees in both rotation and translation, that it might not be able to affect the quadratus lumborum muscle to such an extreme extend. The sacrum is affected when the spine changes in position and the ilium is affected when the lower extremity changes in position.

The sacroiliac joint does not function in isolation and should always be considered with functioning of the lumbosacral joint, the pubic symphysis (which forms part of the pelvic ring) and the two hip joints (Gatterman, 2004).

The muscles that flex, extend, or rotate the vertebral column alters the position of the sacrum. The muscles that flex, extend, abduct, adduct, internally and externally rotate the femur alters the position of the ilium. The muscles that tilt the pelvis anteriorly and posteriorly alters the position of the sacrum and those that tilt the pelvis right or left laterally, alters the position of the ilium (Cox 1999).

According to Porterfield and De Rosa (1998), it should be recognised that with sacroiliac functioning there is a creation of moments rather than a creation of actual movements. These are created by the ground reaction forces, the trunk forces and the muscles
attached to the pelvis.

During standing the weight on the pelvis may shift from one side to the other if the pelvis is not symmetrical. The orientation of the sacroiliac joint changes as the shift on pelvis changes, for example if the lateral pelvic shift is towards the right hand side, the right sacroiliac joint will be more horizontal in orientation and the left sacroiliac joint will be more vertical in orientation. This leads to an increase in compressive forces in the right sacroiliac joint and an increase on shear forces on the left sacroiliac joint. As illustrated in figure 5.1 the ground reaction forces travelling up both lower limbs and gravitational forces originating from the spine meet in the pelvis, thus any changes like rotation or a tilt will alter the location of the two forces meeting and thus it will alter the centre of gravity (Porterfield and De Rosa, 1998).

This could possibly affect the tension at which the quadratus lumborum muscle contracts and lengthens, however the shift in the area where these two forces meet might not be significant enough to cause any change on the muscle's functioning or perpetuate quadratus lumborum trigger points.

*Figure 5.1: Gravitational and ground reaction forces meeting in the pelvis (Gatterman, 2004)*
The movement in the two opposing articulating surfaces of the sacroiliac joint can be seen as track bound motion (Gatterman, 2004).

Although the actual and apparent tape measurement technique is valid and reliable, the difference in leg length might be too insignificant to cause a change in the hypertonicity of the quadratus lumborum muscle and thus it is possible that this might be true that the quadratus lumborum might not be hypertonic enough to cause a significant leg length inequality.

- The sensitivity of the tests and measurements should be brought into question and the following points regarding the available tests should be taken into consideration:

- The examination techniques utilized in this study should also be scrutinized and taken into perspective, that perhaps the findings in real participants are not as obvious or significant due to misleading exaggeration of illustrations.

- The amount of leg length inequality should thus be considered when choosing an examination method and also when explaining a positive finding in an examination technique.

Methods and techniques currently available for examination of a leg length inequality might lack some important information required for a thorough study and might create unrealistic expectations regarding findings. For example the amount of leg length change in the supine-to-sit test might be slightly exaggerated in the illustration. Thus certain illustrated figures should also be taken into consideration when selecting methods of examination. To avoid expectations of great differences in findings when utilizing the test with a minimal leg length inequality, when in fact or in practice the positive findings are not to the extremes of illustrations and possibly even irrelevant to the examiner.
6.1 Conclusion

The aim of this study was to determine whether or not there was a correlation between quadratus lumborum trigger points and a leg length inequality. The correlation was determined by obtaining objective data using the Algometer, Prone Leg-Length Evaluation, Supine-to-Sit Test and measuring leg length with the real and apparent methods.

There was no significant correlation found between the quadratus lumborum muscle trigger points and the leg length inequality. There was however an increased incidence of active trigger points found in the quadratus lumborum muscle in comparison to the latent trigger points found.

The implications for the profession is that when a Chiropractor treats a functional or an environmental leg length inequality of less than 10mm, it is important to educate the patient on muscle imbalances, however it should not affect the practitioner’s approach in treating a leg length inequality.

