The Immediate Effect of Ipsilateral and Contralateral Sacroiliac Joint Manipulation and Sham Laser Intervention on the Hip Range of Motion and Kicking Velocity in Soccer Players

By

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I, Zia ul Mustafa Rehman, do declare that this dissertation is a representation of my own work in both concept and execution.

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DEDICATION

I am grateful to Allah, Lord of the worlds, for if it were not through his abundant mercy and blessings upon me, I would never have been able to progress. I dedicate my life's work to Muhammed, the final Messenger of God (peace and blessings of Allah be upon Him).

I dedicate this thesis to my first teacher my dear most honorable father, whom I lovingly call Abba. I have learnt a vast amount of knowledge from you. I hope I am destined to be like you, and even better, perhaps. May you have a long and healthy life so that I may learn much more from your wisdom and endless experiences.

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ABSTRACT

Background

There is a close biomechanical relationship that exists between the sacroiliac and hip joints. It is essential to have optimum hip range of motion originating from the pelvis in both the kicking and support limbs as both limbs play a role in achieving a high speed kicking velocity. Due to the strenuous activity of soccer players, both hip ranges of motion may be decreased, thus predisposing the player to injuries. This may also affect the kicking velocity. The effects of sacroiliac joint manipulation on hip range of motion and kicking velocity were investigated.

Objectives

The objective of this study was to determine the effect of ipsilateral sacroiliac joint manipulation versus contralateral sacroiliac joint manipulation on bilateral hip range of motion and kicking velocity.

Methods

There were three groups of twenty soccer players. The ipsilateral sacroiliac joint manipulation group, the contralateral sacroiliac joint manipulation group, and the sham laser intervention group. The case history, physical, regional, lumbar and hip exams were done in the Chiropractic Day Clinic. The hip ranges of motion were measured pre- and post-Chiropractic manipulation in all three groups on both limbs in the Fred Crookes Sports Centre (Durban University of Technology). Hip ranges of motion were measured by the Saunders (The Saunders Group, Chaska, MN) digital inclinometer. The kicking velocity of all players were measured pre- and post- manipulation by a speed sport radar gun (Bushnell Speedster Speed Gun; Bushnell Inc, Lenexa, KS).

This was a purposive, investigational study trial where the data was reduced and analysed with the help of a statistician, using the statistical software SPSS version 20.0.The statistical aspect of the research encompassed the following: descriptive statistics used Fischer values, Eta tests, frequency, cross-tabulation tables and various types of graphs (bar charts, scatter graphs etc.); Inferential statistics used Pearson’s and/or Spearman’s correlations at a

significance level of 0.05; testing of hypotheses used chi-square tests for nominal data and ordinal data at a level of significance of 0.05.

Results

The ipsilateral group showed statistically significant results for the right hip in flexion, extension, internal rotation and external rotation, as well as for extension, internal rotation and external rotation in the left hip. The contralateral group showed statistically significant results for the right hip in extension, internal rotation and external rotation, as well as for extension and internal rotation in the left hip. There was a statistically significant improvement in the kicking velocity of the ipsilateral and contralateral group after treatment. There was a strong association between the perception changes to the actual kicking velocity in the soccer players. There was a correlation between the change in hip range of motion and change in kicking velocity, however statistically it was not significant.

Conclusion

The manipulation of ipsilateral or contralateral sacroiliac joint has an effect on the right and left hip range of motion.

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LIST OF DEFINITIONS

Asymptomatic - For the purpose of this study this term shall be defined as the possible presence of a joint restriction in the absence of pain in the sacroiliac joint of a soccer player.

Subluxation - This is the restriction of a joint preventing normal hip range of motion. There are many other terms used interchangeably with subluxation, namely: joint dysfunction, joint restriction, joint fixation, joint lesion, joint blockage or segmental dyskinesia. For the purposes of this study a subluxation will be referred to as a joint restriction.

Joint play - Joint play is described as the soft feel while palpating normal joint motion at the end of passive range of motion.

Passive range of motion - A therapist moves a joint through its range of motion with no effort from the patient.

Manipulation - For the purposes of this study the term manipulation refers to the Chiropractic manipulation of a joint, which by definition is a high velocity low amplitude thrust (Gatterman 2003).

Kicking velocity - This is the resultant speed of the ball after the foot makes impact with the ball in the final stage of the instep kick (Lees and Nolan 1998).

Range of Motion - This is the normal range of motion present in a joint.

Immediate - For this study, the definition by Gross *et al.* (2008) will be used, i.e. a time frame of upto ten minutes.

Ipsilateral - This explains the side that the player uses to kick a ball e.g. if a player's preferred kicking limb is right footed then his right side shall be called ipsilateral. All players in this study were right footed players. This group is also called right sacroiliac group for better appreciation of chapter four.

Contralateral - This is the opposite side to the leg that kicks the ball e.g. if a player's preferred kicking limb is right footed then his left side shall be called contralateral. All players in this study were right footed players. This group is also called left sacroiliac group for better appreciation of chapter four.

Support limb– This is the limb which is grounded while the kicking limb is swinging to perform the instep kick.

Kicking limb- This is the limb that has contact with the ball during the instep kick.

Ergogenecity - This is an asymptomatic player who seeks a performance edge.

Muscle Torque - The force of muscle contraction generated to overcome external forces.

First team soccer squad - This is a university soccer squad which consists of the starting-eleven players and may have up to nine substitute players.

Substitute player - A substitute player is a player who is part of the first team squad but sits on the bench for the duration of the game unless the coach decides to substitute him for a particular reason. A player being injured during a match is an example of such a reason.

LIST OF ABBREVIATIONS

ROM	Range of Motion
CNS	Central Nervous System
PNS	Peripheral Nervous System
SIJ	Sacroiliac Joint
AMI	Arthrogenic Muscle Inhibition
DUT	Durban University of Technology
UKZN	University of Kwazulu-Natal

CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION TO THE STUDY

Soccer is a complex sport in which many movements are performed during a game that lasts for ninety minutes. These movements play a role in the outcome of a game that includes other aspects such as fitness, skill, talent, player psychology and crowd support. The most studied movement in the game is the instep kick, which is the most common technique used to score a goal. This kick can therefore be an important element for winning the game (Wickstrom 1975; Zernicke and Roberts 1978; Luhtanen 1988; Lees *et al*. 1998; Dorge *et al.* 2002).

A successful kick is measured by the speed of the ball after impact (kicking velocity), which depends on the final foot velocity (Luhtanen 1988). The speed generated for the final foot velocity upon impact is initiated in the lumbar spine and pelvis. There are many forces involved in the run-up stages of the soccer kick. These forces act upon the pelvis and lower limb to perform the necessary movements. The highest force recorded at a joint during the instep kick was at the hip, thus showing the vital role it plays in all the stages of the instep kick (Zernicke and Roberts 1978). Concomitantly, there are many forces acting upon the left and right sacroiliac joints in the run-up stages of the soccer kick. The player will either be standing on the support limb or kicking limb during all the stages of the kick. Cibulka, Dellito and Koldehoff (1988) and Cibulka (2013) mention that both the sacroiliac joints are part of one functional unit and work together in unison, thus for every ipsilateral movement there is an equal and opposite reactive motion on the contralateral side. Therefore both joints are involved in the soccer kick, be it on the support limb or kicking limb.

The hip range of motion (ROM) plays a major role in the initiation, implementation and completion of the three different stages of the soccer kick (Amiri-Khorasani, Abu Osman and Yusof 2011). The hip ROM should be within normal values for a successful kick to occur. Many soccer studies have shown that soccer players have a decreased hip ROM compared to non-athletes (Amiri-Khorasani, Abu Osman and Yusof 2011; Rahnama *et al*. 2005 cited in Ostojic and Stojanovic 2007). The significance of the hip ROM in injury prevention was highlighted by Bradley and Portas (2007) who measured the hip ROM in thirty-six soccer players before the season began. It was observed that those players who suffered injuries

during the season had a decreased hip ROM before the season began. Therefore it is possible that a decrease in hip ROM could increase the risk of player injuries and decrease the chances of a successful kick, i.e. a high kicking velocity (Bradley and Portas 2007).

Chiropractic manipulation of the sacroiliac joint has been shown to increase hip ROM (Bisset 2003; Turner 2005). A good hip ROM is important for a successful instep kick to occur (Zernicke and Roberts 1978). It is interesting to note that in a published small placebo controlled trial there was an improvement in muscle torque after sacroiliac joint manipulation (Hillerman *et al*. 2006). Deutschmann (2011) and Rebelo (2011) investigated the effects of manipulation in the lumbar spine and sacroiliac joint and found an increase in lumbar spine and sacroiliac joint ROM and kicking velocity, compared with the control group. Neither of the authors, however, included the hip joint ROM in their study, and neither were the sacroiliac joints investigated ipsilaterally versus contralaterally.

1.2 AIM AND OBJECTIVES OF THE STUDY

The Chiropractic manipulation was performed on the sacroiliac joint of the ipsilateral kicking limb and the contralateral support limb in twenty soccer players, respectively. Twenty soccer players in a control group were treated with sham laser intervention applied to the right sacroiliac joint for sixty seconds per application. Thereafter the kicking velocity and bilateral hip ROM were measured. This study observed and compared the immediate effect of the manipulation on bilateral hip ROM and kicking velocity between the groups.

This study aimed to investigate the bilateral hip ROM and kicking velocity after manipulation, of both the ipsilateral and contralateral side sacroiliac joints respectively.

Several specific objectives were identified and these included:

Objective 1
To compare ipsilateral and contralateral hip flexion ROM before and after the intervention in all three groups.

Objective 2
To compare ipsilateral and contralateral hip extension ROM before and after the intervention in all three groups.

Objective 3

To compare ipsilateral and contralateral hip internal rotation ROM before and after the intervention in all three groups.

Objective 4

To compare ipsilateral and contralateral hip external rotation ROM before and after the intervention in all three groups.

Objective 5

To compare the average kicking velocity before and after the intervention in all three groups.

Objective 6

To compare the perception change in kicking velocity after the intervention for all three groups.

Objective 7

To determine any correlation that may exist between hip ROM and the change in kicking velocity after the intervention.

1.3 HYPOTHESIS

For objectives 1-5 with regards to spinal adjustment, Null Hypotheses (Ho) were set based on the works of Herzog (2000), Gatterman (2003), Bisset (2003) and Turner (2005). These stated that there would be no statistical significance between the changes in:

- Hip flexion range of motion post-intervention.
- Hip extension range of motion post-intervention.
- Hip internal rotation range of motion post-intervention.
- Hip external rotation range of motion post-intervention.
- Kicking velocity post-intervention.
- Perception for kicking velocity post-intervention.
- Correlation between hip ROM and kicking velocity post-intervention.

With respect to the sham laser intervention, the Null Hypothesis was set that there would be no statistically significant change in:

- Hip flexion, extension, internal and external rotation range of motion post-intervention.
- Kicking velocity post-intervention.

Therefore the null hypothesis states that there will be no significant change in hip ROM and kicking velocity within and between all groups.

1.4 BENEFITS OF THE STUDY

Soccer training has been shown to immediately decrease flexibility in players during training and up to twenty-four hours after training. This reduced range of motion progressively decreases over time (Moller, Oberg and Gillquist 1985 cited in Bradley and Portas 2007). This study assumes that after sacroiliac joint manipulation the hip ROM and kicking velocity will increase. The enhancement of soccer performance by increasing hip ROM and kicking velocity may highlight the need for Chiropractic interventions in the sport and show that Chiropractic has an integral role in increasing player performance.

An understanding of Chiropractic treatment in the field of soccer is much needed. There are many research studies (Sandell, Palmgrena and Bjorndahl 2008; Schwartzbauer *et al.*1997; Lauro and Mouch 1991; Miners 2010) that have been conducted on developing the performance of players to an optimum, however research relating to the enhancement of player performance in the Chiropractic profession is lacking. A better insight linking the effect of sacroiliac joint manipulation on hip joint ROM associated with kicking velocity will be explored in this study. This study can assist sports therapists, physicians and researchers in understanding Chiropractic and hopefully create awareness of the role of Chiropractic on kicking performance. Few studies have been done on Chiropractic preventative treatment or ergogenecity. Prophylactic treatment protocols are a better option for soccer players than receiving treatment when the injury occurs or when symptoms present themselves. Players in this study are asymptomatic for any neuromusculoskeletal condition, thus this study will create awareness of the ergogenic effects of Chiropractic to the profession worldwide.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

Since all body parts in sportsmen need to have normal ROM to function well for optimum sports performance, the manipulation can be a useful tool in aiding optimum joint performance. Thus this chapter focuses on the merits of Chiropractic manipulation of the sacroiliac joints, as this can affect hip ROM and kicking velocity in the soccer player. This chapter entails a brief overview of soccer and its biomechanics, followed by the relevant anatomy of the hip and sacroiliac joint. Thereafter, manipulation, neuroanatomy and arthrogenic muscle inhibition are discussed in order to better understand how manipulation may remove a restriction which may cause arthrogenic muscle inhibition via the nervous system.

2.2 AN OVERVIEW OF SOCCER

2.2.1 Soccer

Soccer is a game played with eleven players on the field. There are different positions that players may take up depending on their preferences, skill or talent. The main positions are goalkeepers, defenders, midfielders and strikers. The main technique used to play soccer is the instep kick. The aim of the game is to score as many goals as possible in the opposition's goalposts within the time permitted (Lees and Nolan 1998). The most common technique used to score goals is the instep kick (Lees and Nolan 1998). Hence, this study will focus on the outcomes of manipulation of the sacroiliac joint and whether it affects the instep kicking velocity.

2.2.2 Demographics

In a majority of sporting codes most of the injuries occur in the lower limbs of athletes. In soccer the most prevalent injuries occur in the soft tissue and joints of the lower limbs (Reilly and Howe1996). Injuries of the lower limb and pelvis are common in soccer players for which treatments are sought (Rapoo 2009).

A profile of amateur league indoor, and outdoor soccer players in the greater Durban area by Archary (2008) showed that indoor players were most likely to seek Chiropractic treatment for their injuries compared with outdoor players, who consulted a general practitioner first, followed by a physiotherapist as the second common option. Another study on the management of soccer injuries for professional players in the premier soccer league by Rapoo (2009), reported that 72% of players in South Africa seek treatment outside of their respective clubs, with physiotherapy being the most popular option.

There have been no studies pertaining to the prevalence of sacroiliac joint restrictions in soccer players. The lumbar spine, sacroiliac joint, pubic symphisis and hip joints are all closely linked to each other biomechanically, thus a restriction in one joint could cause a compensatory restriction in another joint (DeFranca and Levine 1996). Studies on sacroiliac joint restriction in soccer players (Deutschmann 2011; Rebelo 2011) have not measured hip ROM and its resultant effect on kicking velocity. In the 2010 FIFA world cup in South Africa, the most common injuries diagnosed were thigh strains and ankle sprains (Dvorak *et al.* 2011). Archary (2008) showed that most soccer injuries occurred in the ankle and knee region. Rapoo (2009) concurred with the above results, but also showed that most recurring injuries occurred in the groin region. Rapoo (2009) also stated that the main criteria as stipulated by club medical staff for a return to play of the soccer player was that the player had to have full range of motion with no pain. Rapoo (2009), however, mentioned that most players returned to play early and thus a high recurrence of groin injuries was observed.

2.3 THE BIOMECHANICS OF SOCCER

Kicking velocity (also known as ball velocity) is the speed of the ball after the foot-ball impact and an important indicator of soccer performance and success. Most studies that are associated with measuring soccer performance (i.e. kicking velocity) have used the instep kick (Wickstrom 1975; Zernicke and Roberts 1978; Luhtanen 1988; Lees and Nolan 1998; Dorge *et al*. 2002). The instep kick is used because of its importance in the game, especially in the penalty kick, as well as being a popular technique in scoring goals.

The biomechanics of the instep kick are explained by Wickstrom (1975). The player approaches the soccer ball by taking a few strides towards the ball where the supporting limb is slightly behind the stationary ball. This gives the pelvis the opportunity to rotate backwards on the opposite leg (Davids, Lees and Burwitz 2000). The kicking leg then extends at the hip and flexes at the knee, rotating the pelvis around the supporting limb to provide the forward motion whereby the hip flexes and the knee extends. The thigh

decelerates and is motionless upon ball impact, while the shank fully extends to kick the ball. The limb straightens upon impact and flexes in the follow through.

Brooke (1924cited in DeFranca and Levine1996) stated that there is contralateral lateral flexion of the sacrum during lumbar spine rotation. The Gillet test (Gillet and Liekens 1968) measures motion occurring similar to that during the instep kick. During the step-up to the kick itself, the hip flexion of the supporting limb will be flexed while the kicking limb will be in the position of sacroiliac joint extension. Gillet and Liekens (1968) indirectly alluded to the importance of the support limb to the kick, thereby associating both the support and non-support limb to all stages of the instep kick. Thus it is essential to compare contralateral hip ROM to ipsilateral hip ROM.

Janse (1978) speaks about ipsilateral sacral nutation and contralateral sacral counter nutation from a seated to a standing position, as cited in DeFranca and Levine (1996). During the sacral motion, the iliac crests move antero-laterally and postero-medially, while being examined in a seated position (Gillet and Liekens 1968 cited in DeFranca and Levine, 1996). This shows the importance of both the ipsilateral and contralateral joints during movement of the lumbo-pelvic region. As both sacroiliac joints are mobile structures, there will be an effect on the overall motion of the lumbo-pelvic region, whether it is the supporting or kicking side.

There are a number of forces acting on the different parts of the lower limb during the three stages of the instep kick. These forces increase at the pelvis which then follows through to the hip, then onto the knee, and finally decreases at the foot (Luhtanen 1988). According to Luhtanen (1988) the muscular forces surrounding the hip and thigh, as well as the consecutive summation of forces, are responsible for the final foot velocity. This increase in foot velocity will affect the kick velocity. Luhtanen (1988) further explains that for a high ball velocity to be achieved, the foot velocity before impact on the ball should have a high velocity. The foot velocity is the final aspect that would determine the ball velocity and occurs as a result of the linear velocity of the knee and the angular velocity of the shank.

Young *et al*. (2004) mentioned that the ROM of the hip will affect the foot velocity. This has been observed by Lees and Nolan (1998) in their research involving soccer players where they studied forces acting upon the hip and thigh. They conclude that in order to achieve a high kicking velocity, both the muscular forces of the hip and thigh and the ROM of the hip are important in the outcome of kicking velocity.

The Gluteus Maximus and Medius are two important muscles that stabilise and maintain pelvic posture during the one-legged stance. The Gluteus Medius also maintains an equal levelled pelvis during the same stance (DeFranca and Levine 1996). Thus DeFranca and Levine (1996) were able to indirectly show the importance of the support limb during a one-legged stance.

Vleeming *et al.* (2012) mentions the kinematic chain of joints present in the lumbo-pelvic-lower limb region and the close link that they have towards each other. It is proposed by DeFranca and Levine (1996) that biomechanical stressors can spread up or down along the kinematic chain. It is normal for ground reaction forces from the ankle to travel upwards reaching the sacroiliac joint. Since the normal functioning of the biomechanics of the support limb has been proven to be as important as the kicking limb during the instep kick, DeFranca and Levine (1996) state that a restricted ipsilateral joint may have an effect on the contralateral joint. This would further decrease the performance of the athlete from the contralateral side as well. Therefore it is essential for the Chiropractor to view the contralateral side as equal in importance to the ipsilateral side.

Similarly to the kinematic chain, Sandoz (1981) describes the motion of the ilium between the side of the flexed thigh, the sacrum in the center and the ilium of the support limb as a chain type movement, i.e. when the bone reaches the end of its motion, it pulls along the next one. During the Gillet leg raising test, the sacrum is nutated on the side of the flexed thigh and the weight-bearing side is counter-nutated. The support limb acts as a base for the pivoting motion of the pelvis during hip extension and flexion of the kicking limb. It is established that at any time during the running cycle and the instep kick, there will always be one side taking the role of the support or kicking limb. During further thigh flexion of the kicking limb, Sandoz (1981) states that the pelvis rotates posteriorly on the support limb at the hip joint, thus using it as a base for the pivoting motion of the pelvis. This clearly demonstrates the importance of the support limb during the instep kick.

DeFranca and Levine (1996) state that a sacroiliac joint restriction may occur if pubic symphysis restriction exists. Hip adductor strain may cause pubic symphysis restriction which will cause sacroiliac joint restriction which moves the sacrum anteriorly into the pelvis. This restriction can be present contralaterally, ipsilaterally or bilaterally. Either way, a restriction on the contralateral or ipsilateral side may affect the kicking velocity. Therefore this study aims to observe the effect of manipulation on the contralateral and ipsilateral sides on hip ROM and kicking velocity.

As is normal during the one-legged stance, the hip abductor muscles of the contralateral limb are contracted when the ipsilateral limb is raised, to prevent the contralateral pelvis

from tilting. Hip muscle weakness affecting the normal balancing strategy of the support limb mechanism may affect the kicking velocity. In most instances during the game, soccer players are almost always performing a single-legged stance. The weight-bearing femur exerts a force on the pubic symphysis. Should there be a pubic symphysis restriction, a rotation of the ipsilateral pelvis is observed. These forces are then conveyed to the sacroiliac joint (DeFranca and Levine 1996). The end result could be a sacroiliac joint restriction. Hence during the soccer instep kick the optimum performance of the support limb biomechanics is essential to a high kicking velocity, due to it being used as a pivot.

DeFranca and Levine (1996) stated that lifting of objects may generate large forces at the hip muscles and low back region. The pelvis is the linking structure between the two structures. Due to the close links between the musculo-skeletal systems in the lumbar spine, pelvis and hip joint, any restriction in any of the three regions may affect hip ROM and kicking velocity. The sacroiliac joint function is to dampen torsional movements of the pelvis to spare the lumbar spine from compensatory motions. Illi (1951 as cited in DeFranca and Levine 1996) and Muscolino (2012) state that in an ipsilateral sacroiliac joint restriction a compensatory contralateral connection occurs in the lumbar spine. A scoliotic deformity or hyperlordosis may occur as compensation due to a problem on the opposite side of a different region to the lumbar spine i.e. the sacroiliac or hip joint and its surrounding musculature. Thus the effect of manipulation on an ipsilateral sacroiliac joint can decrease compensatory mechanisms contralaterally. Therefore it is important to assess the lumbopelvic region in young soccer players to prevent future lumbar spine problems. This would also be necessary to assess as the combined lumbar spine and sacroiliaic joint manipulation group in Deutschmann’s (2011) study showed the highest improvements for kicking velocity. So if pelvic restriction can affect the lumbar spine, which will affect ROM and kicking velocity, then surely this study needs to show the effect of ipsilateral versus contralateral sacroiliac joint manipulation on ROM and kicking velocity.

This may also show that correcting a pelvic restriction may prevent lumbar spine restrictions, serving as an indirect preventative strategy. This further stresses the need to assess the effects of ipsilateral versus contralateral sacroiliac joint manipulation on hip ROM and kicking velocity in asymptomatic players. As this shows that no part of the locomotor system functions without affecting parts elsewhere, ipsilateral restriction may affect the contralateral side and vice versa (DeFranca and Levine 1996; Cibulka 2013). DeFranca and Levine (1996) mention as a clinical consideration that pelvic joint restrictions can affect the entire locomotor system. They describe a simple example of a person’s foot being trampled on and resultant bilateral pupillary dilatory reaction. It can be concluded that the nervous system and the locomotor system have an intimate relationship and the sides are closely linked to

each other i.e. ipsilateral versus contralateral. Ipsilateral hip joint restriction is associated with sacroiliac joint disturbances (DeFranca and Levine 1996). In viewing this link in a soccer kick, if there is a support leg sacroiliac joint restriction then this would affect the kicking velocity of the soccer player.

2.4 ANATOMY OF THE HIP JOINT

The hip joint is a ball and socket type of synovial joint where the head of the femur articulates with the acetabulum of the sacrum. Strength and stability are the key components of the hip joint. The articular surface ensures that the hip joint can withstand large weight-bearing loads. The acetabula labrum functions to create stability between the femoral head and the acetabulum. The joint capsule holds the femoral head in the acetabulum, thus increasing the strength of the hip joint (Moore 1992).

2.4.1 Hip Joint Ligaments

The following ligaments will be discussed in relation to their function (Moore 1992):

Iliofemoral ligament- This is a strong ligament that is tense on full extension of the hip. This occurs to prevent over-extension of the hip joint while maintaining its integrity.

Pubofemoral ligament- The inferior and anterior parts of the capsule are strengthened by this ligament. This ligament helps to prevent over-abduction of the hip joint by increasing its tension during hip extension and abduction.

Ischiofemoral ligament- Prevents hyperextension of the hip while holding the femoral head in the acetabulum.

Ligament of the head of the femur- This is a weak ligament hence it does not have a role in strengthening the hip joint.

2.4.2 Movements of the Hip Joint

Flexibility in an individual is described by Amiri-Khorasani (2011) as the full unrestricted, pain free ROM, in a single joint or a series of joints and the extent of motion within a joint is measured in degrees of a circle. Amiri-Khorasani (2011) also states that gender, age,

hypertonic muscles, ligaments and tendons may affect flexibility and joint ROM. Normal ROM is vital in all structures involved in the instep soccer kick due to flexibility and joint ROM being an important aspect in soccer performance as well as prevention of soccer injuries (Amiri-Khorasani 2011; Young *et al*. 2004). The structures involved are the lumbar spine, sacroiliac, hip, knee and ankle joints as well as all the muscular, ligamentous and fascia components. Roaas and Andersson (1982) measured 210 hips and found the normal passive hip ROM to be the following: flexion = 90 – 150 degrees (mean 120°), extension = 0 – 35 degrees (mean 9.5°), internal rotation = 20 – 50 degrees (mean 32.5°), external rotation = 10 – 55 degrees (mean 33.6°). Roach and Miles (1991) measured active hip ROM of 35 men and found the following mean values: flexion = 115°, extension = 19°, internal rotation = 32°, external rotation = 32°.

According to Magee (2002) the normal hip ROM is as follows:
Flexion = 110 –120 degrees
Extension = 10 –15 degrees
Internal Rotation = 30 –40 degrees
External rotation = 40 –60 degrees

2.5 BONY ANATOMY OF THE SACROILIAC JOINT

The sacrum is positioned at the base of the spinal column and consists of five sacral segments fused together. The two ilium bones of the pelvis are on either side of the sacrum forming the strong weight-bearing sacroiliac joint bilaterally. This serves like a “keystone” which holds structures around it together and also transmits forces from the upper body to the lower limbs via the pelvis (DeFranca and Levine 1996) and vice versa. Similarly, the ground reaction forces acting upon the lower limbs travel upward through to the pelvis. The sacroiliac joint is a true diarthrodial joint and is bicondylar by virtue of the fact that the left and right sacroiliac joints work in unison and synchronisation so much so that if the left joint moves there will be an equal and co-ordinated movement of the right joint. (Vleeming *et al.* 2012; Forst *et al.* 2006; Cibulka *et al.* 1988; Cibulka 2013).

The sacroiliac joint has matching articular surfaces with the joint space filled with synovial fluid and covered with a fibrous capsule on the anterior two thirds (Forst *et al.* 2006). The organisation of the sacroiliac ligaments provides the joint with much-needed support in the absence of the posterior capsule (Moore 1992). The articular surfaces of the ilium and sacrum are covered by fibro and hyaline cartilage respectively. The articular surfaces are rigid and have depressions that minimise movement and enhance stability. The limited

movements in the sacroiliac joint with supporting ligamentous structures contribute to the stability and strength of the sacroiliac joint.

The sacroiliac joint receives its primary stability from the strong meshwork of sacroiliac joint ligaments but also relies on the surrounding musculature which affects range of motion and stability (Forst *et al*.2006). The Lattisimus Dorsi by way of the thoracolumbar fascia, the Gluteus Maximus, and the Piriformis are closely linked to the sacroiliac and the hip joint (Vleeming *et al*. 2012).

2.5.1 Sacroiliac Joint Ligaments

The following sacroiliac ligaments will be discussed in relation to their function:

Anterior SI Ligament- This ligament opposes translation of the sacrum upwards or downwards and prevents separation of the joint surfaces. (Harrison, Harrison and Troyanovich 1997)

Posterior SI Ligament- This serves to protect the sacroiliac joint from violent trauma (Hendler *et al*.1995).

Interosseous SI Ligament- Resists sacroiliac joint separation and translation (Harrison, Harrison and Troyanovich 1997).

Iliolumbar ligament- Restricts motion at the lumbosacral junction and prevents ilia separation from the sacrum (Vleeming *et al*. 2012).

Sacrotuberous ligament- Prevents sacral rotation and assists with stabilisation of the sacroiliac joint (Vleeming *et al*. 2012).

Sacrospinous ligament-Also prevents sacral rotation and is strongly connected to the gluteus maximus muscle (Vleeming *et al*. 2012).

Although this ligamentous meshwork creates a very stable joint, there is evidence that muscular contractions may cause sacroiliac joint restrictions due to the close relationship of the muscles to the ligaments (Bernard and Cassidy 1997; Forst *et al*. 2006; Harrison *et al*. 1997 and Vleeming *et al*.2012). Mechanoreceptors present in the ligaments transmit

information to and from the CNS. Therefore manipulation to this joint can be effective to help with pain and joint restrictions.

2.6 MUSCLES AND INNERVATION OF THE SACROILIAC AND HIP JOINT

The muscles of the thoracolumbar spine and the hip joint interconnect with the ligamentous network of the sacroiliac joint bringing about motion (Bernard and Cassidy 1997;Forst *et al*. 2006). Harrison *et al*. (1997) and Vleeming *et al*. *(*2012) concur with this and state that the main muscles around the sacroiliac joint which have connections to the thoracolumbar fascia are the Quadratus Lumborum, Erector Spinae, Glutueals, Piriformis, Iliacus and Latissimus Dorsi.

The muscles of the hip are outlined as follows, with the muscles that connect to the sacroiliac joint which are in bold (Moore 1992):

Table 2.1: Muscles of the Hip

MOVEMENT	**MUSCLE**	**INNERVATION**
Flexion	**Iliopsoas**, Rectus Femoris and Tensa Fascia Lata	L1-S1
Extension	**Gluteus Maximus** and **Biceps Femoris**	L5-S2
Internal rotation	Tensa Fascia Lata, **Gluteus Medius and Minimus**	L4-S1
External rotation	Obturator Internus and Externus, Gemelli, QuadratusFemoris and **Piriformis**	L3-S2

From the above table one observes the close relationship between the hip muscles and the sacroiliac joint. It is also important to note that the hip muscles fall into the same motor neuron pool as the sensory innervation of the sacroiliac joint (Forst *et al*.2006).There are many studies (Ikeda 1991; Bradley 1974; Grob *et al*.1995; Williard *et al*. 1998; McGrath and Zhang 2005) as cited by Cohen (2005) that state the innervation of the sacroiliac joint viz; ventral lumbopelvic rami, posterior rami L5 to S3, posterior rami S1 to S4, small branches from a communicating branch of L5 and S1-S2 going into the joint and sacral plexus S2 to S4. Hip innervation stems from lumbosacral plexis L2-S1 which is the same nerve supply as thesacroiliac joint (Moore 1992).Thus any restrictions in the sacroiliac joint may cause a reflex inhibition of the hip muscles causing a decrease in hip range of motion and kicking velocity.

2.7 CHIROPRACTIC MANIPULATION

Manipulation is a high velocity low amplitude thrust that imparts mobility to joints. It is usually followed by an audible clicking sound. The restricted joint that requires manipulation has various terms used interchangeably with subluxation, namely: joint dysfunction, joint restriction, joint fixation, joint lesion, joint blockage or segmental dyskinesia. Manipulation would increase joint mobility and flexibility (Gatterman 2003). The post-manipulation effects were also recorded by Pickar (2002) with a change in sensory and neurological outputs and an improvement of the physiological function. DeFranca and Levine (1996) state that assessment of the restricted joint is needed, as manipulation's prime objective is to bring about joint movement and relaxation of hypertonic muscles.

A noticeable decrease in regional and inter-segmental ROM can be found when a lesion is present, thus assessment is needed of lumbo-pelvic, pelvic-hip, inter-segmental facet joints, sacroiliac joint and hip regions. The manipulable lesion has no joint play and is termed joint restriction (DeFranca and Levine 1996). Muscle spasm and muscle balances are also characteristics of a manipulable lesion. Sandoz (1976) characterises total joint ROM into active, passive and paraphysiological zones. Manipulation targets the paraphysiological zone because no interventions, e.g. exercise which affects the active zone or mobilisation which affects the passive zone, can target the paraphysiological zone in the way that manipulation can. Joint play, according to Mennell (1960 cited in DeFranca and Levine 1996), cannot be adjusted back to normal by performing exercise, as exercise is voluntary and joint play is involuntary.

DeFranca and Levine (1996) state that passive stretching does not affect the paraphysiological zone. In keeping with this, Mennell (1960 cited in DeFranca and Levine 1996) relates that exercise could delay restricted joint healing if lack of joint play motion is not addressed by manipulation. Should a restricted joint be exercised early in treatment then this can cause reflex muscle reactions.

The events at the paraphysiological zone during a manipulation were summarised by Sandoz (1976) as the following: a sudden separation of joint surfaces, an audible cracking sound and the appearance of a radiolucent space.

Aside from the mechanical benefits, Pickar (2002) related the beneficial neurophysiological reflex responses post-manipulation. As mentioned previously, sacroiliac joint manipulation often has an effect at distant sites away from the primary treatment site. This occurs due to

the linking pathways of the nervous system, thus manipulation will not only restore ROM but it also re-establishes functional biomechanics of the locomotor system whilst simultaneously stimulating the nervous system (DeFranca and Levine 1996).

In theory, restricted joints and soft tissues send an abnormal message (afferent impulse) via the nervous system which activates reflex mechanisms, such as causing muscle inhibition and reduction in hip ROM. A manipulation on a restricted joint will do two things: reduce abnormal message input and stimulate the joint mechanoreceptors, thus normalising neurological input. Furthermore, there would be no inhibitory reflexogenic effects.

Deutschmann (2011) performed a study to observe the effect of lumbar and sacroiliac joint manipulation on ROM and kicking speed in soccer players. Four groups of ten soccer players were selected and asked to perform an instep soccer kick, whereby measurements were taken pre- and post-intervention. Group one received lumbar spine manipulation, group two received sacroiliac joint manipulation, group three received combined lumbar and sacroiliac joint manipulation, and group four received a sham laser intervention. The results of the study portrayed a significant increase in ROM of the lumbar and sacroiliac joint, as well as an increase in the kicking speed of the soccer players in all three groups i.e. group one, two and three. This study did not include the assessment of the hip ROM. Research has shown that manipulation of the sacroiliac joint increases hip ROM (Bisset 2003; Turner2005), thus this study aims to observe the effect of ipsilateral and contralateral manipulation on bilateral hip ROM.

A study of the efficacy of sacroiliac joint manipulation on hip ROM in sixty patients with sacroiliac syndrome was conducted by Bisset (2003). These patients were in one group and had decreased hip ROM and/or an asymmetrical hip ROM. Sacroiliac joint manipulations were carried out on the involved side, and measurements were taken of both hips with a goniometer and an inclinometer, ten minutes after manipulation and one week thereafter. The results showed a statistically significant increase in hip internal rotation (both active and passive ROM) and no statistical significance in hip external ROM on the involved side.
Bisset (2003) also noted an increase in hip internal and external ROM with no statistical significance after manipulation on the opposite uninvolved site (i.e. the side which was not manipulated). This suggests that the sacroiliac manipulation on the involved side could have a biomechanical effect on the contralateral uninvolved side.

Turner (2005) conducted a clinical trial on the immediate efficacy of sacroiliac manipulation on the hip joint. Participants in this study comprised of sixty patients with sacroiliac syndrome. These sixty patients were randomly allocated to the two groups, one receiving

the sacroiliac manipulation while the other was used as a control. The results showed a significant increase in the hip ranges of motion, although it was not sustained. This is in contrast to Bisset's (2003) study, where the increased hip ranges of motion were sustained for one week. Hence this research will attempt to readdress the notion that a manipulation of the sacroiliac joint could have an effect ipsilaterally and or contralaterally.

In a review article showing the neurophysiological effects of spinal manipulation, Pickar (2002) commented on the improvement of muscle strength post- chiropractic spinal manipulation. A study conducted by Suter *et al*. (2000) on patients with sacroiliac joint restriction and motor inhibition of knee extensor muscles showed a decrease in knee extensor muscle inhibition after sacroiliac joint manipulation of the involved (ipsilateral) side. Suter *et al*. (2000) observed muscle inhibition to be present in both legs but only found the effect of the manipulation in decreasing muscle inhibition on the involved side (i.e. ipsilaterally) with no effect contralaterally.

Lewis (2005) performed a clinical trial on the immediate effects of lumbar spine and sacroiliac joint manipulations on quadriceps and hamstring torque ratios in the contralateral limb. These patients had mechanical low back pain with bilateral arthrogenic muscle inhibition. Fifty-nine patients were randomly assigned to two groups, i.e. the treatment and control group. The peak muscle torque ratios of the quadriceps and hamstrings were measured using the CybexOrthotron Isokinetic Rehabilitation System pre- and post-intervention. The intervention was performed on the most symptomatic side. The results of the study showed a significant increase of the ipsilateral and contralateral hamstring torque ratios. This could suggest that spinal manipulation may have a positive biomechanical effect on the contralateral side as well.Hillerman *et al.*(2006) showed the efficacy of sacroiliac joint manipulation on twenty patients with arthrogenic muscle inhibition. Thereafter, muscle torque was tested using the CybexOrthotron II Isokinetic Rehabilitation System. The results showed a significant increase in quadriceps muscle torque in the group that received the sacroiliac manipulation.

Soccer training has been shown to immediately decrease flexibility in players during training, up to 24 hours after training, and this reduced ROM progressively decreases over time (Moller, Oberg and Gillquist 1985 cited in Bradley and Portas 2007). Thus players could be susceptible to a sacroiliac joint restriction. The implications of this would be less motor unit recruitment, which is what happens in muscle inhibition. This muscle inhibition could decrease peak muscle torque. In turn, the kicking velocity of the player would be decreased.

Muscles involved in the kicking action are the quadriceps and hamstring muscles, which are innervated by the femoral and sciatic nerves respectively. The motor nerve supply of the quadriceps and hamstring muscles falls into the same motor neuron pool as the sensory nerve supply of the sacroiliac joint and lumbar facet joints of L2-5 (Lewis 2005). Suter *et al*. (2000) stated that spinal manipulation affects lower limb muscles due to stimulation of mechanoreceptors which affects afferent impulses.

2.8 RELEVANT NEUROANATOMY

The mechanoreceptors and spinal pathways transmit information to and from the CNS and PNS. The two ascending pathways, the dorsal column-medial lemniscal and the antero-lateral system, transmit sensory information from the body via the dorsal roots of the spinal nerves (Guyton and Hall 1997).

2.8.1 Mechanoreceptors

There are five different types of receptors in the human body, of which this study is influenced to a greater degree by one type i.e. the mechanoreceptors. The main function of the mechanoreceptors is to detect mechanical deformation of the receptor or of the adjacent tissues surrounding the receptors (Guyton and Hall 1997).

There are a number of authors who have investigated the presence of mechanoreceptors within joints and ligaments in animals, such as Freeman and Wyke(1964),Wyke(1967), Sakamoto *et al.*(2001), with studies in humans by authors such as Michelson and Hutchins (1995). Sakamoto *et al.* (2001) and Vilensky *et al.* (2002) observed mechanoreceptors present in the sacroiliac joint which would transmit proprioceptive and nociceptive information to the CNS. Moraes *et al. (*2011) investigated mechanoreceptors in the hip joint and found mechanoreceptors to be present in the capsule, labrum and femoral head ligament. Moraes *et al.*(2011) concurred with the morphological findings of Wyke (1967). The following is a functional description of the mechanoreceptors as classified by Wyke (1967):

- **Type I**– are stimulated by active or passive joint motion. There is sensitivity to movement due to its low threshold and slow adaptive capabilities. Constant firing (transmission of information) even at rest enables this receptor to provide the CNS with postural information (Michelson and Hutchins 1995).

- **Type II**– are stimulated by minor changes and are dynamic with rapid adaptation, also low threshold. The beginning of motion is thought to be sensed by this receptor (Michelson and Hutchins 1995).
- **Type III**– are dynamic type receptors with high threshold and slow adaptation. Type III provides sensations of extreme movements (Michelson and Hutchins 1995).
- **Type IV**–are free nerve endings and convey nociceptive sensation.

Michelson and Hutchins (1995) found abundant Type I and II receptors in human ankle ligaments. This is in contrast to Wyke (1967), who found type I and II receptors predominantly in the joint capsules and minimal, if any, in the ligaments. The type II receptors which are present in the ligaments suggest that at the beginning of movement the human ankle is affected by large stressors which are dissipated by the ligaments. The end range of motion is detected by type III receptors which presumably act as 'informers' to the CNS, warning of any extreme movement.

As mentioned previously, ligaments do not only function as bearers of structural integrity but also as an importantly dynamic structure serving as a communication outpost within structures with its secondary objective of relaying information. Thus a sacroiliac joint restriction will relay abnormal afferent information to the CNS which, according to Hopkins and Ingersoll (2000), is a causative factor for AMI. This muscle inhibition will further decrease kicking velocity of the soccer player.

2.8.2 Neural Circuitry

The receptors above are sensory endings to sensory afferent nerve fibres. This is where communication starts and ends for the soccer kick to occur. The player kicks the ball: the receptors are then stimulated, depolarising the membrane potential to produce an action potential. The dendrite is like a bridge carrying the action potential via the sensory neuron to the dorsal root ganglion close to the spinal cord, reaching the cell body. The cell body in turn communicates with different neurons (Shireen 2004).

This synapse ends at two points: 1) grey matter in the spinal cord producing a reflex response; and 2) in the brainstem. Axons, dendrites and nerve cells are situated in the grey matter with vertically running myelinated and unmyelinated axonal tracts situated in the white matter (Shireen 2004). Shireen (2004) further states that there is a large quantity of

nerves and grey matter present in the lumbosacral spine due to the innervation needs of the large muscle bulk in the lower limbs.

The reflex arc is a simplistic depiction of a neuronal pathway. Shireen (2004) explained the pathway of information flow from a sensory neuron to the spinal cord via an interneuron, back via the motor neuron to its end organ. The afferent impulses travel from the end organ via the type Ia spindle fibers and make precise excitatory connections with the alpha motor neurons in the spine (Prasad and Weiner 2011).

Protective reflexes aid to prevent joint injury by virtue of mechanoreceptor activity which regulates muscle length or tension. Joint proprioceptive mediated response on the alpha-motor-neuron outflow, controls muscle contractility.

2.8.3 Interneuron

Interneurons serve as intermediary messengers between alpha and gamma motorneurons. They function by linking the incoming afferent and outgoing efferent responses, as well as other interneurons. Interneurons are central whereby inhibitory or excitatory motor neuron pool responses are manifested at this neuron. Hopkins and Ingersoll (2000) classified two types of interneurons viz: type Ia inhibitory and type Ib inhibitory or excitatory interneurons.

Prasad and Weiner (2011) state that the proprioceptive afferents make specific monosynaptic connections with motor neurons supplying the same muscles and avoid any connections to motor neuron pool supplying the antagonistic muscles. This is in allowance for co-ordinated muscle movement for which the ventral interneuron is responsible. The ventral interneuron receives collateral branches from type Ia fibers to antagonistic muscles.
Therefore ligaments are not only present for structural integrity, but also serve to provide proprioceptive feedback to the CNS and for control of muscle tone and articular reflexes.

2.8.4 Motor Neurons and Motor Neuron Pool

Darby and Daly (1995) classified two motor neurons according to their diameter. The alpha motor neuron is larger than the gamma motor neuron. Motor neurons function as muscle contraction regulators. Alpha motor neurons innervate extrafusal fibers in skeletal muscles and are fastest in conduction. The gamma motor neurons supply the intrafusal fibers and are slower in conduction. The alpha and gamma motor neurons combined form a motor neuron

pool. The muscle fibres innervated by the motor neuron pool are known as the motor unit (Darby and Daley 1995; Iyer, Mitz and Winstein 1999).

The spinal cord serves as a reflex centre, so too does the interneuron serve as an integration centre. There are many ascending and descending pathways that carry sensory and motor information to and from the spinal cord. A sacroiliac joint restriction may cause a reflex change and may affect the hip muscles, as the two joints share the same motor neuron pool.

As previously mentioned, the inhibitory interneurons regulate the afferent innervation of the motor neuron pool. If a sacroiliac joint restriction is present in a soccer player the efferent innervation to muscle fibres will be reduced causing AMI. Since interneurons receive information from supra spinal structures i.e. from the corticospinal, rubrospinal, vestibulospinal tracts and renshaw cells, the net effect of interneurons is either inhibitory or excitatory on the motor neuron pool (Jankowski and Edgly 2006).

2.8.5 Ascending and Descending Pathways

It is important to understand that impulses are transmitted from the mechanoreceptors by ascending spinal pathways and back down to the target organ by the descending pathways. A brief discussion of the neuronal pathways follows below.

2.8.5.1 Ascending Spinal Pathways

In the ascending dorsal medial lemniscal system, the grey matter in the dorsal horn comprises of ten laminae. Sensory input discharges at the various types of laminae. Type A-delta sensory nerve fibres terminate on lamina I, IV, V and VI. Type C fibres discharge on lamina II. Some type A-beta sensory nerves end on laminae II, III, IV, V and VI (Darby and Daley 1995), in contrast to Guyton and Hall (1997) who mention type A-beta fibres pass through the dorsal horn and terminate on the gracile and cuneate nuclei of the dorsal column in the medulla oblongata.

The ascending fibers of the dorsal column pathway makes its way to the medulla continuing via the medial lemniscus to the posterolateral nucleus of the thalamus ending at the cerebral cortex (Hopkins and Ingersoll 2000; Guyton and Hall 1997). Shireen (2004) explains a typical ascending pathway as a three-neuron set;

1) The first order neuron: sensation travels along the sensory afferent fibres to the dorsal root ganglion of the spinal nerve outside the spinal cord.
2) From the first order neuron, through the axon and up the cord towards the brainstem and into the medulla oblangata where it finally synapses with the second order neuron.
3) Crossing over occurs at this level and ascension into the thalamus where synapse with a third order neuron occurs carrying the impulse to the cerebral cortex.

2.8.5.2 Descending Spinal Pathways

The descending corticospinal tract controls voluntary and involuntary muscle control in the contralateral limb. Axons arise in the cortex, with 90% crossing over at the medulla oblongata ending in the spinal cord; 8% cross over at lower levels in the spinal cord (Shireen 2004).The corticospinal tract synapses with the alpha and gamma motor neurons thus carry motor information towards the motor neurons. The signal for controlling muscle force contraction originates in the corticospinal tract. The majority of neurons have a facilitatory function. There have also been observations of an inhibitory function. The vestibulospinal tract relays information from the lateral vestibular nucleus of the fourth ventricle to the motor and inter-neurons. This tract enables maintenance of upright body posture. These vestibulospinal neurons communicate with inhibitory neurons. The rubrospinal works closely with the corticospinal tract to bring about distal muscle control. It has also been associated with interneuron inhibition.