6.2 Recommendations

During the course of this study, the following areas were identified as recommendations for further studies:

- A larger sample size to ensure a more representative study and conclusion.
- Determining the correlation between myofascial trigger points in quadratus lumborum muscle and a functional leg length inequality versus a structural leg length inequality. In this study structural leg length inequality was not distinguished from a functional leg length inequality and might have a possible influence on the perpetuating factor of quadratus lumborum trigger points. It might conclude more
significant results due to the increase in difference in structure leg length inequality compared to that of functional and environmental leg length inequality.

- A study should be conducted that only utilizes road runners as participants to establish whether or not it is a plausible mechanism of perpetuating quadratus lumborum trigger points and or a environmental leg length inequality.

- A study should be conducted to establish what significance an individual’s daily activities has on developing a possible leg length inequality and or perpetuating quadratus lumborum trigger points.

- More research should be done on the affects of quadratus lumborum functioning on the sacroiliac joint. The quadratus lumborum might have an effect on pelvic torsion due to its attachment sites, however this has not been proven.
REFERENCES


Clinical Orthopaedics and Related Research. 466(12): pp. 2910-2922.


APPENDIX A
Dear Participant,

My name is Charissa Swan, and I am doing my Master’s Degree at the University of Johannesburg. I would like to invite you to consider participating in my research study entitled “A correlation study between quadratus lumborum trigger points and a leg length inequality.”

Before agreeing to participate, it is important that you read and understand the following explanation of the purpose of the study, the study procedures, benefits, risks, discomforts, and precautions as well as the alternative procedures that are available to you, and your right to withdraw from the study at any time.
This information leaflet is to help you to decide if you would like to participate. You need to understand what is involved before you agree to take part in this study. You may find that this form may contain words that you do not understand. If you have any questions, do not hesitate to ask me. You may also take home a copy of this form before signing the consent form to think about or discuss with family or friends before making your decision.

Purpose of the study

By replying to my advert you have indicated that you have a leg length inequality, which means you have one leg that is longer than the other.

The purpose of this study is to determine whether there is a correlation between the muscle in your lower back and the leg length inequality.

Procedure

Should you decide to partake in this study you will first be screened for what we call inclusion and exclusion criteria.” The inclusion criteria for this study are that the participants should have a leg length inequality and they should be between the ages of 18 and 40 years. The exclusion criteria include that the participants should not have had any previous surgery of the spine nor have an antalgic list which means you are walking or standing in a position where you tend to lean away from the pain. The participant should not be on pain medication nor have a BMI above 24. Also, please be open with me regarding your health history, since you may otherwise harm yourself by participating in this study.

After the screening has been done and a leg length inequality has been confirmed, I will be taking a reading of your quadratus lumborum muscle with the algometer which is a small non invasive measuring device that measures the amount of pressure the trigger point area can handle before discomfort arises. This procedure is done to ensure that the information gathered during this study is as accurate as possible.
A hundred participants will participate in this study and it will only be performed in South Africa. The entire study, including all measurements will take place at the University of Johannesburg’s Chiropractic day clinic. The total amount of time required for your participation in this study will be a maximum of 15 min. It is a once off consultation and no follow-up consultation will be required.

There are no anticipated risks to this study however if you have any concerns please feel free to contact me throughout your participation in this study. The benefits of this study are that it could assist practitioners in a more efficient treatment protocol for a leg length inequality.

As your participation in this study is entirely voluntary you can decline to participate, or stop at any time, without stating any reason. Your withdrawal will not affect your access to other medical care.

If at any time you have any questions during the study please do not hesitate to contact me. The 24 hour telephonenumber through which you can reach me is 073 111 6754.

If you want any information regarding your rights as a research participant, or complaints regarding this research study, you may contact Professor Marie Poggenpoel, Chairperson of the University of Johannesburg’s Academic Ethics committee which is an independent committee established to help protect the rights of research participants. Tel. 011 559 2860.