2.9 ARTHROGENIC MUSCLE INHIBITION

A reflex inhibition of the muscles surrounding a joint occurs after joint injury, which is known as arthrogenic muscle inhibition (AMI). Suter *et al*. (2000) explained the inability of a muscle to recruit all motor units during AMI. An inhibited muscle may cause immobilisation and decreased ROM. This stimulates the inhibitory inter-neuronal pathways in turn initiating AMI (Hopkins and Ingersoll 2000: Hart *et al.* 2010: Rice and McNair 2010).

In keeping with the explanation of Suter *et al*. (2000) and Lewis (2005), Hillerman *et al*. (2006) discussed how muscle inhibition occurs. The origination of the motor neuron pool supplying the quadriceps muscle is the same as for the sacroiliac joint, which is L2-4. At the sacroiliac joint the afferent mechanoreceptor activity is altered, which causes muscle inhibition in the quadriceps muscle. Suter *et al*. (2000) stated that clinical observations suggested anterior knee pain to be associated with sacroiliac joint restriction.

Joint receptors act as informers, communicating between the central nervous system (CNS) and the peripheral nervous system (PNS). Joint proprioception and nociceptive information are relayed via the spinal pathways in order for an appropriate muscle response for joint stability and mobility. Joint receptors are present in joint capsules and ligaments (Rice and McNair 2010). There are four types of joint receptors as classified by Wyke (1967): Type I, II, and III are encapsulated mechanoreceptors and Type IV are free nerve endings.

Sakamoto *et al*. (2001) and Vilensky *et al*. (2002) observed mechanoreceptors present in the sacroiliac joint which might transmit proprioceptive and nociceptive information to the CNS. AMI is thought to primarily occur due to the activity of the joint mechanoreceptors. Damaged or distended joint structures stimulate the activity of the mechanoreceptors at the joint and the inhibitory interneurons in the spine, thus promoting AMI and decreasing motor neuron pool recruitment ability. The maximum muscle force contraction initiated by the motor neuron pool is reduced (Palmieri *et al*. 2003).Since AMI may cause reduced muscle torque which may in turn decrease hip ROM and further decrease kicking velocity. Consideration needs to be given to both legs of the soccer player.

2.9.1 Ipsilateral Versus Contralateral Spinal Pathways

Conventionally, the corticospinal tract is known to be a crossed pathway and thus any lesion in this pathway will cause contralateral impairment in movement, as in the example of a stroke patient. It is observed that ipsilateral impairments exist as well (Yelnik *et al.* (2006); Marque et al. (1997); Kim *et al.* (2003) and Yarosh *et al.* 2004 in Jankowski and Edgly 2006). Jankowski and Edgly (2006) state that this may indicate a contribution of ipsilateral movement by corticospinal neurons. This activity could relate to many aspects of altered function, one of which may be that the corticospinal system may also mediate commands ipsilaterally. In neuroanatomical studies the contralateral spinal projections of the corticospinal tracts are mentioned due to inadequate studies on the more difficult to analyse poly synaptic ipsilateral corticospinal projections.

Neuronal networks operate bilaterally as stated by Jankowski and Edgly (2006), who relate how neurons interconnect at both sides of the grey matter in the brainstem and spinal levels. Thus the ipsilateral nervous system does communicate with the contralateral side. Therefore this study is based on the idea that there is possible bilateral afferent input and efferent output from the ascending and descending tracts via the spinal cord.

2.9.2 AMI in the Contralateral Limb

An ipsilateral joint restriction may alter biomechanical properties of neuro-muscular-skeletal structures on the ipsilateral or contralateral side or both. Neurogenic reflex impulses from the unilateral side can spread via crossed spinal pathways to the contralateral side (Suter *et al*.2000). Joint afferent information has excitatory effects on the central nervous system, thus efferent information from spinal and supra spinal pathways may inhibit bilateral quadriceps muscles (Rice and McNair 2010). The aforementioned authors state that AMI is present in the contralateral limb but to a lesser degree when compared to the injured limb. The results of Rice and McNair (2010) differed from the Palmiere *et al.* (2003) study on AMI. Palmiere *et al*. (2003) performed simulated ipsilateral knee effusion and showed that there was no AMI in the contralateral non-affected knee.

Chiropractic research has shown that manipulation has beneficial results with regards to increasing ROM in both the lumbar and sacroiliac segments (Deutschmann 2011; Herzog 2000; Bisset 2003; Gatterman 2003; Turner 2005).Therefore the mechanical effect and the neurological output after a sacroiliac joint manipulation could increase hip joint ROM (Gatterman 2003) and increase kicking velocity (Pickar 2002) in soccer players, respectively. There is no literature to date, however, that determines the immediate effect of contralateral sacroiliac joint manipulation and its effect on hip ROM and kicking velocity.

2.10 ERGOGENECITY

Ergogenic is defined as the tendency to increase work and is used in sport to describe methods used to improve energy production or sport performance (Thein *et al.* 1995). There are four classes of ergogenic aid as mentioned by Thein *et al.* (1995): nutritional, pharmacological, physiological, or psychological. Some ergogenic aids are acceptable e.g. carbohydrate loading, whereas some are illegal such as anabolic androgenic steroids. There is an alternative method to achieve ergogenic aid with no side effects (Sandell, Palmgren and Bjorndahl 2008).

Lauro and Mouch (1991) made the following statement, “What research has not conjectured is spinal manipulation to correct spinal joint dysfunction or subluxation on the well or asymptomatic athlete and the effect of this manipulation on athletic performance.”

The player perceives himself/herself to be asymptomatic because he/she is pain free and thus does not take a restricted joint into consideration. This could mean that the player, in

spite of been healthy, is not performing at his/her optimum level. Therefore these players may use Chiropractic care to achieve their optimum performance and this is termed the ergogenic effect (Sandell, Palmgren and Bjorndahl 2008).

Sandell, Palmgren and Bjorndahl (2008) investigated the improvement of function and performance in asymptomatic participants through the application of manipulation. He termed this performance-enhancement in athletes as the ergogenic effect. Sandell, Palmgren and Bjorndahl (2008) pointed out that only two studies were performed on ergogenic effects of manipulation. Sandell, Palmgren and Bjorndahl (2008) performed a randomised controlled trial on seventeen middle distance runners. He measured the effect of manipulation on hip extension ability and running speed in athletes and showed an improvement of hip extension ability after manipulation. The results also indicated an improvement in time taken to complete a 30m run up, but this result did not meet the criteria for statistical significance.

Lauro and Mouch (1991) performed a study to observe a change in athletic ability after chiropractic care. The results of the study showed an increase in athletic ability of 10.57% in the experimental group after six weeks of Chiropractic care. This value further increased to 16.7% after an additional six weeks of care. The control group depicted a result of 4.5% after only being in this study for six weeks. This shows the large percentage difference between the experimental and control group. This also supports the role of Chiropractic care in athletic performance.

Kilding, Tunstall and Kuzmic (2008) stated the likelihood of leg power being associated with the improvement of athletic performance with regards to jumping and sprinting abilities. They also highlighted that leg power may reduce the risk of injury in the lower limb (Chandy and Grana 1985 cited in Kilding, Tunstall and Kuzmic 2008). There is a strong association between manipulation and improved muscle torque (Hillerman *et al.* 2006). Hillerman *et al.* (2006) performed a study to test Quadriceps Femoris muscle torque after-manipulation of the sacroiliac joint and found an increase in the Quadriceps Femoris muscle torque. Improving athletic performance by manipulation shows an increase in muscle torque which may also improve kicking velocity.

Thus, if Chiropractic treatment could improve muscle torque and ROM (Sandell, Palmgren and Bjorndah l2008; Hillerman *et al.* 2006; Herzog 2000; Gatterman 2003), it stands to reason that a manipulation of the sacroiliac joint could in turn enhance the kicking velocity of soccer players. There are other studies in support of this (Deutschmann 2011; Rebelo 2011)

but no study has considered the effects of manipulation on the contralateral sacroiliac joint on hip ROM and kicking velocity. Therefore this study aims to look at the effect of sacroiliac joint manipulation, with consideration to the restrictions in both sacroiliac joint on the hip ROM and kicking velocity.

2.11 CONCLUSION

As discussed in the literature review, manipulation on the sacroiliac joints does have an effect on the hip range of motion. It was proposed that both contralateral and or ipsilateral sacroiliac joint manipulation could have an effect on hip range of motion and kicking velocity.

CHAPTER THREE

METHODOLOGY

3.1 STUDY DESIGN

This study was a placebo controlled investigational clinical trial.

3.2 POPULATION

The population size consisted of 60 male soccer players between the ages of 18-35. The players were from the first team university league. The players were from various ethnic backgrounds.

3.3 ADVERTISING

The coaches from the universities in the greater Durban area received **Appendix A** requesting permission to use the soccer players for the clinical trial. The coaches also received **Appendix B,** which was distributed to the players.

3.4. RECRUITMENT

The recruitment process of first team soccer players occurred from the following instituitions: Durban University of Technology (Durban campus, Midlands campus, City Campus); University of KwaZulu-Natal (Howard College Campus, Westville Campus, Edgewood campus, Pietermaritzburg campus); and Varsity college (Durban North, Westville). The recruitment of the players took place at their respective institutional training facilities.

3.5 SAMPLING

3.5.1 Sampling Method

Non-probability purposive sampling was used and the sample was divided into three groups of twenty based on their motion palpation findings. This was to ensure that there was a

sacroiliac joint restriction present in the treatment groups. The researcher motion palpated the sacroiliac joints and placed a player with a right sacroiliac joint restriction into the ipsilateral group. A player who presented with a left sacroiliac joint restriction was placed in the contralateral group. A player with no sacroiliac joint restriction was placed in the placebo group.

3.5.2 Inclusion and Exclusion Criteria

3.5.2.1 Inclusion Criteria

1. Participants were male between the ages of 18 and 35.
2. Participants played and trained with their first team university soccer squad.
3. Participants had no history of low back and lower limb surgery nor suffered from any debilitating illnesses.
4. Participants were asymptomatic with regards to low back and bilateral lower limb pain i.e. lumbar spine, sacroiliac joint, hip pain, knee pain, ankle pain.
5. A joint fixation had to be present in participants, as this may have decreased hip range of motion which may have affected kicking velocity. (Gatterman 2003; Lees and Nolan 1998).
6. Participants read and signed the Letter of Information and Informed Consent.

3.5.2.2 Exclusion Criteria

1. Any participants with contra indications to spinal manipulation were excluded from the study e.g. hypermobility of functional segmental unit, tumours or bone infections.
2. Participants with any neuromusculoskeletal conditions affecting the spine, hip, knee, ankle.

3.6 GILLET METHOD OF SACROILIAC JOINT MOTION PALPATION

According to Morgan (Bergman, Petersen and Lawrence 1993; Gillet and Liekens 1968) the following motion palpation technique was used:

The subject was seated while the researcher examined the end feel of the upper and lower sacroiliac joints and compared it to the opposite side. A hard or blocked end feel post-

palpation indicated a joint restriction in that sacroiliac joint. If any uncertainty regarding the exact location of the manipulable lesion existed, then a modification of the motion palpation procedure was used.

The procedure was as follows:

1. The subject stood holding the wall as a support.
2. The researcher stood behind the subject while placing a thumb contact on the posterior superior iliac spine (PSIS) and the other thumb contacting the second or fourth sacral tubercle (depending on the upper or lower sacroiliac joint).
3. The subject was asked to raise the ipsilateral leg to 90 degrees while flexing the hip and sacroiliac joint.
4. An approximation of the thumbs indicated normal movement where the sacrum moves postero-inferiorly relative to the sacral tubercle.
5. Failure of the thumbs to approximate indicated a flexion restriction.
6. The same procedure was carried out but the contralateral leg was raised to palpate for an extension restriction as this induced posterior nodding of the sacral base and sacroiliac extension on the side of palpation. Normal movements would be apparent if the thumbs moved apart as the PSIS moves antero-superiorly.

3.7 MEASUREMENT TOOLS

3.7.1 Digital Inclinometer

This study used the Dualer system of inclinometry (Jtech Medical industries 4314 Zevex Park lane, Salt lake city, UT 84123 USA, tel 801/264-1001).Goniometers are less accurate in measuring the larger joints of the limbs in comparison to the inclinometer (Livingston 1992). The inclinometer is more accurate than the goniometer due to its insensitivity to placement. The reliability and validity of this measuring tool has been shown in the three studies by Bisset (2003), Morgan (2005) and Turner (2005).Studies by Bisset (2003), Turner (2005) and Morgan (2005) showed that the electronic inclinometer is a reliable and valid tool to measure hip ranges of motion after sacroiliac manipulation. Ellison (as cited in Bisset 2003) has also established the intra-rater and inter-rater reliability of the electronic inclinometer. Livingstone (1992) has mentioned the increased accuracy of the electronic inclinometer as compared to the goniometer for measuring the ranges of motion of large extremities. The researcher's assistant, who was not blinded to the study, measured the hip ROM.

Range of motion measurement procedure: (Livingstone 1992; Morgan 2005)

This study used the degrees of hip range of motion from Magee (2002).

Hip flexion:

1. The player was supine, with the opposite hip flexed and locked.
2. The limb to be measured was in a neutral position, and the tester zeroed the sensor.
3. The player flexed the hip to maximum hip flexion and was asked to stop if the tester observed any movement in the pelvis which would indicate hyperflexion. The angle was recorded.

Hip extension:

1. The sensor was attached to the thigh in any orientation.
2. The player was prone.
3. The limb was extended in a neutral position, and the sensor was then zeroed.
4. The subject extended the hip maximally and angle was recorded.

Hip internal/external rotation:

1. The subject was placed in a prone position
2. The hip to be measured was placed in neutral, while the opposite hip was abducted to 30 degrees.
3. The knee of the hip that was measured was flexed to 90 degrees and an inclinometer was placed below the ankle
4. Tibia was aligned at 90 degrees and then the sensor was zeroed.
5. The player internally rotated maximally and the angle was recorded.
6. The player externally rotated maximally and the angle was recorded.

3.7.2 Radar Speed Gun

The Bushnell® Speedster Sport radar gun was used to measure the speed (velocity) of the football after impact. A radar speed gun is a tool used to measure the speed of moving objects by transmitting radar signals. A frequency is transmitted to the moving object and then back from the moving object. The Doppler Effect is calculated by the difference in transmitted waves to and from the object thus a velocity measurement is seen on the display. The transmitted signal can pass through netting thus the speed gun was placed behind the goalpost for protection (Sood 2008; Deutschmann 2011). The reliability and validity of the speed gun has been shown in numerous studies where kicking velocity has been measured (Dorge *et al.* 2002; AmiriKhorasani 2011; Sood 2008; Deutschmann 2011; Rebelo 2011).

The radar speed gun was held up by the research assistant 7.5 metres away from the kicking point (to increase accuracy in reading), behind the netting of the goal and in an indoor arena, thus minimizing the effect of wind and humidity as well as to protect the device (Sood 2008; Deutschmann 2011). The accuracy of the radar is within 2-3 km/h (Sood 2008). The diagram below shows the setup of the radar speed gun. Markers were used to show ball placement and research assistant positioning for the duration of data collection.

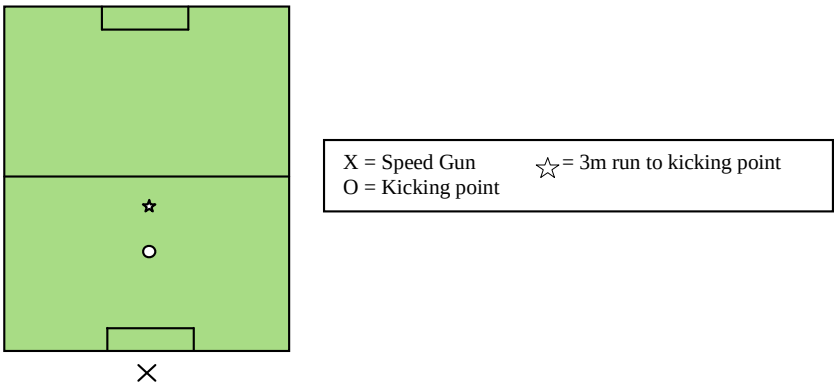


Figure 3.1 Position of players and speed gun on soccer field

3.8 OUTCOME MEASURES

Outcome measures for this research included the following:

- The range of motion of the hip in flexion, extension, internal and external rotation, bilaterally, post intervention measured with the dualer electronic inclinometer. (Dualer system of inclinometry, Jtech Medical industries 4314 Zevex Park Lane, Salt Lake City, UT 84123 USA).
- The player's kicking speed was measured in km/h with a speed sport radar gun. (Bushnell® Speedster Speed Gun; Bushnell Inc., Lenexa, KS).
- The players' perception of kicking speed post intervention (Appendix D).

3.9 RESEARCH PROCESS

Consultations were held in the Chiropractic Day Clinic at Durban University of Technology. The research process was explained to the players, thereafter the player signed a letter of information and informed consent **(Appendix B)** stating that they are willing to be part of the research. At the initial and only consultation the players were examined for any contra-indications to participation by means of a case history evaluation (**Appendix F**) and a full physical **(Appendix G)**, together with a lumbar and hip examination **(Appendix H)**.

The players were allocated by purposive sampling to one of three groups after motion palpation findings by the researcher. The players with ipsilateral joint restrictions were placed into the ipsilateral group and the players with contralateral restrictions were placed in the contralateral group. The placebo group did not have any sacroiliac joint restrictions. Group one received ipsilateral (dominant side) sacroiliac manipulation. Group two received contralateral (opposite) sacroiliac manipulation. Group three received sham laser intervention (control group).

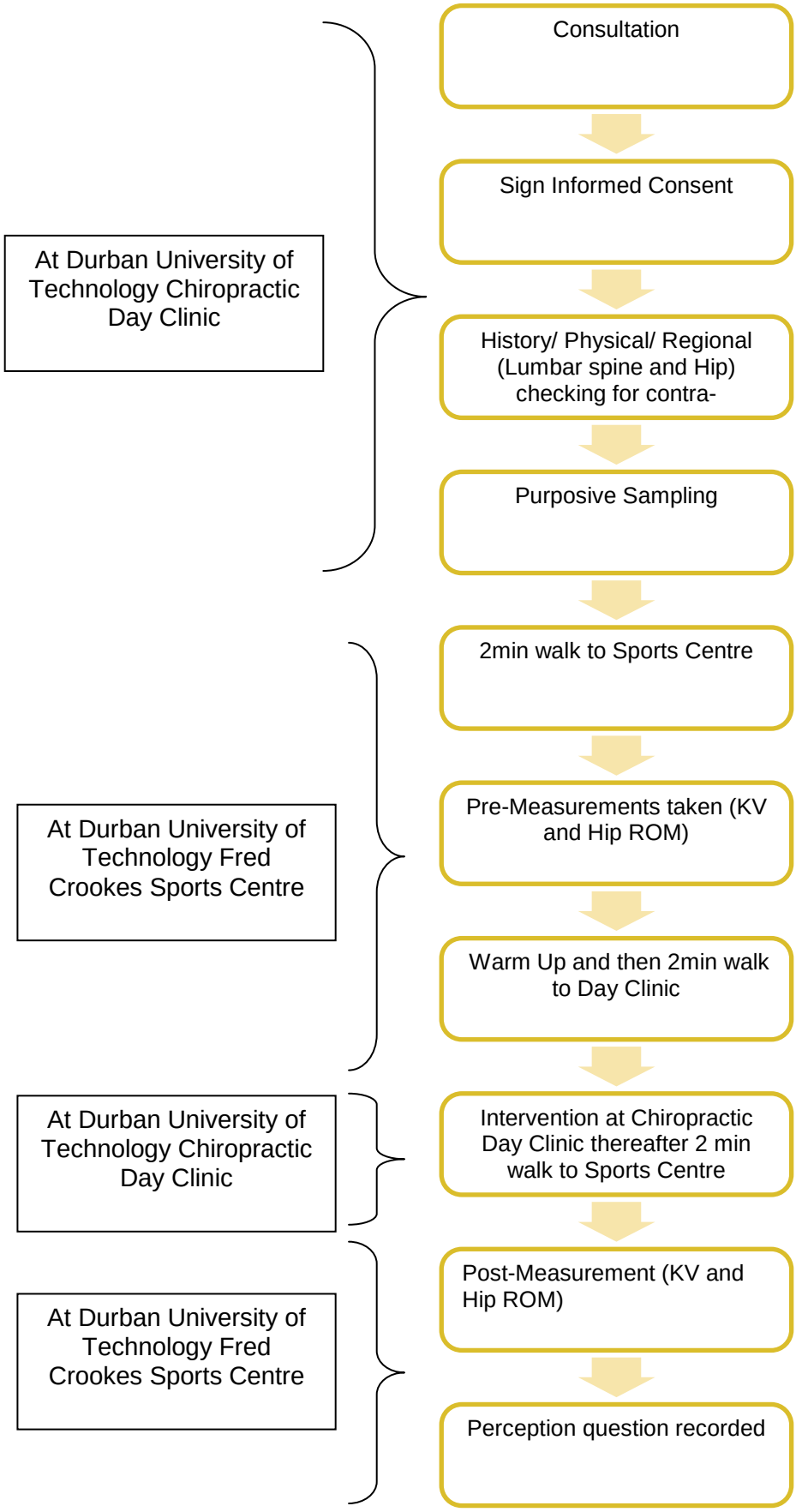
The case history, physical and regional exam were carried out at the Chiropractic Day Clinic, thereafter the Fred Crookes Sports Centre (Durban University of Technology) was used for this study. The measurements (pre- and post-) were taken at the Fred Crookes Sport centre whereas the manipulation occurred at the Chiropractic Day Clinic. Permission was obtained from the Head of Department for the Fred Crookes Sports Centre to utilise the premises (**Appendix C**). The Fred Crookes Sports centre was hired for the duration of the study. The sports centre was closed during the time taken for the measurements and intervention to occur to allow for privacy. The process was supervised at all times by the supervisor and clinicians at the Chiropractic Day Clinic. The researcher was responsible for the manipulation of the groups receiving treatment.

Participants performed a five minute cardiovascular jog in the Fred Crookes Sports Centre which served as warm up. According to Amiri-Khorasani (2011) the principle muscles stretched during an instep kick are the following: gluteals, hip flexors, quadriceps, hamstrings and gastrocnemii, thus these muscles were stretched for 15 seconds bilaterally **(Appendix E)**.

The hip ranges of motion (bilateral) were then measured by an assistant who was non-blinded and already had training on how to perform the measurements with a digital inclinometer. Thereafter the players had a three step run-up and three chances to kick were allowed, whereby the velocity of each kick was measured with a Bushnell® Speedster Sport Radar Gun and the average velocity was taken. This was measured before manipulation. All players in the three groups performed the instep kick with the right foot i.e. ipsilateral side. Active ranges of motion were measured for the actions of the hip on both limbs.

The manipulation was administered by the researcher (non-blinded) to the study to the groups that received treatment. The chiropractic technique used on the sacroiliac joint was the side posture, pisiform contact on the posterior superior iliac spine (Bergmann, Petersen and Lawrence 1993). Participants who received manipulation may have wanted to try and impress the researcher during the post- intervention measurements, thus it was necessary to introduce a sham laser intervention. The sham laser intervention was to clarify whether the outcome of the study was due to the participant's perception or whether it was actually the neurological or mechanical effect of the manipulation.