This study protocol has been submitted to the University of Johannesburg’s Academic Ethics Committee and written approval has been granted by that committee. The study has been structured in accordance with the Declaration of Helsinki of 2008, which deals with the recommendations guiding doctors in biomedical research involving human participants.

Should any injuries occur as a result of this study the University of Johannesburg has medical insurance that will cover the expenses related to the injury.

Confidentiality
All information obtained during the course of this study will be kept strictly confidential. Recorded data used for the statistical analysis by STATKON will not include any information that identifies you as a participant in this study. Data that may be reported in scientific journals will not include any information that identifies you as a participant in this study.

Any information uncovered regarding your test results or state of health as a result of your participation in this study will be held in strict confidence. You will be informed of any finding of importance to your health or continued participation in this study but this information will not be disclosed to any third party without your written consent. The only exception to this rule will be cases of communicable diseases were a legal duty of notification of the Department of Health exists. In this case, you will be informed of my intent to disclose such information.

Thank you for taking the time to read this form and consider participation in this study.

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

Researcher: Name: Charissa Swan Telephone number: 073 111 6754
Supervisor: Name: Dr. C. Yelverton Telephone number: 011 559 6218
Chair Ethics: Name: Prof. M. Poggenpoel Telephone number: 011 559 2860

UJ Ethics clearance number: AEC-01-41-2014

APPENDIX B
DEPARTMENT OF CHIROPRACTIC

Date: ____________________

CONSENT FORM

Dear participant

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

Personal doctor/specialist notification option

Please indicate below, whether you want me to notify your personal doctor or your specialist of your participation in this study:

- YES, I want you to inform my personal doctor/specialist of my participation in this study
- NO, I do not want you to inform my personal doctor/specialist of my participation in this study
- I do not have a personal doctor/specialist

Do you have any questions related to this study?

INFORMED CONSENT

- I hereby confirm that I have been informed by the researcher Charissa Swan about the
nature, conduct, benefits and risks of this study with the title Correlation study between quadratus lumborum trigger points and a leg length inequality.

- I have also received, read and understood the above written information (participant information leaflet) regarding this study
- I am aware that the results of this study, including personal details regarding my gender, age, date of birth, 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
- I may, at any stage, without prejudice, withdraw my consent and participation in this study
- I have had sufficient opportunity to ask questions and (of my own free will) I declare myself prepared to participate in this study.

Signed Participant

Printed name
Date and time

Signed Researcher

Printed name
Signature
Date and time

APPENDIX C
DEPARTMENT OF CHIROPRACTIC

Information sheet

Name: __________________________
Age: __________________________
Gender: ________________________
Patient Number: __________________________
File Number: __________________________
Adams Test: __________________________

ASIS Asymmetry: LHS higher & RHS lower | RHS higher & LHS lower | NAD
PSIS Asymmetry: LHS higher & RHS lower | RHS higher & LHS lower | NAD

Prone Leg-Length Evaluation: LHS Short | RHS Short | NAD
Supine-to-sit: Supine:

Seated:

Actual: LHS: ___________ cm  RHS: ___________ cm
Apparent: LHS: ___________ cm  RHS: ___________ cm

________________________________________  __________________________
Name of Practitioner  Signature

________________________________________
Date

APPENDIX D
DEPARTMENT OF CHIROPRACTIC

Information sheet

Name and Surname: __________________________
Patient Number: __________________________
File Number: __________________________

**QL Trigger point most tender side:** Right/Left

**Trigger Point:** Active/Latent

**Algometer reading:** LHS: ______________ RHS: ______________

**BMI:** __________________________
(normal ranges between 19 and 24)

BMI calculation: BMI = Weight(kg) / Height (m) x Height (m)
APPENDIX E

Is one of your legs longer than the other?

You are invited to participate in a research study to determine whether it is a muscle in your lower back that is causing your one leg to be longer than the other.

This study will be conducted at the UJ clinic, Sherwell street, Doornfontein.

Kindly contact Charissa Swan at the given contact details if you are interested in participating.

Charissa Swan
073 111 6754

Charissa Swan
Charissa Swan
Charissa Swan
Charissa Swan
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073 111 6754