The participants in the sham laser group were placed in a prone position whereby the laser was shown to them on the back of their hand to confirm that it was working. They were then asked to place their head down to safeguard themselves from the damaging effects of looking into the laser. The laser was then switched off and placed on the participant's right sacroiliac joint for sixty seconds (Deutschmann 2011). The hip ranges of motion (bilateral) were again measured, followed by a three step run-up and three chances to kick once again post-manipulation. The kicking velocity was measured while the player kicked the ball post-manipulation (average velocity taken).The players were asked the question, "Did you feel any change in your kicking velocity after the chiropractic adjustment. If yes, did it increase or decrease?" **(Appendix D),** after the chiropractic adjustment. Thus it was observed if their kicking velocity increased, decreased or remained the same. On the following page the research process is shown in a flow diagram from the first step of the research study to the last step.


Consultation
Sign Informed Consent
At Durban University of Technology Chiropractic Day Clinic
History/ Physical/ Regional (Lumbar spine and Hip) checking for contra-
Purposive Sampling
2min walk to Sports Centre
At Durban University of Technology Fred Crookes Sports Centre
Pre-Measurements taken (KV and Hip ROM)
Warm Up and then 2min walk to Day Clinic
At Durban University of Technology Chiropractic Day Clinic
Intervention at Chiropractic Day Clinic thereafter 2 min walk to Sports Centre
Post-Measurement (KV and Hip ROM)
At Durban University of Technology Fred Crookes Sports Centre
Perception question recorded

3.10. VARIABLES

- A FIFA Approved ball was used, which was of standard size, weight and inflation.
- The ball had to be stationary at the place kick as this suffices as the penalty kick (Dorge *et al*. 2002).
- A specific angle of between 30-45 degrees was chosen for the player as this improves resultant ball speed (Lees and Nolan 1998).
- The indoor soccer arena at Fred Crookes Sports Centre was used for this study in order to minimise the potential effects of humidity and wind on the kick velocity and the soccer ball, compared to wind and humidity effects in an outside environment. This was for the standardisation of measures for all players.

3.11. STATISTICS

The statistical aspect of the research encompassed the following: descriptive statistics used Fisher exact values, Eta tests, frequency, cross-tabulation tables and various types of graphs (including bar charts, scatter graphs etc.); inferential statistics using Pearson's and/or Spearman's correlations at a significance level of 0.05 will be used, testing of hypotheses using chi-square tests for nominal data and ordinal data at a level of significance of 0.05.
This study was a placebo -controlled investigational trial where the data was reduced and analysed with the help of a statistician, using the statistical software SPSS version 20.0.

3.12 LIMITATIONS

The limitations of the study were that the participants were all male, however this was to ensure a more homogenous population. This study concentrated on the instep kick in an indoor arena to minimise variables that may affect kicking velocity. Players from the first team university leagues were chosen to participate in this study due to their slightly better kicking techniques when compared with amateur players. These players play all their games with outdoor boots in an outdoor environment and were limited to using indoor soccer boots and kicking indoors in this study. The scope of this study did not concentrate on the effect of manipulation on muscle strength, thus no electromyographic measurements were taken. This study only considered sacroiliac joint manipulation restrictions and did not assess for restrictions in the lower limb. The range of motion difference between the right and left hip for flexion may also have been due to inadequate training on the digital inclinometer.

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter presents the results of the study as per each objective. The raw data used to develop these statistics can be viewed in **Appendix K**. The discussion of these results will follow in chapter five. The students that were recruited from the three institutions were represented as follows: 25 students from DUT, 22 from the Durban campus and 3 from the City campus. There were 35 students that attended from UKZN, 7 from Howard campus, 20 from Edgewood campus and 8 from Westville campus.

4.2 POSITIONS AND DEMOGRAPHICS

The table below represents the demographic information of the soccer players.

Table 4.1: Positions

			Intervention			Total
			Right Sacroiliac	Left Sacroiliac	Placebo	
Position	Defense	Count	8	7	7	22
		% within Intervention	40.00%	35.00%	35.00%	36.70%
		% of Total	13.30%	11.70%	11.70%	36.70%
	Midfield	Count	5	10	8	23
		% within Intervention	25.00%	50.00%	40.00%	38.30%
		% of Total	8.30%	16.70%	13.30%	38.30%
	Striker	Count	6	2	4	12
		% within Intervention	30.00%	10.00%	20.00%	20.00%
		% of Total	10.00%	3.30%	6.70%	20.00%
	Goalkeeper	Count	1	1	1	3
		% within Intervention	5.00%	5.00%	5.00%	5.00%
		% of Total	1.70%	1.70%	1.70%	5.00%
Total		Count	20	20	20	60
		% within Intervention	100.00%	100.00%	100.00%	100.00%
		% of Total	33.30%	33.30%	33.30%	100.00%

Of all the participants who underwent Right Sacroiliac joint manipulation (n = 20):

8 (40.0%) played in the defense position. This grouping of participants formed 13.3% of the total sample.

5 (25%) played in the midfield position. This grouping of participants formed 8.3% of the total sample.

6 (30%) played in the striker position. This grouping of participants formed 10% of the total sample.

1 (5%) played in the goalkeeper position. This grouping of participants formed 1.7% of the total sample.

Of all the participants who underwent Left Sacroiliac joint manipulation (n=20):

7 (35.00%) played in the defense position. This grouping of participants formed 11.7% of the total sample.

10 (50%) played in the midfield position. This grouping of participants formed 16.7% of the total sample.

2 (10%) played in the striker position. This grouping of participants formed 3.3% of the total sample.

1 (5%) played in the goalkeeper position. This grouping of participants formed 1.7% of the total sample.

Of all the participants who underwent placebo intervention (n=20):

7 (35.00%) played in the defense position. This grouping of participants formed 11.7% of the total sample.

8 (40%) played in the midfield position. This grouping of participants formed 13.3% of the total sample.

4 (20%) played in the striker position. This grouping of participants formed 6.7% of the total sample.

1 (5%) played in the goalkeeper position. This grouping of participants formed 1.7% of the total sample.

In total, 22 (36.7%) participants played in Defense, 23 (38.3%) participants played in Midfield, 12 participants played as Strikers and 3 (5%) played as Goalkeepers.

Table 4.2: Demographics

The table below is a statistical summary of the biographical characteristics of the soccer players by the intervention type.

Report

Intervention		Weight (kg)	Height (m)	Age (years)
Right Sacroiliac	N	20	20	20
	Mean	68.3000	1.7190	22.0000
	Std. Deviation	9.28553	.06223	1.48678
Left Sacroiliac	N	20	20	20
	Mean	66.3500	1.7010	22.3000
	Std. Deviation	8.06732	.06240	1.65752
Placebo	N	20	20	20
	Mean	68.1000	1.7035	21.1500
	Std. Deviation	7.93991	.04804	1.78517
Total	N	60	60	60
	Mean	67.5833	1.7078	21.8167
	Std. Deviation	8.35503	.05752	1.69237
Fisher's Exact Test		48.922	29.331	15.107

None of the Fisher exact values were significant. There was no statistical significant difference between any of the three groups with regards to age, height and weight.

4.3 ANALYSIS OF OBJECTIVES

Prior to analysis, the shapes of the distributions were tested for normality using the Kolmogorov Smirnov test, per intervention type. It was observed that more than 90% of the distributions were not normally distributed. Hence, non-parametric procedures had to be used. The Sign Test was used as this is the equivalent non-parametric test to the 2-sample t-test. Most of the procedures that follow are paired comparisons. The traditional approach to reporting a result requires a statement of statistical significance. A **p-value** is generated from a **test statistic.** A significant result is indicated with "$p < 0.05$". In all of the comparisons that are significant, you can refer to the mean values or to the graphs to show which is larger.

4.3.1 Objective One

To compare ipsilateral and contralateral hip flexion ROM before and after the intervention in all three groups.

4.3.1.1 Right Hip Flexion

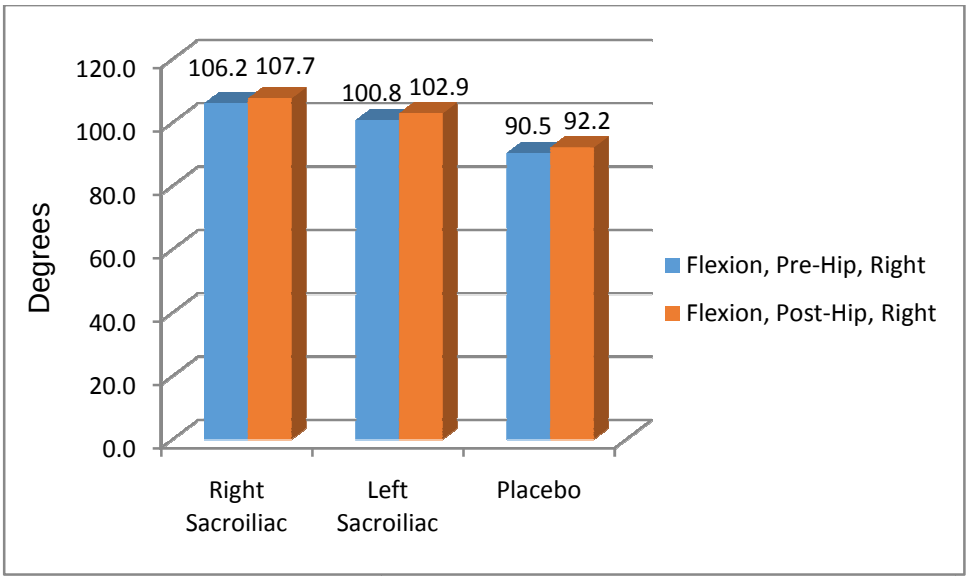


Figure 4.1 Results of right hip flexion, before and after intervention in all three groups.

It is noted that in all three interventions, the post-hip values are slightly larger than the pre-hip values. It is also noted that the Right Sacroiliac value is the highest for both pre- and post-tests. The placebo group has the lowest values.

Table 4.3 The table below indicates whether the differences were significantly different from the central (median) value in the right hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.012
Left Sacroiliac	0.109
Placebo	0.581

4.3.1.2 Left Hip Flexion

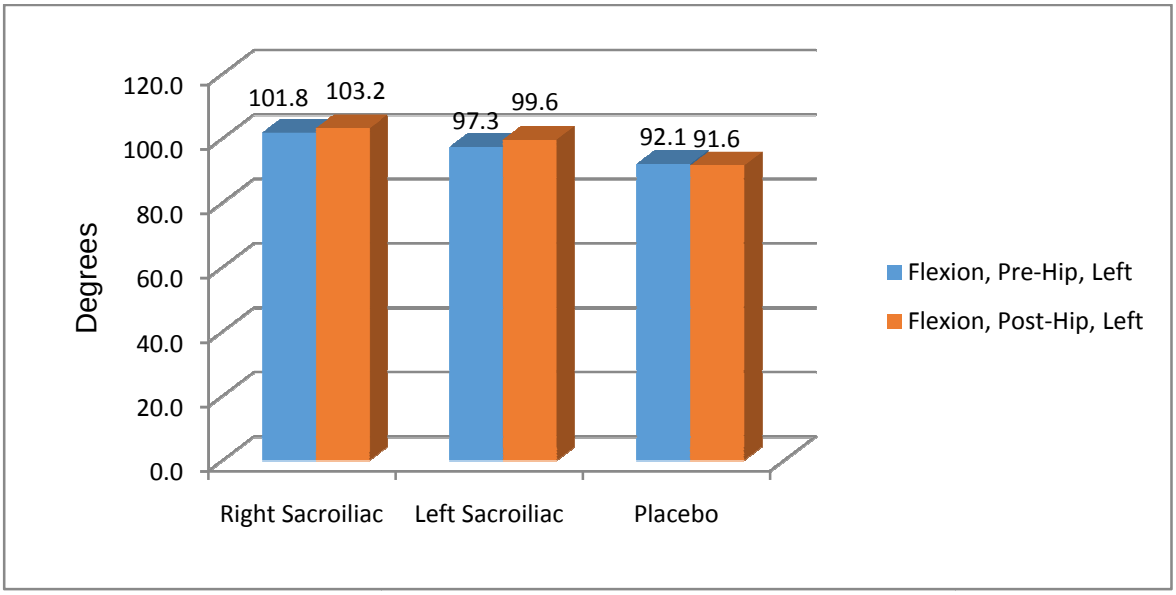


Figure 4.2 Results of left hip flexion, before and after intervention in all three groups.

The patterns observed are similar to the right hip, with the placebo group having a higher pre-test value.

Table 4.4 The table below indicates whether the differences were significantly different from the central (median) value in the left hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.289
Left Sacroiliac	0.125
Placebo	1.000

4.3.1.3 Summary of Results for Flexion

The right sacroiliac group showed an increase in hip ROM for both right and left hip joint flexion. The average right hip ROM of this group increased by 1.5 degrees **(Figure 4.1)** when compared to the average left hip ROM of this group, which increased by 1.4 degrees **(Figure 4.2)**. After performing a Sign test on right hip flexion, the P-value for the right sacroiliac group was 0.012**(Table 4.3)**. This was lower than the level of significance of 0.05 and thus showed that manipulation of the right sacroiliac group had a statistically significant effect in increasing right hip flexion ROM after manipulation. There was no statistically significant increase in flexion of the left hip in the right sacroiliac group.

The left sacroiliac group also showed an increase in hip ROM for both right and left hip joint flexion. The average right hip ROM of this group increased by 2.1 degrees **(Figure 4.1)** when compared with the average left hip ROM of this group, which increased by 2.3 degrees **(Figure 4.2)**. There were no statistically significant increases in flexion of the right and left hips in the left sacroiliac group.

The placebo group showed an increase in hip ROM for flexion in the right hip and a decrease in hip ROM for flexion in the left hip. The average right hip ROM of this group increased by 1.7 degrees **(Figure 4.1)** when compared to the average left hip ROM of this group, which decreased by 0.5 degrees **(Figure 4.2)**. There were no statistically significant increases in flexion of the right and left hips in the placebo group.

4.3.2 Objective Two

To compare ipsilateral and contralateral hip extension ROM before and after the intervention in all three groups.

4.3.2.1 Right Hip Extension

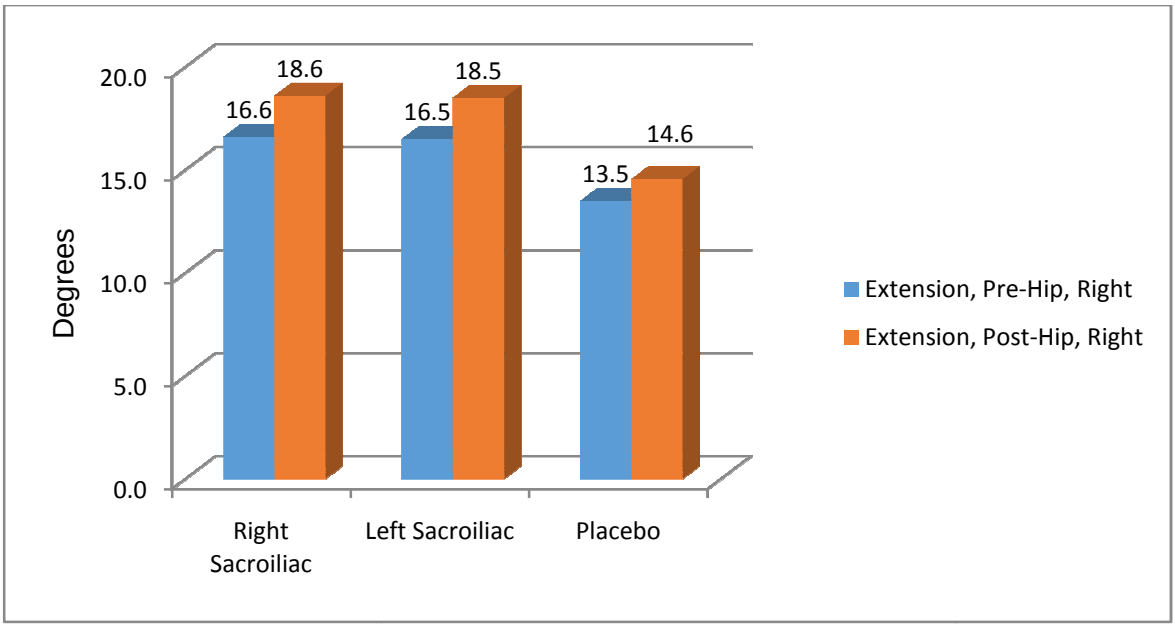


Figure 4.3 Results of right hip extension, before and after intervention in all three groups.

The ipsilateral sacroiliac joint manipulation group showed a higher post- test value when compared to the contralateral sacroiliac joint manipulation and placebo group. It is noted that in all three interventions, the post-hip values are slightly larger than the pre-hip values. The placebo group has the lowest values.

Table 4.5 The table below indicates whether central differences were significant from the central (median) value in the right hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.003
Left Sacroiliac	0.013
Placebo	0.180

4.3.2.2 Left Hip Extension

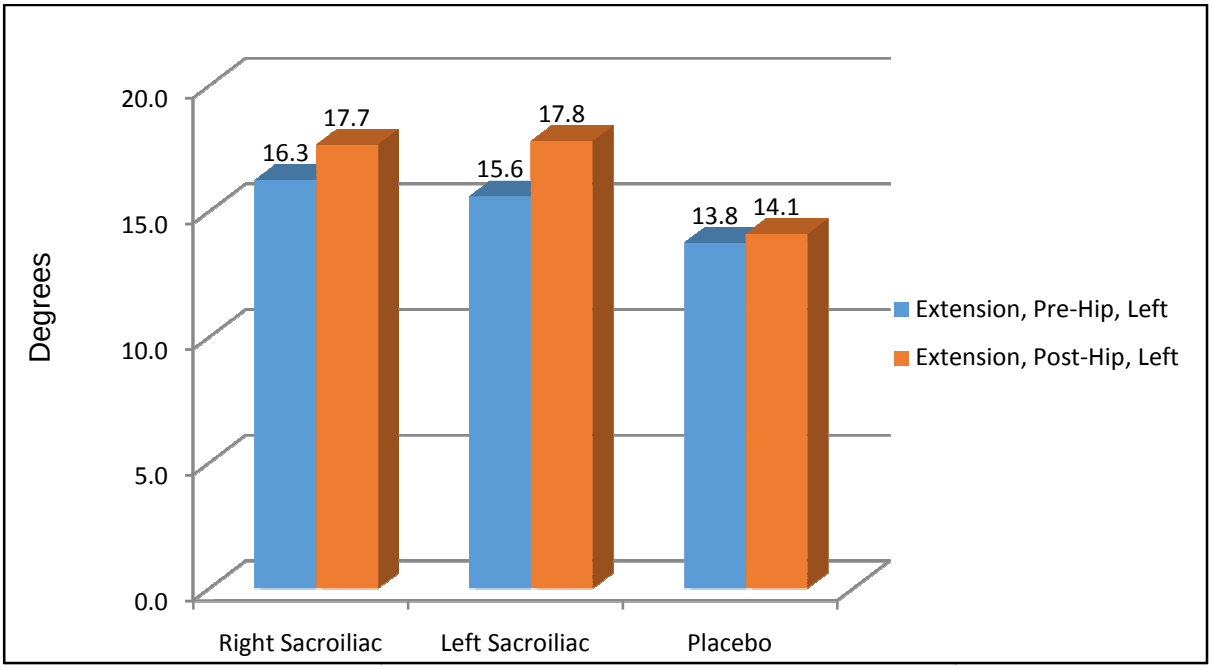


Figure 4.4 Results of left hip extension, before and after intervention in all three groups.

The patterns observed are similar to the right hip, with the left sacroiliac group having the highest post-test value.

Table 4.6 The table below indicates whether central differences were significant from the central (median) value in the left hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.039
Left Sacroiliac	0.000
Placebo	1.000

4.3.2.3 Summary of Results for Extension

The right sacroiliac group showed an increase in hip ROM for extension in both right and left hips. The average right hip ROM of this group increased by 2 degrees **(Figure 4.3)** when compared with the average left hip ROM of this group, which increased by 1.4 degrees **(Figure 4.4)**. After performing a Sign test, the P-value for the right sacroiliac group on right hip extension was 0.003 **(Table 4.5)** and the P-value on left hip extension was 0.039 **(Table 4.6)**. These are lower than the level of significance of 0.05 and thus showed that manipulation had a statistically significant effect in increasing right and left hip extension ROM post manipulation.

The left sacroiliac group also showed an increase in hip ROM for extension in both right and left hips. The average right hip ROM of this group increased by 2 degrees **(Figure 4.3)** when compared with the average left hip ROM of this group, which increased by 2.2 degrees **(Figure 4.4)**. After performing a Sign test, the P-value for the left sacroiliac group on right hip extension was 0.013 **(Table 4.5)** and the P-value on left hip extension was 0.000 **(Table 4.6)**. These are lower than the level of significance of 0.05 and thus showed that manipulation had a statistically significant effect in increasing right and left hip extension ROM post manipulation.

The placebo group also showed an increase in hip ROM for extension in both right and left hips. The average right hip ROM of this group increased by 1.1 degrees **(Figure 4.3)** when compared with the average left hip ROM of this group, which increased by 0.9 degrees **(Figure 4.4)**. The warm up exercises may have accounted for this change in degree of ROM. There were no statistically significant increases in extension of the right and left hips in the placebo group.

4.3.3 Objective Three

To compare ipsilateral and contralateral hip internal rotation ROM before and after the intervention in all three groups.

4.3.3.1 Right Hip Internal Rotation

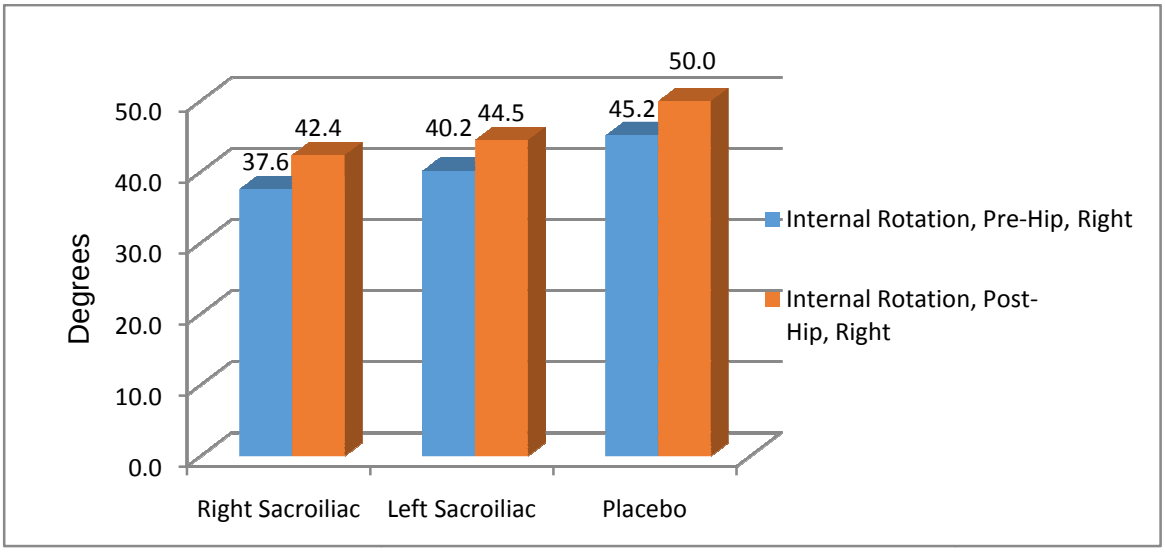


Figure 4.5 Results of right hip internal rotation, before and after intervention in all three groups.

It is noted that in all three interventions, the post-hip values are larger than the pre-hip values. It is also noted that the placebo group value is the highest for both pre- and post-tests. The ipsilateral sacroiliac joint manipulation group has the lowest values.

Table 4.7 The table below indicates whether central differences were significant from the central (median) value in the right hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.000
Left Sacroiliac	0.001
Placebo	1.46

4.3.3.2 Left Hip Internal Rotation

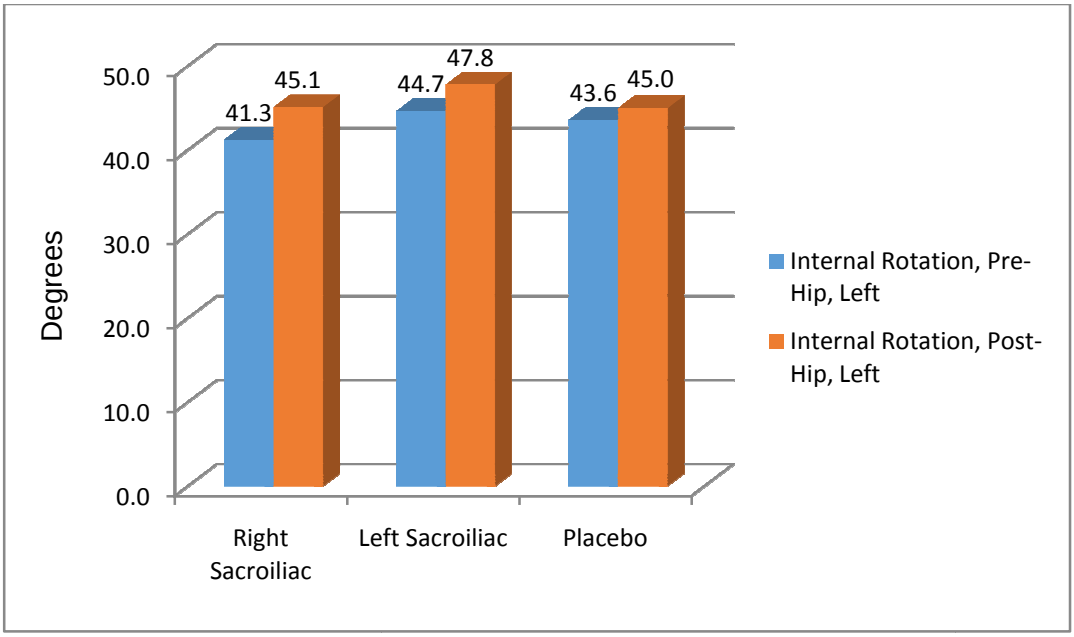


Figure 4.6 Results of left hip internal rotation, before and after the intervention in all three groups.

It is noted that in all three interventions, the post-hip values are larger than the pre-hip values. It is also noted that the contralateral sacroiliac manipulation group value is the highest for both pre- and post-tests. The ipsilateral sacroiliac joint manipulation group has the lowest pre-test values.

Table 4.8 The table below indicates whether central differences were significant from the central (median) value in the left hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.000
Left Sacroiliac	0.002
Placebo	1.000

4.3.3.3 Summary of Results for Internal Rotation

The right sacroiliac group showed an increase in hip ROM for internal rotation in both right and left hips. The average right hip ROM of this group increased by 4.8 degrees **(Figure 4.5)** when compared with the average left hip ROM of this group, which increased by 3.8 degrees **(Figure 4.6)**. After performing a Sign test, the P-value for the right sacroiliac group on right hip internal rotation was 0.000 **(Table 4.7)** and the P-value on left hip internal rotation was

0.000 **(Table 4.8)**. These are lower than the level of significance of 0.05 and thus showed that manipulation had a statistically significant effect in increasing right and left hip internal rotation ROM post manipulation.

The left sacroiliac group also showed an increase in hip ROM for internal rotation in both right and left hips. The average right hip ROM of this group increased by 4.3 degrees **(Figure 4.5)** when compared with the average left hip ROM of this group, which increased by 3.1 degrees **(Figure 4.6)**. After performing a Sign test, the P-value for the left sacroiliac group on right hip internal rotation was 0.001 **(Table 4.7)** and the P-value on left hip extension was 0.002 **(Table 4.8)**. These are lower than the level of significance of 0.05 and thus showed that manipulation had a statistically significant effect in increasing right and left hip internal rotation ROM after manipulation.

The placebo group showed an increase in hip ROM for internal rotation in both right and left hips as well. The average right hip ROM of this group increased by 4.8 degrees **(Figure 4.5)** when compared to the average left hip ROM of this group, which increased by 1.4 degrees **(Figure 4.6)**. There were no statistically significant increases in internal rotation of the right and left hips in the placebo group.

4.3.4 Objective Four

To compare ipsilateral and contralateral hip external rotation ROM before, and immediately after the intervention, in all three groups.

4.3.4.1 Right Hip External Rotation

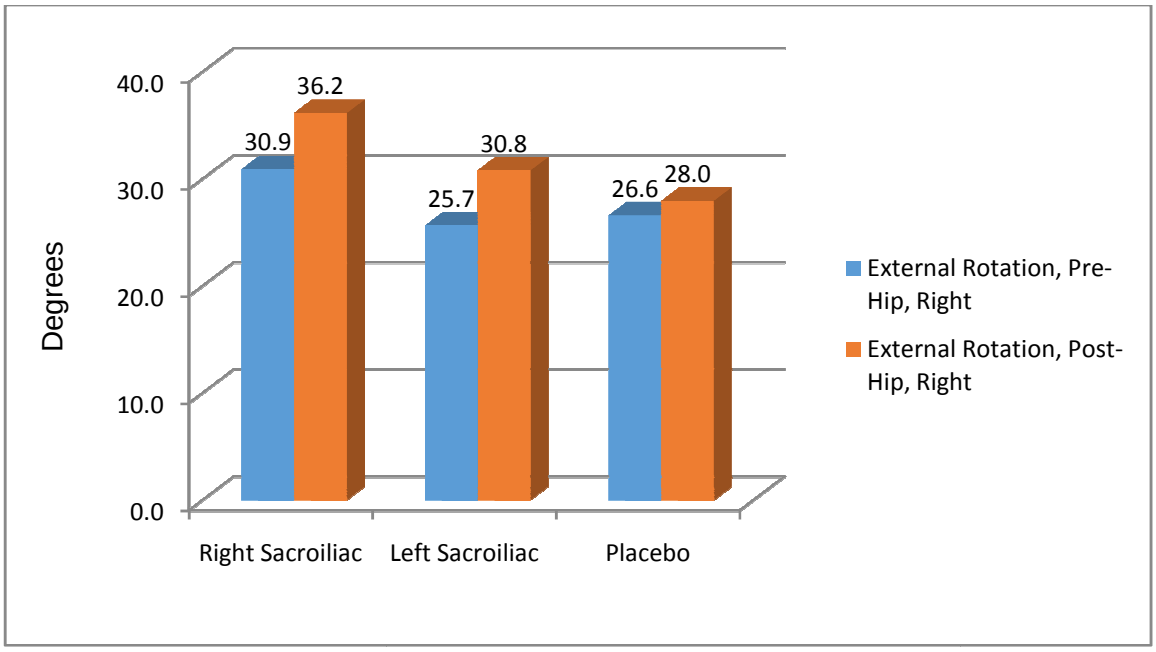


Figure 4.7 Results of right hip external rotation, before and after the intervention in all three groups.

The ipsilateral sacroiliac joint manipulation group showed higher pre- and post- test values when compared with the contralateral sacroiliac joint manipulation and placebo group. It is noted that in all three interventions, the post-hip values are slightly larger than the pre-hip values

Table 4.9 The table below indicates whether central differences were significant from the central (median) value in the right hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.001
Left Sacroiliac	0.007
Placebo	0.388

4.3.4.2 Left Hip External Rotation

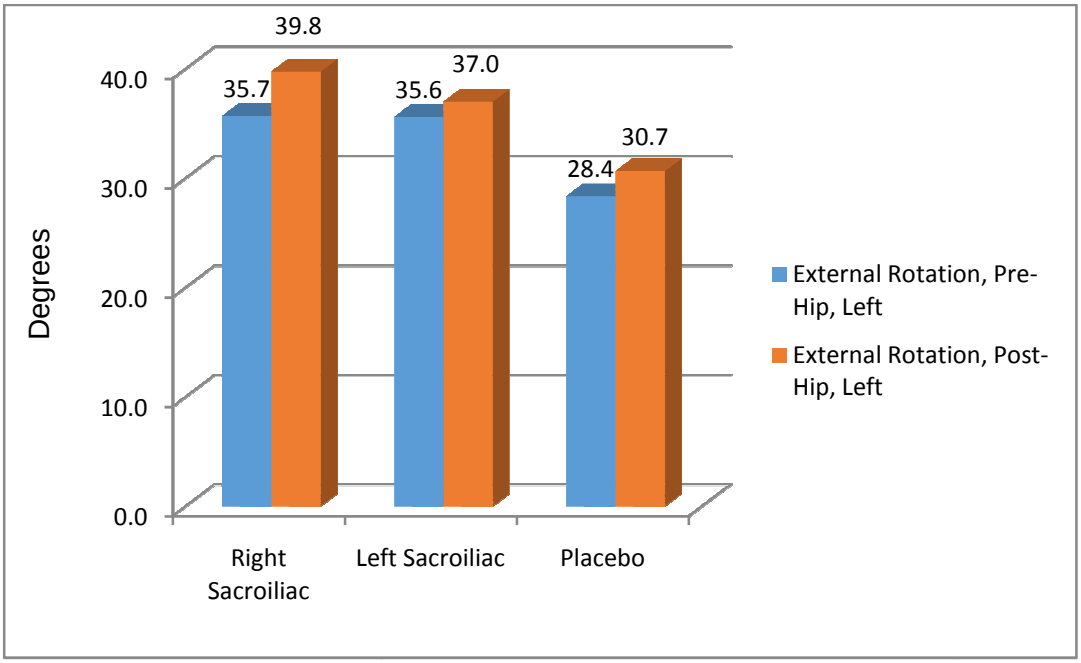


Figure 4.8 Results of left hip external rotation, before and after intervention in all three groups.

It is noted that in all three interventions, the post-hip values are slightly larger than the pre-hip values. It is also noted that the ipsilateral sacroiliac joint manipulation group has the highest values for both pre- and post-tests. The placebo group has the lowest values.

Table 4.10 The table below indicates whether central differences were significant from the central (median) value in the left hip.

Intervention Type	Sign-Test Significance Value
Right Sacroiliac	0.000
Left Sacroiliac	0.424
Placebo	0.549

4.3.4.3Summary of Results for External Rotation

The right sacroiliac group showed an increase in hip ROM for external rotation in both right and left hips. The average right hip ROM of this group increased by 5.3 degrees **(Figure 4.7)** when compared with the average left hip ROM of this group, which increased by 4.1 degrees **(Figure 4.8)**. After performing a Sign test, the P-value for the right sacroiliac group on right hip external rotation was 0.001 **(Table 4.9)** and the P-value on left hip internal rotation was 0.000 **(Table 4.10)**. These are lower than the level of significance of 0.05 and thus showed

that manipulation had a statistically significant effect in increasing right and left hip internal rotation ROM post manipulation

The left sacroiliac group also showed an increase in hip ROM for external rotation in both right and left hips. The average right hip ROM of this group increased by 5.1 degrees **(Figure 4.7)** when compared to the average left hip ROM of this group, which increased by 1.4 degrees **(Figure 4.8)**. After performing a Sign test, the P-value for the left sacroiliac group on right hip internal rotation was 0.007 **(Table 4.9)**. This was lower than the level of significance of 0.05 and thus showed that manipulation had a statistically significant effect in increasing right hip external rotation ROM post-manipulation. There was no statistically significant increase in external rotation of the left hip in the left sacroiliac group.

The placebo group showed an increase in hip ROM for external rotation in both right and left hips as well. The average right hip ROM of this group increased by 1.4 degrees **(Figure 4.7)** when compared with the average left hip ROM of this group, which increased by 2.3 degrees **(Figure 4.8)**. There were no statistically significant increases in external rotation of the right and left hips in the placebo group.

4.3.5 Objective Five

To compare the kicking velocity before intervention to kicking velocity after intervention in all three groups.

4.3.5.1 Average Kicking Velocity

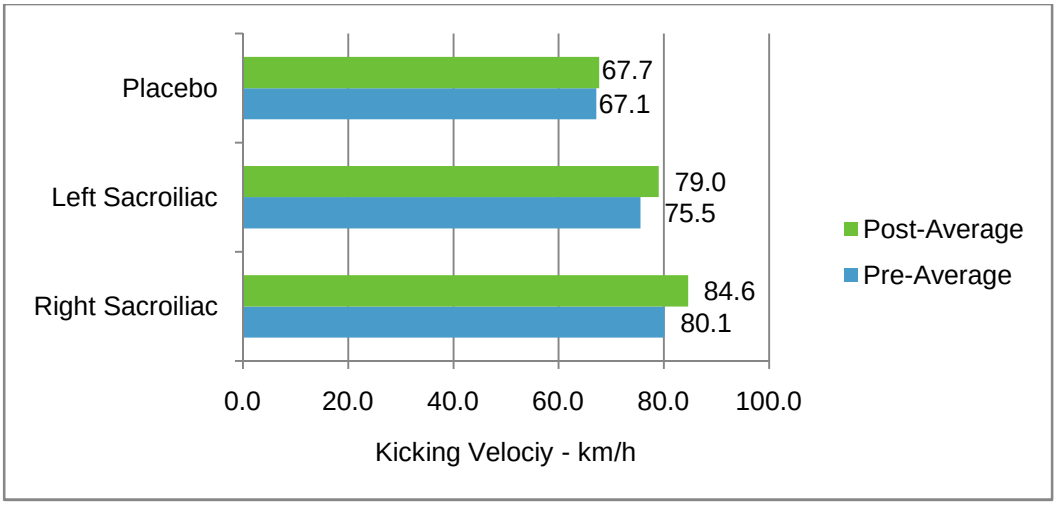


Figure 4.9 Average kicking velocities pre- and post-intervention in all three groups.

The results show that both the right and left manipulation groups have higher pre-test average kicking velocity when compared with the placebo group. A large increase in the average kicking velocity of the right and left sacroiliac manipulation groups was observed.

Table 4.11 The table below indicates whether central differences were significant for average kicking velocity for each intervention type.

Intervention Type	Sign-Test Significance Value	Paired t-test Significance Value
Right Sacroiliac	0.000	0.000
Left Sacroiliac	0.008	0.002
Placebo	0.648	0.700

These distributions were normally distributed. Hence, in addition to the Sign test, a paired t-test was also done for purposes of verification. The right and left sacroiliac manipulation groups showed a statistical significance on average kicking velocity of soccer players. The placebo group showed no statistical significance for average kicking velocity.

4.3.6 Objective Six

To compare the perception change to change in average kicking velocity after intervention in all three groups.

Table 4.12 Cross tabulation between perception questionnaire and average change in kicking velocity in all three groups.

Right Sacroiliac Group			Objective Change in Kicking Speed (avg)			Total
			Decrease	Same	Increase	
Subjective Change in Kicking Speed	Decrease	Count	0	0	1	1
		%	0%	0%	100%	100%
	Increase	Count	1	0	18	19
		%	5%	0%	95%	100%
Total		Count	1	0	19	20
		%	5%	0%	95%	100%

Left Sacroiliac Group			Objective Change in Kicking Speed (avg)			Total
			Decrease	Same	Increase	
Subjective Change in Kicking Speed	Decrease	Count	1	0	0	1
		%	100%	0%	0%	100%
	Increase	Count	2	2	15	19
		%	11%	11%	79%	100%
Total		Count	3	2	15	20
		%	15%	10%	75%	100%

Placebo Sacroiliac Group			Objective Change in Kicking Speed (avg)			Total
			Decrease	Same	Increase	
Subjective Change in Kicking Speed	Decrease	Count	0	0	0	0
		%	0%	0%	0%	0%
	Same	Count	7	1	3	11
		%	64%	9%	27%	100%
	Increase	Count	1	0	8	9
		%	11%	0%	89%	100%
Total		Count	8	1	11	20
		%	40%	5%	55%	100%

The table above shows how the players perceived the change of their kicking velocity after treatment in comparison with the actual change of their kicking velocity. For the right sacroiliac group, eighteen soccer players said that their kicking velocity increased after manipulation of the right sacroiliac joint (subjective change). This matched the actual change in their kicking velocity as measured by the speed gun (objective change). One soccer

player said that his kicking velocity decreased and it actually increased. Another soccer player said that his kicking velocity increased and it actually decreased. These two players may have not understood the perception question adequately enough.

For the left sacroiliac group, fifteen soccer players said that their kicking velocity increased after manipulation of the left sacroiliac joint (subjective change). This matched the actual change in their kicking velocity as measured by the speed gun (objective change). Two soccer players said that their kicking velocity increased, however it stayed the same. One soccer player said that his kicking velocity decreased and it actually did decrease. One soccer player said that his kicking velocity increased but it actually decreased.

In the placebo group, eight soccer players said that their kicking velocity increased and it did increase marginally. None of the soccer players said that their kicking velocity decreased. One soccer player said that his kicking velocity stayed the same and it actually stayed the same. Seven soccer players mentioned that their kicking velocity stayed the same when it actually decreased. Three soccer players mentioned that their kicking velocity stayed the same when it actually increased. One soccer player mentioned an increase in his kicking velocity when it actually decreased.

When the dependent variable uses an interval or ratio scale, and the independent variable is nominal or ordinal then we use the statistical data called Eta, where values of association from the cross tabulation as shown below in **Table 4.13.**The association refers to a wide variety of coefficients which measure the effect size (strength of relationship), defined by various ways. In common usage "association" refers to measures of the strength of relationship in which at least one of the variables is a dichotomy, nominal, or ordinal value. Two eta values are computed: one treats the row variable as the interval variable, and the other treats the column variable as the interval variable. Like most measures of association, eta can vary from -1.0 to +1.0. This means that a high positive or negative numbers indicate a strong association between the two variables. Positive values are directly proportional and negative values are inversely proportional.

Table 4.13 Eta Directional Measures for the three groups.

Right

Directional Measures

			Value
Nominal by Interval	Eta	Average Kicking Velocity Dependent	.214
		Did you feel any change in your kick after the chiropractic treatment? Dependent	1.000

Left

Directional Measures

			Value
Nominal by Interval	Eta	Average Kicking Velocity Dependent	.244
		Did you feel any change in your kick after the chiropractic treatment? Dependent	1.000

Placebo

Directional Measures

			Value
Nominal by Interval	Eta	Average Kicking Velocity Dependent	0.0015
		Did you feel any change in your kick after the chiropractic treatment? Dependent	1.000

The patterns observed **(Table 4.13)** were as follows;

The Eta value was used to determine the strength of the association between “Change in Kicking speed” and “Perception of Effect” in all three groups. The right sacroiliac groups Eta value was 0.214 which when viewed on the table in **Appendix L** (Morgan *et al.* 2004) shows a medium to typical effect size. That is, the change in kicking speed is typical because of the intervention used. Eta squared would be 0.05, indicating that the two variables share 5% common variance. The left sacroiliac group Eta value was 0.244 which when squared also shows a medium to typical effect size.

4.3.7 Objective Seven

To determine any correlation that may exist between hip ROM and the change in kicking velocity after intervention.

A direct proportional relationship exists between the increase in hip ROM and increased kicking velocity for all **figures 4.10 to 4.17** below.

4.3.7.1 Flexion

In the right sacroiliac group **(Figures 4.10 and 4.11)**, as the right and left hip flexion ROM increased by 1.5 degrees **(Figure 4.1)** and 1.4 degrees **(Figure 4.2)** respectively, the kicking velocity increased by 4.5 km/hr **(Figure 4.9)**. In the left sacroiliac group **(Figures 4.10 and 4.11)**, as the right and left hip flexion ROM increased by 2.1 degrees **(Figure 4.1)** and 2.3 degrees **(Figure 4.2)** respectively, the kicking velocity increased by 3.5 km/hr **(Figure 4.9)**.

In the placebo group **(Figure 4.10)**, as the right hip flexion ROM increased by 1.7 degrees **(Figure 4.1)**, the kicking velocity increased by 0.7 km/hr **(Figure 4.9)**. The placebo group **(Figure 4.11)** reflected an indirect proportionate relation with regard to left hip flexion ROM, as it decreased by 0.5 degrees **(Figure 4.2)** and the kicking velocity increased by 0.7 km/hr **(Figure 4.9)**. 0.5 degrees is considered to be a marginal decrease and thus not statistically significant.

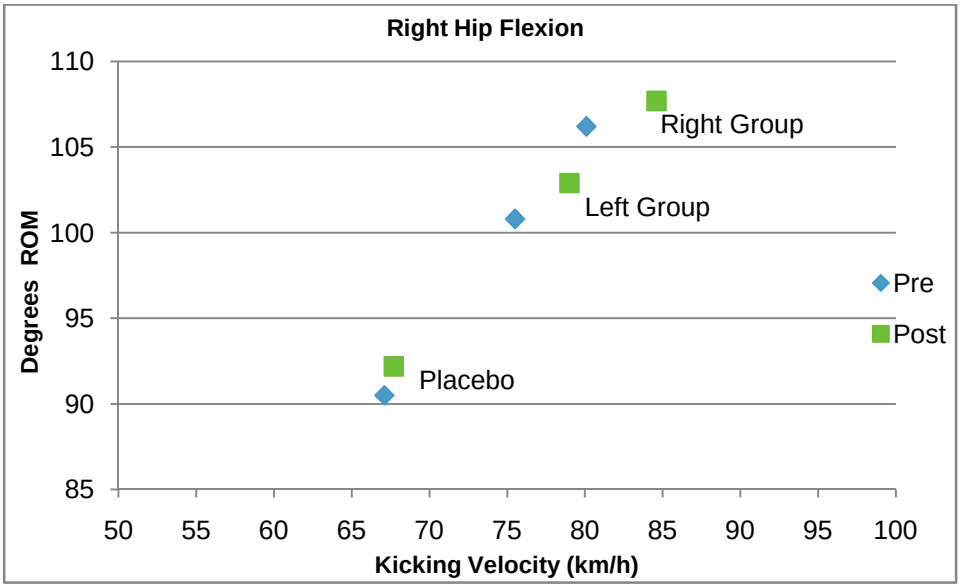


Figure 4.10 Correlation of change in right hip flexion to change in kicking velocity post manipulation in all three groups

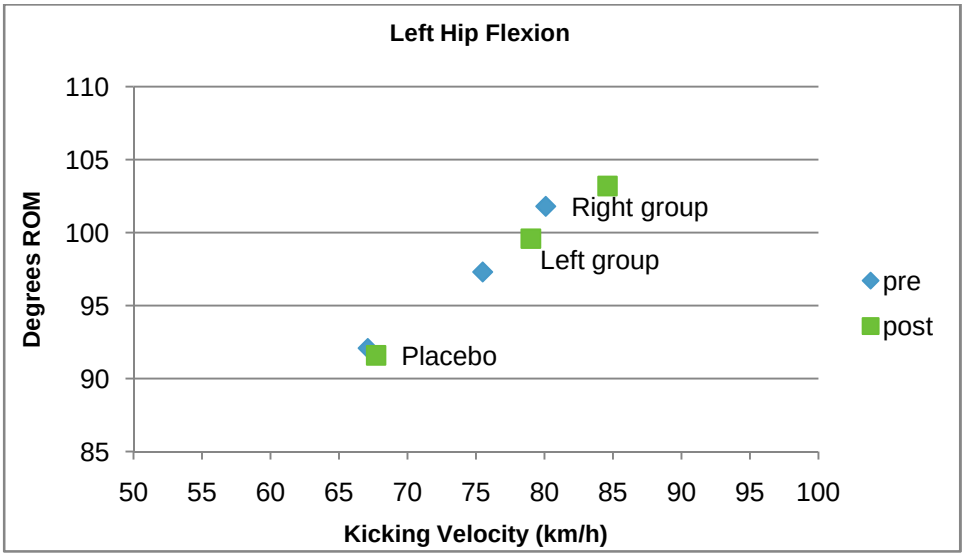


Figure 4.11 Correlation of change in left hip flexion to change in kicking velocity post manipulation in all three groups

4.3.7.2 Extension

In the right sacroiliac group **(Figures 4.12 and 4.13)**, as the right and left hip extension ROM increased by 2 degrees **(Figure 4.3)** and 1.4 degrees **(Figure 4.4)** respectively, the kicking velocity increased by 4.5 km/hr **(Figure 4.9)**. In the left sacroiliac group **(Figures 4.12 and 4.13)**, as the right and left hip extension ROM increased by 2 degrees **(Figure 4.3)** and 2.2 degrees **(Figure 4.4)** respectively, the kicking velocity increased by 3.5 km/hr **(Figure 4.9)**.

In the placebo group **(Figures 4.12 and 4.13)**, as the right and left hip extension ROM increased by 1.1 degrees **(Figure 4.3)** and 0.9 degrees **(Figure 4.4)** respectively, the kicking velocity increased by 0.7 km/hr **(Figure 4.9)**.

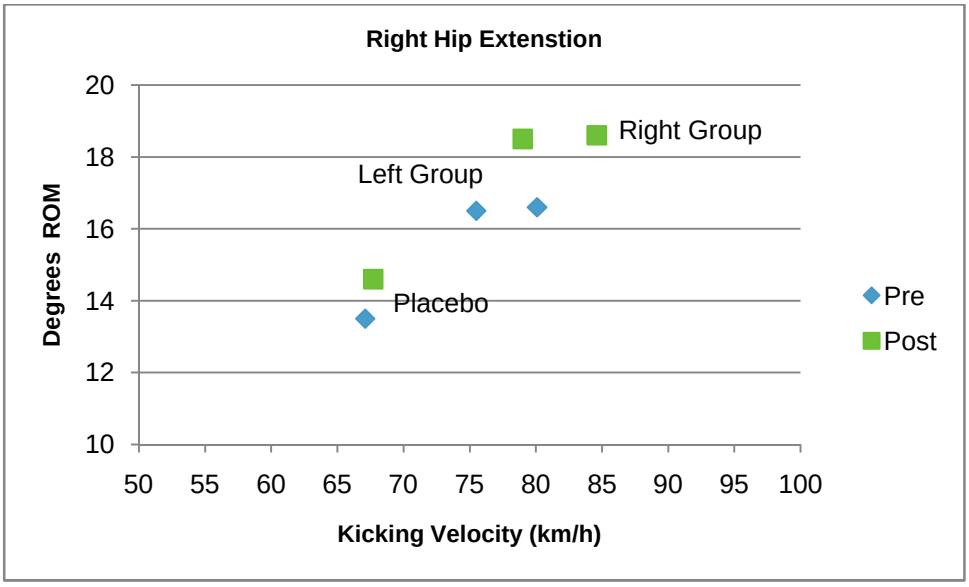


Figure 4.12 Correlation of change in right hip extension to change in kicking velocity post manipulation in all three groups

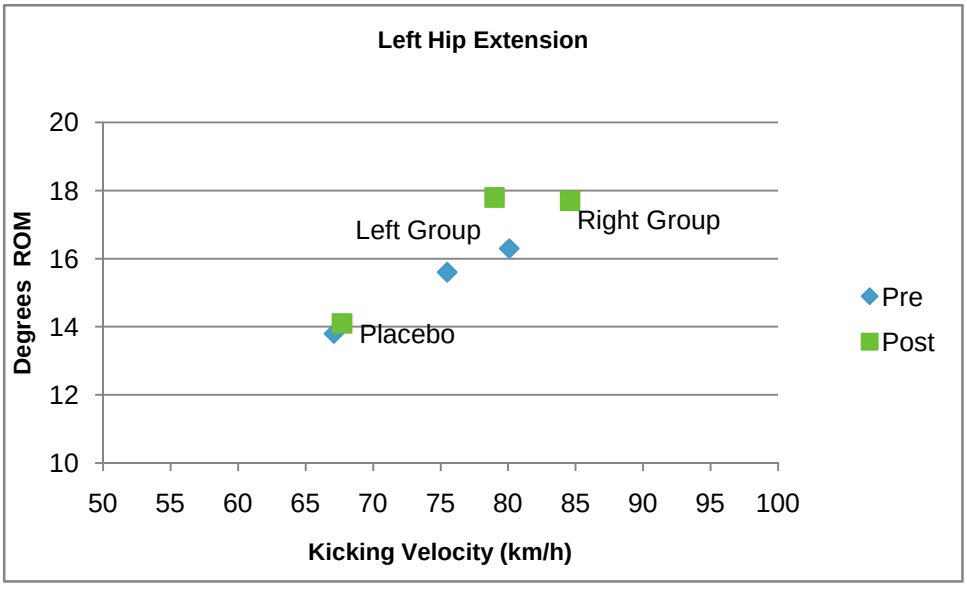


Figure 4.13 Correlation of change in left hip extension to change in kicking velocity post manipulation in all three groups

4.3.7.3 Internal Rotation

In the right sacroiliac group **(Figures 4.14 and 4.15)**, as the right and left hip internal rotation ROM increased by 4.8 degrees **(Figure 4.5)** and 3.8 degrees **(Figure 4.6)** respectively, the kicking velocity increased by 4.5 km/hr **(Figure 4.9)**. In the left sacroiliac group **(Figures 4.14 and 4.15)**, as the right and left hip internal rotation ROM increased by 4.3 degrees **(Figure 4.5)** and 3.1 degrees **(Figure 4.6)** respectively, the kicking velocity increased by 3.5 km/hr **(Figure 4.9)**.

In the placebo group **(Figures 4.14 and 4.15)**, as the right and left hip internal rotation ROM increased by 4.8 degrees **(Figure 4.5)** and 1.4 degrees **(Figure 4.6)** respectively, the kicking velocity increased by 0.7 km/hr **(Figure 4.9)**.

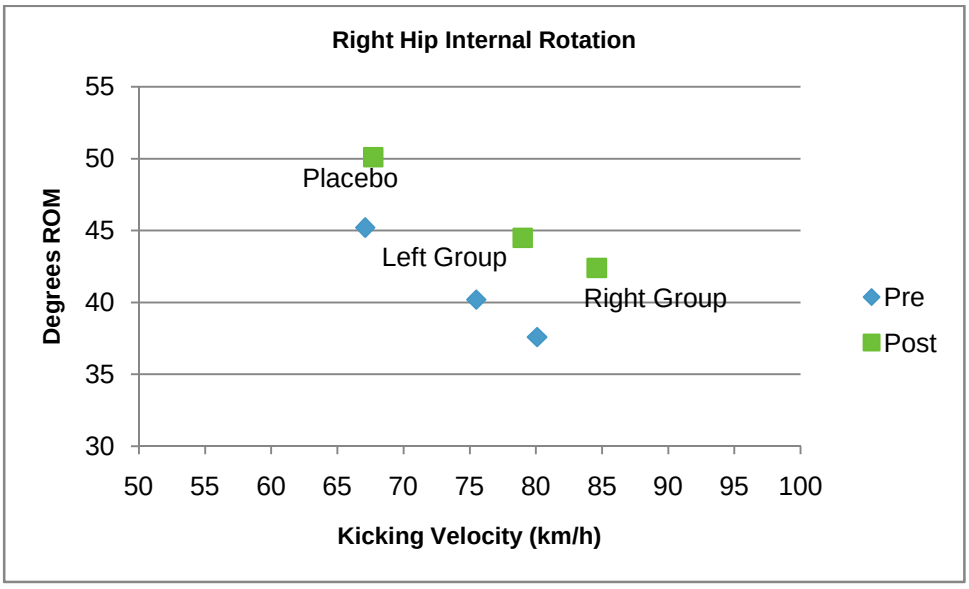


Figure 4.14 Correlation of change in right hip internal rotation to change in kicking velocity post manipulation in all three groups

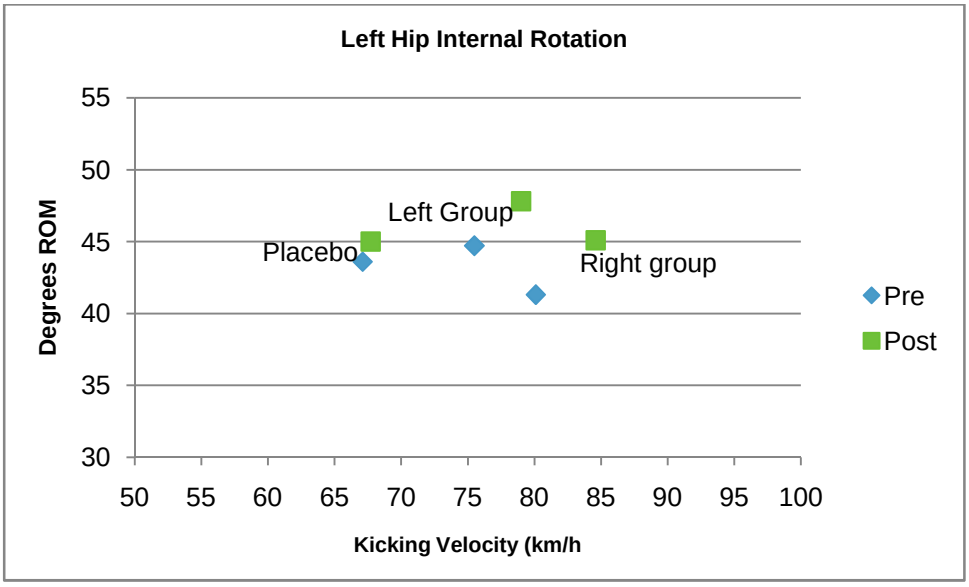


Figure 4.15 Correlation of change in left hip internal rotation to change in kicking velocity post manipulation in all three groups

4.3.7.4 External Rotation

In the right sacroiliac group **(Figures 4.16 and 4.17)**, as the right and left hip external rotation ROM increased by 5.3 degrees **(Figure 4.7)** and 4.1 degrees **(Figure 4.8)** respectively, the kicking velocity increased by 4.5 km/hr **(Figure 4.9)**. In the left sacroiliac group **(Figures 4.16 and 4.17)**, as the right and left hip external rotation ROM increased by 5.1 degrees **(Figure 4.7)** and 1.4 degrees **(Figure 4.8)** respectively, the kicking velocity increased by 3.5 km/hr **(Figure 4.9)**.

In the placebo group **(Figures 4.16 and 4.17)**, as the right and left hip external rotation ROM increased by 1.4 degrees **(Figure 4.7)** and 2.3 degrees **(Figure 4.8)** respectively, the kicking velocity increased by 0.7 km/hr **(Figure 4.9)**.

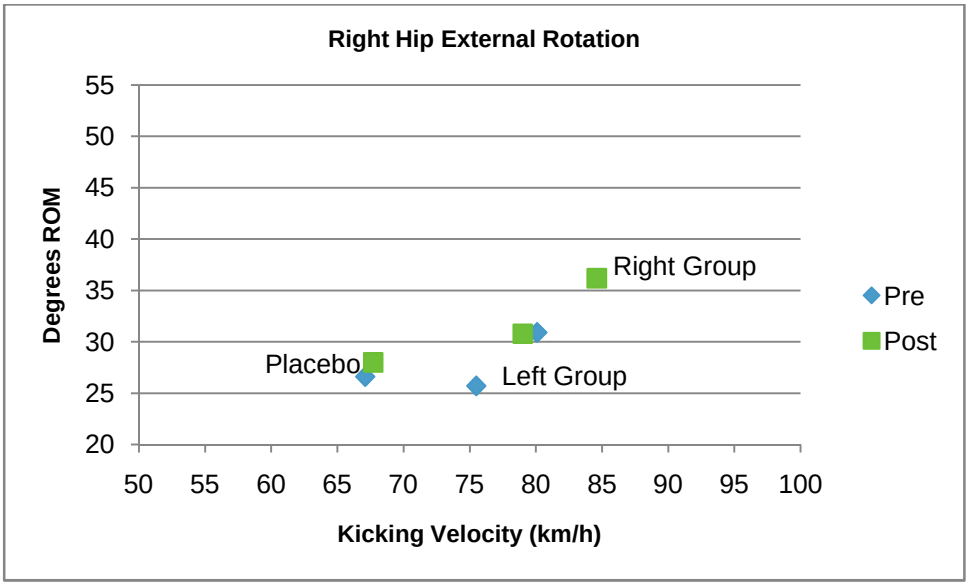


Figure 4.16 Correlation of change in right hip external rotation to change in kicking velocity post manipulation in all three groups

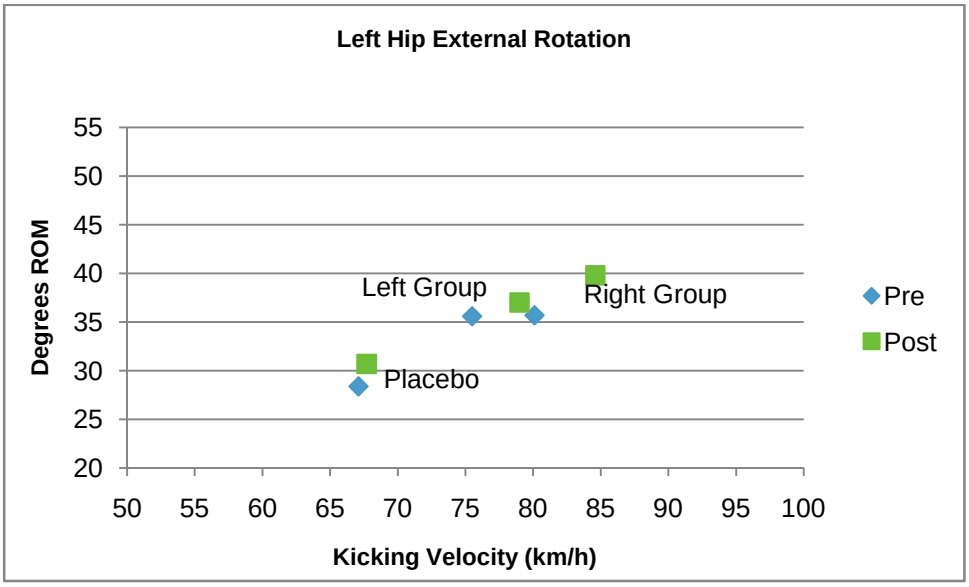


Figure 4.17 Correlation of change in left hip external rotation to change in kicking velocity post manipulation in all three groups

Table 4.14 Correlation table of change in Hip ROM to change in average kicking velocity post manipulation in all three groups.

		Right Sacroiliac	Left Sacroiliac	Placebo
		Average Kicking Velocity		
Change in right hip Flexion from Pre- to Post-	Pearson Correlation	-.051	.173	-.398
	Sig. (2-tailed)	.831	.465	.082
	N	20	20	20
Change in left hip Flexion from Pre- to Post-	Pearson Correlation	-.084	-.071	-.143
	Sig. (2-tailed)	.725	.765	.548
	N	20	20	20
Change in right hip Extension from Pre- to Post-	Pearson Correlation	.114	.040	-.352
	Sig. (2-tailed)	.633	.867	.128
	N	20	20	20
Change in left hip Extension from Pre- to Post-	Pearson Correlation	-.034	-.040	-.370
	Sig. (2-tailed)	.886	.867	.108
	N	20	20	20
Change in right hip Int Rotation from Pre- to Post-	Pearson Correlation	.043	-.431	-.052
	Sig. (2-tailed)	.858	.058	.829
	N	20	20	20
Change in left hip Int Rotation from Pre- to Post-	Pearson Correlation	.088	.387	-.241
	Sig. (2-tailed)	.711	.092	.306
	N	20	20	20
Change in right hip Ext Rotation from Pre- to Post-	Pearson Correlation	.088	.387	-.241
	Sig. (2-tailed)	.711	.092	.306
	N	20	20	20
Change in left hip Ext Rotation from Pre- to Post-	Pearson Correlation	-.129	.155	-.256
	Sig. (2-tailed)	.587	.514	.276
	N	20	20	20

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

CHAPTER FIVE

DISCUSSION

5.1 INTRODUCTION

The following chapter aims to discuss and explain the outcome of the results as depicted in chapter four in view of the reviewed literature. The discussion on the hip range of motion findings will be divided into the right and left hips. This is to better understand the effects of the ipsilateral and contralateral group on both hips.

5.2 POSITION AND DEMOGRAPHICS

The player positions **(Table 4.1)** were not equally distributed between the groups and may have influenced average kicking velocity of the soccer players as reflected in **Figure 4.9**. The ipsilateral group consisted of eight defenders and six strikers when compared with the contralateral group, which had ten midfielders and two strikers. It could be a possibility that different player positions may have an effect on the average kicking velocity. Therefore the ipsilateral group may have had an advantage over the contralateral group for kicking velocity.

The results within the three groups pertaining to the age, height and weight in **Table 4.2** had no statistical significant differences present. The biographical statistics for the three groups remained constant with a minimal standard deviation value for all three groups. This helped to eliminate inter-group bias as any differences that may have been present in the age, height or weight could play a role in affecting kicking velocity (Dorge *et al.* 2002). The height and weight, however, are of amateur first team university soccer players and are not aligned with measurements for professional soccer players. The skill levels of the players were not the same as mentioned in the literature review and this may have been a factor in affecting the results of the study.

5.3 HIP RANGE OF MOTION

5.3.1 Right Hip

The ipsilateral group showed a statistically significant effect:

- on the right hip for flexion **(Table 4.3)**,
- on the right hip for extension **(Table 4.5)**,
- on the right hip for internal rotation **(Table 4.7)**,
- on the right hip for external rotation **(Table 4.9)**.

The contralateral group showed no statistically significant effect on the right hip for flexion.
The contralateral group showed a significant effect:

- on the right hip for extension **(Table 4.5)**,
- on the right hip for internal rotation **(Table 4.7)**,
- on the right hip for external rotation **(Table 4.9)**.

The placebo group showed no statistical significance on the right hip for flexion, extension, internal and external rotation **(Table 4.3 to 4.10)**.

The right hip was expected to increase in range of motion for all actions due to the biomechanical effects of manipulation (Sandoz 1976; Pickar 2002; Herzog 2000; Gatterman 2003). The high forces exerted on the hip joint during the different stages of the kick may explain the susceptibility of soccer players to present with sacroiliac joint restrictions. This is attributed to the close relationship of the hip and sacroiliac joint. This restriction decreases hip ROM and inhibits hip muscle function (Bisset 2003; Turner 2005; Lewis 2005; Hillerman *et al.*2006). The manipulation of the right sacroiliac joint in the ipsilateral group showed a significant effect in increasing the right hip flexion, extension, internal and external rotation. The manipulation of the left sacroiliac joint in the contralateral group showed a significant effect on the right hip ROM for extension, internal and external rotation.

The explanation for the effects of the ipsilateral group on the right hip ROM has been shown in the literature. The effects of the contralateral group on the right hip ROM can be due to the biomechanical effect of manipulation. The right hip inserts into the acetabelum which is formed by the ilium, ischium and pubic bones. The ilium articulates with the sacrum forming the sacroiliac joint. The sacroiliac joints work in unison with each other (Cibulka, Dellito and Koldehoff 1988; Cibulka 2013), thus a restriction in one joint may affect the opposite joint

biomechanics because of the close anatomical and mechanical relationship. A restriction in one joint may also cause a compensatory change in the joints on the opposite side. Therefore, a manipulation of the contralateral sacroiliac joint may correct the mechanics of the ipsilateral hip joint due to the close relationship in the bony anatomy of the pelvis.

Ipsilateral side joint restrictions have shown that muscle inhibition of the lower limbs is present bilaterally (Suter *et al.* 2000; Rice and McNair 2010; Lewis 2005) but manipulation on the contralateral side has not shown any conclusive evidence that it has a statistically significant effect on the opposite side.The sacroiliac and hip joint have the same motor neuron pool supply, which could explain the increase in right hip ROM in the contralateral group. The contralateral manipulation may have had an effect on the right hip by stimulating the mechanoreceptors to send altered afferent and efferent impulses which may have reduced muscle inhibition in the right hip.This study did not measure the muscle torque to observe the effect of the muscle inhibition on bilateral hip musculature or the muscle torque after manipulation, but based on the studies of Suter *et al.* (2000), Rice and McNair (2010) and Palmiere *et al*. (2003) the research cannot ignore the biomechanical effect of manipulation on the contralateral side.

As all the soccer players were right footed and performed the instep kick by kicking into flexion, it was observed that the right hip flexion was higher in these soccer players when compared with the left hip. The ipsilateral group showed a statistically significant effect on the right hip for extension, as was expected (Sandell, Palmgren and Bjorndahl 2008).The statistically significant effect of the ipsilateral group on improving the internal and external right hip ROM was expected (Bisset 2003).

During the lumbar regional examination of the soccer players it was observed that many players had lumbar spine restrictions. The Iliopsoas muscle is a strong hip flexor and is innervated by the first three lumbar nerves (DeFranca and Levine 1996).Moore (1992) states that the Iliopsoas, Rectus Femoris and Tensor Fascia Lata receive their nervous supply from L1-S1 nerves. A restriction in the lumbar spine may cause inhibition of the muscles that the nerves supply. The players also mentioned anterior thigh muscle tightness in the case history because of the increasing intensity in the training schedules as the season progressed. The lumbar restrictions coupled with high intensity training may have had an effect on the decrease in the pre- hip flexion results in the contralateral group **(Figure 4.1)**. Although the players were placed into the groups by purposeful sampling it is observed that the contralateral group soccer players may have had restrictions in the lumbar spine and in

joints in the lower kinematic chain other than the hip joint, which may have contributed to the low pre- measurement values for hip flexion.

The measurements for right hip flexion were lower than the normal flexion values of 110-120 degrees (Magee 2002) in all three groups. This also suggests that restrictions such as hip flexor contracture may be present in the lower kinematic chain of the soccer players. The sample size of the groups was small and thus it was possible that players with decreased hip flexion ROM were present in the contralateral group, therefore explaining the difference in hip flexion values of the ipsilateral and contralateral group.

The right limb is the dominant kicking limb for the majority of the soccer players. The right hip joint may have shown a greater potential flexibility due to all the players being right-footed soccer players. This means that during the game majority of the players will be kicking with their right limb and this motion may serve as a dynamic stretching action on the hip muscle itself.

The placebo group showed no statistical significance on the left hip for flexion, extension, internal and external rotation **(Table 4.3 to 4.8)**. This was expected, as this group did not receive a manipulation but received a placebo intervention of a switched off laser treatment which did not have any effect on the sacroiliac joint (Sood 2008; Deutschman 2011). The increases in the range of motion of the hip for the placebo group may have occurred due to the kicking action itself. The stages of the kick where the hip is first extended, then flexed, may serve as a warm up or a dynamic stretch and may thus have attributed to a marginal increase in hip ROM readings after manipulation.

5.3.2 Left Hip

The ipsilateral group showed no statistical significance on the left hip for flexion **(Table 4.4)**.

The ipsilateral group showed a significant effect:

- on the left hip for extension **(Table 4.6)**,
- on the left hip for internal rotation **(Table 4.8)**,
- on the left hip for external rotation **(Table 4.10)**.

The contralateral group showed no statistical significance on the left hip for flexion **(Table 4.4)** and external rotation **(Table 4.10)**.

The contralateral group showed a significant effect

- on the left hip for extension **(Table 4.6)**,
- on the left hip for internal rotation **(Table 4.8)**.

There was no statistical significance of the contralateral group on the left hip for extension and external rotation, as the researcher performing the manipulation may have had a propensity for the right sided manipulation group as it was his dominant side. The effect of the manipulation on the left side sacroiliac joint may not have responded adequately due to poor technique and or no cavitations occurring (Sandoz 1976).

This study showed a statistical significance of the ipsilateral group on the left hip extension, internal and external rotation. These internal and external hip rotation results showed a significant effect after the manipulation within the ten minute time period, in comparison to Bisset's 2003 study which showed a significant effect after one week. This is important to note as treatment may be administered during the half time interval of a soccer match, thus showing that manipulation on either sacroiliac joints may improve bilateral hip ROM immediately.

The placebo group showed no statistical significance on the left hip for flexion, extension, internal and external rotation **(Table 4.3 to 4.10)**. This was expected as this group did not receive a manipulation but received a placebo intervention of a switched off laser treatment, which did not have any effect on the sacroiliac joint (Sood 2008; Deutschman 2011). The increases in the range of motion of the hip for the placebo group may have occurred due to the kicking action itself. The stages of the kick where the hip is first extended, then flexed,

may serve as a warm up or a dynamic stretch. This warm up or dynamic stretch may have been the reason as to why the hip ROM may have improved marginally in the placebo group.

5.4 KICKING VELOCITY

The sacroiliac joint does have a role in the soccer kick as Cibulka, Dellito and Koldehoff (1988), Cibulka (2013), Defranca and Levine (1996), Howe (1996) and Sandell, Palmgren and Bjorndahl (2008) have mentioned, thus we cannot rule out that there may have been improvement within the sacroiliac joint range of motion itself which in turn could affect the kicking velocity. The manipulation of the sacroiliac joint and removing the improvement observed in the hip ranges of motion may have also increased the kicking velocity of the soccer players (Deutschmann 2011).

The ipsilateral group showed a statistically significant effect on improving the average kicking velocity of the soccer players **(Table 4.11)**. The ipsilateral groups average kicking velocity increased by 4.5 km/h, which also shows the possible effect of manipulation on the soccer players kicking performance.

The contralateral group showed a statistically significant effect on improving the average kicking velocity of the soccer players **(Table 4.11)**. The contralateral groups average kicking velocity increased by 3.5 km/h, which also shows the effect of manipulation on the soccer players kicking performance. It is interesting to note that the contralateral group had an effect on improving average kicking velocity of the soccer players even though all soccer players kicked with the right foot.

The placebo groups average kicking velocity increased by 0.6 km/h, which was of no statistical significance as was expected. This group received a sham laser intervention which would have no effect on the sacroiliac joint, thus the kicking velocity did not increase by a large value when compared with the ipsilateral and contralateral groups.

5.5 PERCEPTION

In **Table 4.12** the players were asked if they felt any change in their average kicking velocity after the intervention. This was compared with the objective change in their kicking velocity after the intervention. The P value **(Table 4.13)** for the ipsilateral and contralateral groups shows a statistical significance in the association between the perceptive change (subjective

questionnaire) and the actual average kicking velocity (objective measurement with the speed gun).The **Table 4.13** also shows that there was a ninety-five percent match when comparing the soccer players perceptive change with the objective change in the ipsilateral group, who said that their kicking velocity had increased after the manipulation when it actually did increase. The results were similar for the contralateral group, where the perceptive change of the soccer players matched their objective measurements by seventy-nine percent. The soccer players also made very similar remarks that were recorded within the two manipulation groups **(Appendix D)**. The most common terms used to describe any change that a player may have felt in the kicking velocity are as follows, *verbatim*;

- My hip feels lighter.
- My hip feels like it has more motion.
- My leg feels free.
- I feel more power.
- I feel more flexible.

The players may have felt this way due to the effects of the manipulation (Herzog 2000; Pickar 2002; Gatterman 2003).There is a need for further research on the possible manipulative effect on the psychological aspect of the soccer player as well (Miners 2010*;* Deutschmann 2010).

5.6 CORRELATION BETWEEN HIP ROM AND KICKING VELOCITY

The results for objective seven **(Figures 4.10 to 4.17)** show a directly proportional relationship between the change in hip ROM and the change in average kicking velocity for the ipsilateral and contralateral groups. The direct proportional relationships observed in **Figures 4.10 to 4.17** showed that there was an improvement in the kicking velocity of the ipsilateral and contralateral groups after hip ROM increased. The change between pre- and post- values of the right and left hips for flexion, extension, internal and external rotation in all three groups, however, were too small in order to show a statistical significance between correlation of hip ROM and kicking velocity as shown in **Table 4.13**.

5.7 SUMMARY OF DISCUSSION

The explanation for the effects of the right and left sided manipulation on the right hip ROM has been reviewed in the literature. The review of the literature has shown possible

mechanisms for the improvement of the right hip ROM after the right sacroiliac joint manipulation. Although there is literature supporting the effects of the contralateral sacroiliac joint manipulation on the right hip, this study further shows a statistically significant effect of the ipsilateral and contralateral sacroiliac joint manipulation on bilateral hip ROM. This shows that not only does the right sacroiliac joint manipulation group have an effect on the right hip as per previous studies, but also has an effect on the opposite hip ROM. This is the same for the left sacroiliac joint manipulation group, which not only showed a statistically significant effect on the left hip ROM but also showed that the manipulation has a statistically significant effect on the opposite, right hip ROM. The left hip improved in ROM, which may improve the swinging limb arc due to the keystone effect mentioned previously **(section 2.5).**

The placebo group showed no statistical significance for any hip ranges of motion for both the right and left hips (**Table 4.3 to 4.10)**. This was expected as this group did not receive a manipulation but received a placebo intervention of a switched off laser treatment which did not have any effect on the sacroiliac joint.

CHAPTER SIX
CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study aimed to investigate the effect of the ipsilateral versus contralateral sacroiliac joint manipulation on bilateral hip ROM and kicking velocity of the soccer players. It was observed that the ipsilateral group improved the right hip ROM as well as the left hip ROM. The contralateral group had improved the left hip ROM as well as the right hip ROM. It has been shown that a correlation exists between improved hip range of motion and soccer kick performance.

The objectives for this study are mentioned below:

- To compare the right and left hip flexion, extension, internal and external rotation ROM before and after the intervention in all three groups.

- To compare the average kicking velocity before and after intervention in all three groups.

- To compare the perception of kicking velocity after intervention in all three groups.

- To determine any correlation that may exist between hip ROM and the change in kicking velocity after intervention in all three groups.

The statistically significant effects for the three groups are as follows:

- For the right hip, the ipsilateral group showed a statistical significance in flexion, extension, internal and external rotation. In the same hip, the contralateral group showed a statistical significance in extension, internal and external rotation except for flexion.
- For the left hip, the ipsilateral group showed a statistical significance in extension, internal and external rotation except for flexion. In the same hip, the contralateral group showed a statistical significance for extension and internal rotation except for flexion and external rotation.

- The placebo group was not statistically significant for any hip ranges of motion of the right and left sides.
- For the average kicking velocity, the ipsilateral and contralateral groups showed a statistical significance after intervention. The placebo group was not statistically significant.
- For the perception change in kicking velocity after the intervention, there was a statistical significance in all three groups.
- The correlation between the change in hip range of motion and the change in the average kicking velocity showed no statistical significance.

The Null Hypothesis stated that there would be no statistically significant change in:

- Hip flexion, extension, internal and external rotation range of motion post-intervention in all groups.
- Kicking velocity post-intervention in all groups.
- Perception for kicking velocity post-intervention in all three groups.
- Correlation between hip ROM and kicking velocity post-intervention.

For the Null Hypotheses (Ho), the following were accepted or rejected;

For the Right hip: the Null Hypothesis was rejected for hip flexion, extension, internal and external rotation in the ipsilateral group. In the same hip, the Null Hypothesis was accepted for hip flexion in the contralateral group and rejected for extension, internal and external rotation hip ROM.

For the Left hip: the Null Hypothesis was rejected for hip extension and internal and external rotation in the ipsilateral group and accepted for hip flexion. In the same hip, the Null Hypothesis was rejected for hip extension and internal rotation in the contralateral group and accepted for hip flexion and external rotation.

The perception change of a soccer player in kicking velocity after the intervention was statistically significant, thus the Null Hypothesis was rejected.

The correlation between the changes in hip ROM was clinically significant but not statistically significant therefore the Null Hypothesis was accepted.

6.2 RECOMMENDATIONS

The sample size consisted of 60 players, each with 20 players per group. A larger sample size may be used in order to prevent a type two error.

An independent examiner/clinician that is blinded to the study should be used for sampling, measurements and treatments.

The effect of manipulation on other/all lower limb restrictions in kicking velocity i.e. foot/ankle, knee and hip joints should be considered and then a comparison can be made with lumbar and or sacroiliac joints. A separate study recording objective measurements on all the joints involved in the soccer kick should be done and then compared to this study. This would be more objective in understanding the results of this study when compared to a study on the results of manipulation on all the joints involved in lower limb activities.

A study should be done to explain the effects of manipulation on the hip ROM after manipulation of the hip joint.

For future research one needs to take pre- and post-warm up measurements on hip ROM. This is needed in order to measure the difference in degree of motion between pre- and post- warm up measurements. One also needs to consider if kicking velocity measurements should be taken before or after hip ROM measurements due to the fact that the kick itself may affect hip ROM.

The speed gun and digital inclinometer are both hand held devices and are susceptible to human error. Future research studies should use devices that are mounted and operated by a machine to decrease operator induced error.

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APPENDIX A - LETTER OF INFORMATION TO SPORTS DEPARTMENT

Dear Sir/Mam

I am a Chiropractic student completing my Masters Degree at the Durban University of Technology.
I, Zia M Rehman, hereby respectively inform you that I shall be conducting research on the players that are participating in my study.

Title of the Research Study: The immediate effect of ipsilateral versus contralateral sacroiliac joint manipulation on the kicking velocity and hip range of motion in soccer players
Principal Investigator/s/researcher: Zia ul Mustafa Rehman, Bachelors in Technology: Chiropractic
Co-Investigator/s/supervisor: Dr H Kretzman, M. Dip. C; CCFC (SA)

Kind Regards,
Zia M Rehman.

APPENDIX B - LETTER OF INFORMATION AND INFORMED CONSENT (PLAYER)

Dear Sir/Mam

I am a Chiropractic student completing my Masters Degree at the Durban University of Technology.
I, Zia M Rehman, hereby respectively request your permission to participate in my research study.

Title of the Research Study: The immediate effect of ipsilateral versus contralateral sacroiliac joint manipulation and sham laser intervention on the kicking velocity and hip range of motion in soccer players
Principal Investigator/s/researcher: Zia ul Mustafa Rehman, Bachelors of Technology: Chiropractic
Co-Investigator/s/supervisor: Dr H Kretzman, M. Dip. C; CCFC (SA)

Brief Introduction and Purpose of the Study:

This study aims to determine the immediate effect of chiropractic treatment on hip range of motion and kicking speed in soccer players.
Hip ranges of motion are the movements of the hip that occur during a soccer kick. These movements together with muscle strength have an effect on ball speed after a soccer kick. There are also forces that occur in the leg, that when added together also have an effect on ball speed. A high ball speed is important to score a goal. If the range of motion of the hip is not normal then the movements, muscle strength and forces won't be functioning at its best.

If the leg is not functioning at its best movement, the resulting ball speed after a soccer kick won't be at its maximum speed.
Hip movements and muscle power have been shown to increase after chiropractic treatment of the spine. Therefore if hip movement and muscle power is increased, the ball speed after a soccer kick should increase as well.

This study aims to measure the movements of the hip joint and ball speed after the chiropractic treatment in order to observe changes in hip movements and ball speed of a soccer player.

Outline of the Procedures: for you to take part in the study, you must meet the following criteria.

Inclusion criteria

1. Participants were male between the ages of 18 and 35.
2. Participants played and trained with their first team university soccer squad.
3. Participants had no history of low back and lower limb surgery or suffered from any debilitating illnesses.
4. Participants were asymptomatic with regards to low back and bilateral lower limb pain i.e. lumbar spine, sacroiliac joint, hip pain, knee pain, ankle pain.
5. A joint fixation had to be present in participants, as this may have decreased hip range of motion which may have affected kicking velocity. (Gatterman 2003; Lees *et al*. 1998).
6. Participants read and signed the Letter of Information and Informed Consent.

Exclusion criteria

1. Any participants with contra indications to spinal manipulation were excluded from the study e.g. hypermobility of functional segmental unit, tumours or bone infections.
2. Participants with any neuromusculoskeletal conditions affecting the spine, hip, knee, ankle.
3. Participants with no sacroiliac joint restrictions were placed in the placebo group.

Consultations will be held in the Chiropractic Day Clinic at Durban University of Technology. The research process will be explained to you thereafter you will be required to sign a letter of information and informed consent **(Appendix B)** stating that you are willing to be a part of the research. At the consultation you will be examined for any contra-indications to participation by means of a case history evaluation and a full physical **(Appendix G)** and lumbar and hip examination **(Appendix H)**.

There will be a 33 percent chance of you falling into one of the 3 groups i.e. the ipsilateral group, contralateral group or placebo group.
Group one will receive ipsilateral (dominant side) lumbar and sacroiliac manipulation. Group two will receive contralateral (opposite side) lumbar and sacroiliac manipulation. Group three will receive sham laser intervention (control group).

You will be required to perform a five minute cardiovascular jog which will serve as warm up and lower limb stretch routine, which will include quadriceps, hamstrings and calves.
The hip ranges of motion (bilateral) will then be measured by an assistant who would've already had training on how to perform the measurements properly with a digital inclinometer.

Thereafter you will have a 3 step run-up and 3 chances to kick will be allowed whereby the velocity of the 3 kicks will be measured with a Speed sport radar gun (average velocity will be taken). This will be measured pre manipulation.
The interventions will occur at the Fred Crookes sports centre at the Steve Biko campus DUT by the researcher. The hip ranges of motion (bilateral) will again be measured, followed by a 3 step run-up and 3 chances to kick will be allowed once again post manipulation. The kicking velocity will be measured while you kick the ball post manipulation (average velocity taken).
The researcher will then ask you for your perception (before and after chiropractic treatment); whether you thought your kicking velocity increased, decreased or remained the same.

Risks or Discomforts to the Participant: You may develop transient discomfort in surrounding musculature or at the joint that was adjusted that may last for a few minutes or for a few hours. If the discomfort persists for more than 24 hours the researcher will be contacted and advice will be given to place an ice pack for ten minutes on the area of discomfort.

Benefits: The coaches and players will be able to view the speed of their kicks. The results of this study will be published in the form of a dissertation and kept at the DUT Library.

Reason/s why the Participant May Be Withdrawn from the Study: You may withdraw from the study at any time should you wish to do so. Reasons for withdrawal from this study

may include sickness, injury or any other unforeseen circumstances. There shall be no adverse consequences for you should you choose to withdraw.

Remuneration: the will be no remuneration for participating in the study

Costs of the Study: You will not need to cover any costs incurred in the conduction of the study

Confidentiality: Your information will be kept confidential. Your identity will also be kept confidential. Information will be stored in the Chiropractic Day Clinic for 15 years, after which it will be shredded.

Research-related Injury: the research will be non-invasive and there is minimal to no risk of injury to you.

Time taken for the player to complete the process: the time taken for you to complete the process would be 75 minutes. The player would be present at Durban University of Technology for the duration of the process which is 75 minutes.

Persons to Contact in the Event of Any Problems or Queries:
Please contact: Dr. H Kretzman 072 601 4405 (Research supervisor) Zia M Rehman: 076 606 7786 (Researcher) Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F.Otieno on 031 373 2382 or dvctip@dut.ac.za.

Your participation is highly appreciated and essential to the growth of research in chiropractic and sport.
Kind Regards,
Zia M Rehman.

Permission provided by:

Name:

Signature:

Position:

Date:

INFORMED CONSENT

Statement of Agreement to Participate in the Research Study:

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

_____ _____ _____ _____

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

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

_____ _____ _____

Full Name of Researcher **Date** **Signature**

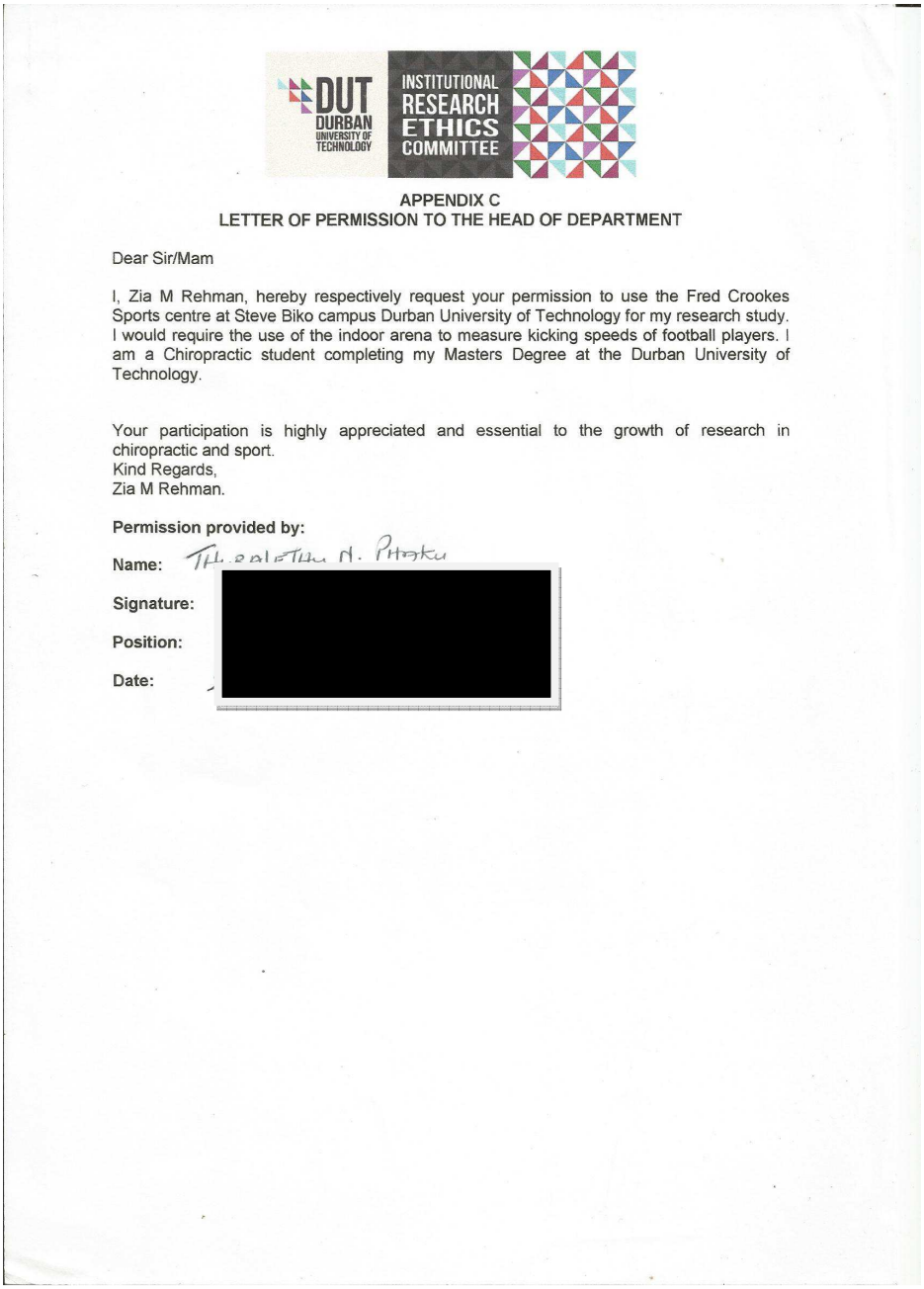
_____ _____ _____

Full Name of Witness (If applicable) **Date** **Signature**

_____ _____ _____

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

APPENDIX C - LETTER OF PERMISSION TO THE HEAD OF DEPARTMENT



APPENDIX C
LETTER OF PERMISSION TO THE HEAD OF DEPARTMENT

Dear Sir/Mam

I, Zia M Rehman, hereby respectively request your permission to use the Fred Crookes Sports centre at Steve Biko campus Durban University of Technology for my research study. I would require the use of the indoor arena to measure kicking speeds of football players. I am a Chiropractic student completing my Masters Degree at the Durban University of Technology.

Your participation is highly appreciated and essential to the growth of research in chiropractic and sport.
Kind Regards,
Zia M Rehman.

Permission provided by:

Name: [illegible]

Signature: [redacted]

Position:

Date:

APPENDIX D - PLAYERS' PERCEPTION OF KICKING SPEED POST INTERVENTION

Ipsilateral group	Ave pre kick velocity	ACTUAL CHANGE Ave post kick velocity	Did you feel any change in your kick after treatment	PERCEIVED CHANGE If yes did it INCREASE,DECREASE or STAY THE SAME	Comments by players after treatment
1	79.3	79.0	Yes	INCREASE	Hip feels more lighter
2	73.3	78.0	Yes	INCREASE	Felt an incr in power post tx
3	78.0	80.0	Yes	INCREASE	Felt leg more free
4	79.7	84.7	Yes	INCREASE	Feels more comfortable
5	82.7	84.3	Yes	DECREASE	No change
6	75.7	76.0	Yes	INCREASE	Leg feels more motion
7	86.0	90.0	Yes	INCREASE	Feels more motion
8	100.7	102.7	Yes	INCREASE	Feels more power
9	87.3	90.0	Yes	INCREASE	Hip feels better more looser
10	87.0	89.3	Yes	INCREASE	Feel better now more lose
11	93.0	97.7	Yes	INCREASE	0
12	85.3	98.0	Yes	INCREASE	0
13	73.3	78.0	Yes	INCREASE	0
14	76.3	81.3	Yes	INCREASE	0
15	67.3	73.0	Yes	INCREASE	0
16	79.3	85.0	Yes	INCREASE	Hip lighter
17	66.7	75.0	Yes	INCREASE	Felt leg more free
18	86.0	95.7	Yes	INCREASE	Power
19	69.7	72.3	Yes	INCREASE	0
20	76.0	81.7	Yes	INCREASE	0

Contralateral group	Ave pre kick velocity	**ACTUAL CHANGE** Ave post kick velocity	**Did you feel any change in your kick after treatment**	**PERCEIVED CHANGE If yes did it INCREASE,DECREASE or STAY THE SAME**	**Comments by players after treatment**
1	79.3	80.0	Yes	INCREASE	Joints feel less stuck. Feel more flexible
2	83.3	79.3	Yes	INCREASE	0
3	68.3	76.3	Yes	INCREASE	Feels looser more flexible more balance
4	74.7	77.0	Yes	INCREASE	0
5	68.7	71.0	Yes	INCREASE	0
6	62.3	62.3	Yes	INCREASE	Increase
7	75.3	72.0	Yes	INCREASE	Feels little bit better
8	80.3	79.3	Yes	DECREASE	0
9	76.7	82.3	Yes	INCREASE	0
10	73.0	77.3	Yes	INCREASE	15% change
11	77.7	78.0	Yes	INCREASE	Feels lighter, before had no balance feels has more balance
12	86.7	86.7	Yes	INCREASE	0
13	84.7	86.7	Yes	INCREASE	Feel kick more power
14	79.7	81.7	Yes	INCREASE	0
15	77.0	84.3	Yes	INCREASE	0
16	74.7	83.3	Yes	INCREASE	0
17	77.7	84.3	Yes	INCREASE	0
18	64.3	74.0	Yes	INCREASE	0
19	71.0	81.7	Yes	INCREASE	0
20	75.3	83.0	Yes	INCREASE	0

Placebo group	Ave pre kick velocity	**ACTUAL CHANGE** Ave post kick velocity	**Did you feel any change in your kick after treatment**	**PERCEIVED CHANGE If yes did it INCREASE,DECREASE or STAY THE SAME**	**Comments by players after treatment**
1	67.3	71.7	Yes	INCREASE	Slight inc
2	46.0	53.3	No	SAME	0
3	57.3	45.7	No	SAME	0
4	56.7	65.0	Yes	INCREASE	Feels improvement
5	59.7	75.0	Yes	INCREASE	0
6	70.7	62.0	No	SAME	0
7	64.0	54.7	No	SAME	0
8	61.3	66.3	Yes	INCREASE	0
9	71.3	64.0	Yes	INCREASE	Thinks a bit faster
10	69.3	69.7	Yes	INCREASE	Felt slight change
11	63.0	69.0	Yes	INCREASE	Thinks a little bit faster
12	72.7	71.7	No	SAME	0
13	63.0	63.0	No	SAME	0
14	71.3	69.7	No	SAME	0
15	81.0	81.3	No	SAME	0
16	70.0	69.7	No	SAME	0
17	80.3	79.7	No	SAME	0
18	64.3	65.3	No	SAME	0
19	74.3	77.3	Yes	INCREASE	Feel more power
20	79.0	79.7	Yes	INCREASE	0

APPENDIX E - WARM-UP ROUTINE

WARM UP STRETCHES FOR THE PARTICIPANTS

The participants will follow these stretches shown by the researcher which will take five min to complete as described by Vizniak (2010).

ALL THESE STRETCHES WILL BE DONE BILATERALLY AND HELD FOR 15 SECONDS WITH A REPETITION OF 3 TIMES

GLUTS

The participant should lay supine. Bring both knees to the chest and hold.

HAMSTRINGS

The participant would be standing and slowly bends down reaching for his toes.

QUADRICEPS

Participant is standing and brings ankle backwards so that the heel touches the buttocks while supporting the ankle with his hand.

HIP FLEXOR

Participant is standing and places one leg infront of him at 90 degrees and the other behind as far back as you can, and hold the stretch.

GASTROCS

Participant stands facing a wall resting both hands on the wall and places one leg a step infront of the other. The other leg is placed further back and then he will lean forward and hold the stretch.

ADDUCTORS

Patient sits on the floor and sits in a butterfly position with both soles of foot touching each other then pushing down on the knees and holding the stretch.

APPENDIX F - CASE HISTORY

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: _____ Date: _____

File #: _____ Age: _____

Sex: _____ Occupation: _____

Student: _____ Signature _____

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:
Previous: Current:

X-Ray Studies:
Previous: Current:

Clinical Path. lab:
Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:
Reason for Conditional:

Signature: Date:

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

Case Summary signed off: Date:

Page 1 of 4

Student's Case History:

1. **Source of History:**

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

3. **Present Illness:**

	Complaint 1 (principle complaint)	Complaint 2 (additional or secondary complaint)
Location		
Onset : Initial:		
Recent:		
Cause:		
Duration		
Frequency		
Pain (Character)		
Progression		
Aggravating Factors		
Relieving Factors		
Associated S & S		
Previous Occurrences		
Past Treatment		
Outcome:		

4. **Other Complaints:**

5. **Past Medical History:**

General Health Status

Childhood Illnesses

Adult Illnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

Current Medication
Analgesics/week:
Other (please list):

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

Age of all family members
Health of all family members
Cause of Death of any family members

	Noted	Family member		Noted	Family member
Alcoholism			Headaches		
Anaemia			Heart Disease		
Arthritis			Kidney Disease		
CA			Mental Illness		
DM			Stroke		
Drug Addiction			Thyroid Disease		
Epilepsy			TB		
Other (list)					

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

9. Review of Systems (please highlight with an asterisk those areas that are a problem for the patient and require further investigation)

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

APPENDIX G - FULL PHYSICAL

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DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

PHYSICAL EXAMINATION: SENIOR

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

Student: **Signature:**

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

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

SYSTEM SPECIFIC EXAMINATION:

CARDIOVASCULAR EXAMINATION

RESPIRATORY EXAMINATION

ABDOMINAL EXAMINATION

NEUROLOGICAL EXAMINATION

COMMENTS

Clinician: **Signature:**

Page 1

APPENDIX H - LUMBAR AND HIP EXAMINATION

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DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION

LUMBAR SPINE AND PELVIS

Patient: _____ File#: _____ Date: _____

Student: _____ Clinician: _____

STANDING:

Posture– scoliosis, antalgia, kyphosis
Body Type
Skin
Scars
Discolouration

Minor's Sign
Muscle tone
Spinous Percussion
Schober's Test (6cm)
Bony and Soft Tissue Contours

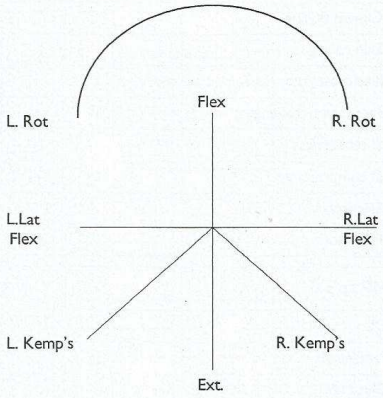
GAIT:

Normal walking
Toe walking
Heel Walking
Half squat

ROM:

Forward Flexion = 40-60° (15 cm from floor)

Extension = 20-35°
L/R Rotation = 3-18°
L/R Lateral Flexion = 15-20°



Which movement reproduces the pain or is the worst?

- Location of pain
- Supported Adams: Relief? (SI)
- Aggravates? (disc, muscle strain)

SUPINE:

Observe abdomen (hair, skin, nails)
Palpate abdomen\groin
Pulses - abdominal
- lower extremity
Abdominal reflexes

		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
SLR	**L**										
	R										

	L	R
Bowstring		
Sciatic notch		
Circumference (thigh and calf)		
Leg length: actual -		
apparent -		
Patrick FABERE: pos\neg – location of pain?		
Gaenslen's Test		
Gluteus max stretch		
Piriformis test (hypertonicity?)		
Thomas test: hip \ psoas \ rectus femoris ?		
Psoas Test		

SITTING:

Spinous Percussion
Lhermitte

Valsalva

Page 1 of 4

TRIPOD SI, +, ++		Degree	LBP?	Location	Leg pain	Buttock	Thigh	Calf	Heel	Foot	Braggard
	L										
	R										

SLUMP 7 TEST											
	L										
	R										

LATERAL RECUMBENT:	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:	L	R
Gluteal skyline		
Skin rolling		
Iliac crest compression		
Facet joint challenge		
SI tenderness		
SI compression		
Erichson's		
Pheasant's		

MF tp's	**Latent**	**Active**	**Radiation**
QL			
Paraspinal			
Glut Max			
Glut Med			
Glut Min			
Piriformis			
Hamstring			
TFL			
Iliopsoas			
Rectus Abdominis			
Ext/Int Oblique muscles			

NON ORGANIC SIGNS:

Pin point pain
Trunk rotation
Flip Test
Ankle dorsiflexion test
Axial compression
Burn's Bench test
Hoover's test
Repeat Pin point test

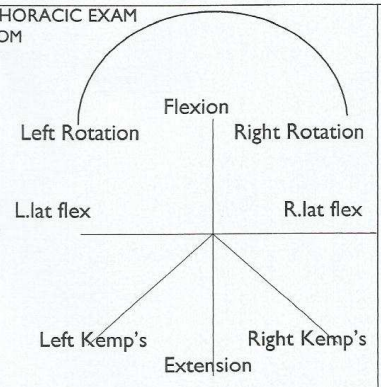
NEUROLOGICAL EXAMINATION

Fasciculations						
Plantar reflex						
level	**Tender?**	**Dermatomes**		**DTR**		
		L	**R**		**L**	**R**
T12				Patellar		
L1				Achilles		
L2						
L3				Proprioception		
L4						
L5						
S1						
S2						
S3						

MYOTOMES

Action	Muscles	Levels	L	R	
Lateral Flexion spine	Muscle QL				
Hip flexion	Psoas, Rectus femoris				5+ Full strength
Hip extension	Hamstring, glutes				4+ Weakness
Hip internal rotation	Glutmed, min, TFL, adductors				3+ Weak against grav
Hip external rotation	Gluteus max, Piriformis				2+ Weak w\o gravity
Hip abduction	TFL, Glut med and minimus				1+ Fascic w\o gross movt
Hip adduction	Adductors				0 No movement
Knee flexion	Hamstring,				
Knee extension	Quad				W - wasting
Ankle plantarflexion	Gastrocnemius, soleus				
Ankle dorsiflexion	Tibialis anterior				
Inversion	Tibialis anterior				
Eversion	Peroneus longus				
Great toe extensor	EHL				

BASIC THORACIC EXAM
Passive ROM



History :

Orthopedic assessment:

BASIC HIP EXAM

History
ROM: Active
Passive: Medial rotation: A) Supine (neutral) If reduced
- hard \ soft end feel

B) Supine (hip flexed):
- Trochanteric bursa

MOTION PALPATION AND JOINT PLAY	L	R
Thoracic Spine		
Lumbar Spine		
Sacroiliac Joint		

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HIP REGIONAL EXAMINATION

Patient: _____ File no: _____ Date: _____

Student: _____ Signature: _____

_____

Clinician: _____ Signature: _____

Hip with complaint: Right ☐ Left: ☐

OBSERVATION

- Gait: _____
- Posture: _____
- Weight-bearing symmetry: _____
- Balance and proprioception (Stork-standing test): _____
- Bony / soft tissue contours: Buttock contour _____
  Hip flexion contracture _____
  Lumbar lordosis _____
  Scoliosis _____
- Skin: _____
- Swelling: _____

PALPATION

· Anterior aspect

			Right	Left
1.	Iliac crests			
2.	Greater trochanter			
3.	Pubic symphysis and tubercle			
4.	Femoral head			
5.	Femoral ☐	Femoral artery		
		Lymph nodes		
6.	ASIS's			
7.	Inguinal ligament			
8.	Inguinal hernia			
9.	Muscles -	Quadriceps		
		Adductors		
		Abductors		
		Psoas		

· Posterior aspect

			Right	Left
1.	Iliac crests posteriorly			
2.	Ischial tuberosity			
3.	Muscles	Piriformis		
		Gluteals		
		Hamstrings		
4.	PSIS's			
5.	Sciatic notch			
6.	SI joints			
7.	Lumbar Spine			
8.	Sacrum + coccyx			

ACTIVE MOVEMENTS *(note rom and pain)*		Right	Left
1.	Flexion (110-120°)		
2.	Extension (10-15°)		
3.	Adduction (30°)		
4.	Abduction (30-50°)		
5.	Medial rotation (30-40°)		
6.	Lateral rotation (40-60°)		

PASSIVE MOVEMENTS (*note end-feel, rom and pain*)			Right	Left
1.	Flexion (tissue stretch or approximation)			
2.	Extension (tissue stretch)			
3.	Adduction (tissue stretch or approximation)			
4.	Abduction (tissue stretch)			
5.	Medial rotation (tissue stretch)			
6.	Lateral rotation (tissue stretch)			
RESISTED ISOMETRIC MOVEMENTS (*note strength and pain*)			Right	Left
1.	Hip Flexion			
2.	Hip Extension			
3.	Adduction			
4.	Abduction			
5.	Medial rotation			
6.	Lateral rotation			
7.	Knee flexion			
8.	Knee extension			
REFLEXES			Right	Left
1.	Patella			
2.	Achilles			
DERMATOMES (*indicate deficits by level & location*)				
1.	Level			
2.	Location			
JOINT PLAY MOVEMENTS			Right	Left
1.	Caudal glide (long axis traction superior – inferior)			
2.	Compression@ 90° (inferior – superior)			
3.	Medial ➢ lateral @ 180° / @ 90°			
4.	Lateral ➢ medial @ 180° / @ 90°			
5.	Internal rotation			
6.	External rotation			
7.	Anterior ➢ posterior			
8.	Posterior ➢ anterior			
9.	Quadrant (scouring) test			
SPECIAL TESTS			Right	Left
1.	Patrick FABER Test			
2.	Trendelenberg Test			
3.	Craig's Test			
4.	Leg Length	Actual		
		Apparent		
5.	Sign of the Buttock			
6.	Thomas Test (hip flexion contracture)			
7.	Rectus Femoris Contracture Test			
8.	Iliopsoas contracture Test			
9.	Ely's Test (rectus femoris hypertonicity)			
10.	Ober's Test (ITB contracture)			
11.	Noble Compression Test (ITB Friction Syndrome)			
12.	Piriformis Test			
13.	Hamstrings	Hamstring Contracture Test		
		Tripod Test		

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

Patient Name: **File number:** **Page:**

Date: **Visit:** **Student:**

Attending Clinician: **Signature:**

S: Numerical Pain Rating Scale (Patient) Student Rating **A:**

Least 0 1 2 3 4 5 6 7 8 9 10 Worst ☐

O: **P:**

E:

Special attention to: **Next appointment:**

Date: **Visit:** **Student:**

Attending Clinician: **Signature:**

S: Numerical Pain Rating Scale (Patient) Student Rating **A:**

Least 0 1 2 3 4 5 6 7 8 9 10 Worst ☐

O: **P:**

E:

Special attention to: **Next appointment:**

Date: **Visit:** **Student:**

Attending Clinician: **Signature**

S: Numerical Pain Rating Scale (Patient) Student Rating **A:**

Least 0 1 2 3 4 5 6 7 8 9 10 Worst ☐

O: **P:**

E:

Special attention to: **Next appointment:**

APPENDIX I - STATISTICIAN AGREEMENT

The Research Committee
Durban University of Technology
Durban

2 Dec 2013

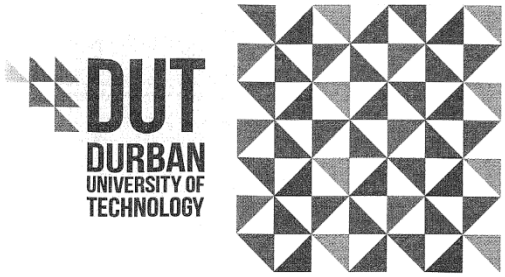
Re: Zia Rehman Research

This is to confirm that I have been consulted by the above-mentioned student from the Chiropractic Department at DUT. I am satisfied with the proposed analysis and have agreed to analyse the data for this research project.

Yours sincerely

Deepak Singh
DUT Statistician

APPENDIX J - ETHICS CLEARANCE CERTIFICATE



Institutional Research Ethics Committee
Faculty of Health Sciences
Room MS 49, Mansfield School Site
Gate 8, Ritson Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2900
Fax: 031 373 2407
Email: lavishad@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

23 January 2014

IREC Reference Number: **REC 70/13**

Mr Z U M Rehman
16 Blinkbonnie Road
Bonela
Mayville
4091

Dear Mr Rehman

The immediate effect of ipsilateral and contralateral sacroiliac joint manipulation on the hip range of motion and kicking velocity in soccer players

I am pleased to inform you that Full Approval has been granted to your proposal REC 70/13.

The Proposal has been allocated the following Ethical Clearance number **IREC 002/14**. Please use this number in all communication with this office.

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

Any adverse events [serious or minor] which occur in connection with this study and/or which may alter its ethical consideration must be reported to the IREC according to the IREC SOP's. In addition, you will be responsible to ensure gatekeeper permission.

Please note that any deviations from the approved proposal require the approval of the IREC as outlined in the IREC SOP's.

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC

APPENDIX K- DATA READINGS

Flexion			Extension				Int Rot				Ext Rot				Pre			
-Hip	Post Hip		Pre-Hip		Post Hip		Pre-Hip		Post Hip		Pre-Hip		Post Hip					
Left	Right	Left	right	Left	Right	Left	right	Left	Right	Left	right	Left	Right	Left	Kick One	Kick Two	Kick Three	Average
100	116	103	29	26	34	29	29	39	30	39	27	30	47	43	76	81	81	79.3
104	106	104	16	14	19	24	39	39	40	48	29	29	29	30	74	72	74	73.3
98	112	111	19	19	26	20	24	38	44	56	23	26	46	46	76	68	90	78.0
96	98	96	26	26	27	25	44	40	44	52	41	49	41	49	83	78	78	79.7
108	97	108	15	16	15	16	44	37	47	38	50	44	52	45	79	84	85	82.7
103	111	103	16	15	16	15	38	35	44	35	44	66	49	70	77	73	77	75.7
120	117	120	19	15	19	16	31	33	36	36	30	36	32	37	86	85	87	86.0
94	100	100	11	14	15	14	34	31	39	35	27	24	29	28	103	99	100	100.7
117	117	117	15	15	15	15	27	31	32	35	48	57	49	58	84	89	89	87.3
101	113	103	16	14	15	15	41	42	43	44	35	60	37	65	88	93	80	87.0
101	96	101	14	14	14	14	31	54	33	55	29	27	31	29	95	83	101	93.0
101	99	101	14	14	15	14	31	54	33	56	27	27	31	28	88	83	85	85.3
104	106	104	16	14	19	24	39	38	48	42	29	29	29	30	74	72	74	73.3
92	105	87	16	16	17	17	60	58	59	49	15	30	13	23	77	74	78	76.3
92	111	87	13	14	15	15	55	49	60	52	15	30	15	30	68	65	69	67.3
99	116	100	25	21	28	22	29	39	32	39	30	32	47	43	76	83	79	79.3
98	112	111	19	19	26	20	24	38	44	56	23	26	46	46	65	68	67	66.7
94	109	94	10	14	14	14	45	31	50	33	26	24	28	25	91	85	82	86.0
112	113	112	11	12	11	11	41	50	43	52	31	33	32	34	66	78	65	69.7
101	99	101	12	13	12	13	45	49	46	50	39	35	40	36	74	75	79	76.0
90	116	109	17	15	16	17	35	51	54	60	14	13	20	15	80	82	76	79.3
92	105	87	16	16	17	17	60	58	59	49	15	30	13	23	80	85	85	83.3
83	88	83	15	16	17	21	38	36	38	43	16	56	40	56	70	66	69	68.3
102	116	119	16	14	19	19	15	26	34	38	26	25	35	39	73	70	81	74.7
93	105	98	22	12	28	24	39	33	41	46	34	35	33	39	67	69	70	68.7
89	100	89	10	13	10	13	34	39	37	39	24	43	32	43	59	64	64	62.3
96	98	96	9	9	11	10	15	39	23	39	25	24	25	24	75	69	82	75.3
102	111	106	19	26	18	26	68	72	79	72	16	45	48	43	82	78	81	80.3
116	101	116	22	20	29	20	35	40	35	41	33	33	42	33	77	73	80	76.7
106	96	106	16	14	25	16	30	45	35	45	39	42	46	41	71	75	73	73.0
106	98	106	25	17	26	24	45	60	56	60	48	49	52	49	84	76	73	77.7
98	98	98	19	18	25	19	40	52	43	52	31	34	31	39	88	85	87	86.7
115	112	115	14	13	14	13	60	45	62	46	40	35	41	38	82	84	88	84.7
103	112	105	18	25	18	26	67	71	68	75	15	46	16	45	80	75	84	79.7
94	105	94	21	13	21	13	40	33	41	38	35	36	36	38	74	81	76	77.0
90	101	90	15	15	17	16	35	45	35	51	14	14	14	14	81	69	74	74.7
102	101	102	16	14	16	15	15	26	16	28	26	25	28	29	78	80	75	77.7
87	105	87	15	15	17	17	58	44	59	49	13	29	13	23	66	65	62	64.3
84	89	88	15	14	15	14	37	39	37	40	17	55	19	60	65	70	78	71.0
98	101	98	10	13	11	16	37	39	37	45	32	43	32	49	80	68	78	75.3
92	77	85	9	12	16	6	22	25	51	50	9	45	9	45	65	66	71	67.3
96	106	85	8	9	8	9	47	57	58	50	26	19	45	45	53	24	61	46.0
73	82	99	11	16	22	26	32	35	57	59	32	15	39	47	62	55	55	57.3
72	90	85	19	15	16	15	37	41	51	22	11	46	4	26	72	26	72	56.7
64	81	64	24	24	25	25	50	34	50	35	5	8	6	10	72	56	51	59.7
94	77	79	12	12	14	15	46	46	57	42	25	25	26	24	77	67	68	70.7
74	78	76	15	14	15	13	48	45	47	45	31	33	33	35	65	60	67	64.0
87	71	69	15	15	14	14	60	40	52	47	30	35	35	41	72	66	46	61.3
100	87	96	15	15	15	14	60	40	58	36	34	8	32	8	64	79	71	71.3
100	88	90	15	15	15	15	59	47	60	48	14	19	15	19	68	70	70	69.3
74	85	86	12	12	14	15	48	44	60	46	8	4	7	3	63	65	61	63.0
103	99	101	12	13	13	13	47	45	50	51	20	25	22	23	68	75	75	72.7
100	100	100	13	14	13	14	55	49	55	49	35	38	35	38	61	65	63	63.0
88	88	89	9	8	9	8	25	29	25	29	30	28	30	28	74	75	65	71.3
99	95	99	9	10	9	10	45	44	45	44	30	33	30	33	88	81	74	81.0
113	110	113	13	14	13	14	45	49	45	49	33	33	33	33	64	75	71	70.0
118	120	118	9	10	9	10	58	57	58	57	38	37	38	38	85	81	75	80.3
114	114	114	14	14	14	14	59	60	59	59	29	27	29	27	65	66	62	64.3
100	104	102	17	17	17	16	15	30	16	28	32	40	31	40	74	76	73	74.3
80	91	82	19	16	20	16	45	55	45	54	60	49	60	50	77	79	81	79.0

APPENDIX L - INTERPRETATION OF THE STRENGTH OF A RELATIONSHIP

Table 6.5 ***Interpretation of the Strength of a Relationship (Effect Sizes)***

General Interpretation of the Strength of a Relationship	The *d* Family[a]	The *r* Family[b]		
	d	*r* and Φ	*R*	η (eta)[d]
Much larger than typical	≥1.00[c]	≥.70	.70+	.45+
Large or larger than typical	.80	.50	.51	.37
Medium or typical	.50	.30	.36	.24
Small or smaller than typical	.20	.10	.14	.10

[a] *d* values can vary from 0.0 to + or −1.0 infinity, but *ds* greater than one is uncommon.

[b] *r* family values can vary from 0.0 to + or −1.0, but except for reliability (i.e., same concept measured twice), *r* is rarely above .70. In fact, some of these statistics (e.g., phi) have a restricted range in certain cases; that is, the maximum phi is less then 1.0.

[c] We interpret the numbers in this table as a ran ge of values. For example a *d* greater than .90 (or less than −.90) would be described as "much larger than typical" a *d* between say .70 and .90 would be called 'larger than typical," and *d* between say .60 and .70 would be "typical to larger than typical" We interpret the other three columns similarly.

[d] Partial etas from SPSS multivariate tests are equivalent to *R*. Use *R* column.