THE IMMEDIATE EFFECT OF LUMBAR SPINAL MANIPULATIVE THERAPY ON PERFORMANCE IN FEMALE FIELD HOCKEY PLAYERS

By

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This work is submitted in partial compliance with the requirements for the Master's degree in Technology: Chiropractic at the Durban University of Technology

I, Arline Muller, do declare that this dissertation is representative of my own work in both conception and execution

June 2021

___ 15/06/2021____

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DEDICATION

To my amazing and loving family Willie, Hannelie, Stian, Minette and Liam without whom I could not have completed this adventure.

- If your dreams do not scare you, they are not big enough -

ACKNOWLEDGEMENTS

First and foremost, I would like to thank my heavenly Father that blessed me with opportunities to follow my dreams.

With many thanks to Dr Matkovich for your guidance and great insights into the planning and completion of this project. I would like to say a special thanks to Dr Prince, your continued support, encouragement, and thoughtful comments in the field has made this an inspiring experience for me.

I would like to thank everybody that made this project possible. Linda Twiggs and Amanda Makhonza for the organization in the clinic and booking participants, Tonya Estherhuizen for all the advice and performing statistical analysis, Linda Coertze for proof reading, the lecturers on the DRC committee that guided the study and last but not least all the participants that gave their all during testing.

Some people come into your life and leave footprints that can never be erased. Dr Korporaal you have been our rock at DUT. Thank you for all the hours and hours spent at sports events, extra time in the prac room, 24/7 availability, dedication to Chiropractic profession but most of all your kind heart and beautiful soul.

Thank you to all the love and support that my family has given me, I would not have started this adventure if it were not for your encouragement. I appreciated every phone call, meal, hug and endless conversations.

My Chiropractic journey would have been impossible to complete without the support of my colleagues the past six years. Imé, Rochelle, Izanne and Shinay I appreciate you more than you will ever know. You are great tutors, but you are even better friends.

ABSTRACT

Background:

Hockey is a popular recreational sport that is played not only by South Africans but people worldwide. Like all athletes, hockey players are continually seeking to improve their performance which can be measured by means of a sport-specific test battery (SSTB). Spinal manipulative therapy (SMT) has been demonstrated to improve performance in some sports and also in field hockey. Moreover, it has been shown to be effective in improving a single movement but it is unknown if it can improve the overall performance of a recreational field hockey player.

Aim:

The aim was to determine the immediate effect of spinal manipulative therapy (SMT) on the performance of female field hockey players.

Methods:

A quantitative control crossover study involving 20 recreational female field hockey players was chosen for this study. The sample was randomly assigned to either Group 1 or Group 2. The 20 participants completed a field hockey SSTB consisting of the sit-and-reach, vertical jump, 40 m sprint, and the 5-0-5 agility test to establish baseline scores. In phase one, after baseline testing, Group 1 received SMT of fixated joints in the lumbar region as determined by lumbar regional assessment. Group 2 received a control treatment involving setting up the participant for an adjustment but not administering the thrust. In phase two, Group 1 received the control treatment and SMT was administered to Group 2. Thereafter all the participants completed the SSTB and the results were compared to their earlier baseline scores. A 0.05 p-value was considered statistically significant.

Results and discussion:

There was a significant improvement in the results of the sit-and-reach, vertical jump, 40 m sprint and 5-0-5 tests after the administration of SMT. A carryover effect was detected

in the 40 m sprint test indicating that the treatment effect could not be interpreted as the effect of treatment depended on the order in which the participants received the treatments.

Conclusion:
Lumbar spinal manipulation therapy can improve the performance of female recreational field hockey players in terms of a sport specific tests battery (SSTB).

Key Words: *Chiropractic, Spinal manipulative therapy, Sport performance, Field hockey, Sport specific test battery*

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LIST OF ABBREVIATIONS

ANOVA	Analysis of variance
BMI	Body mass index
CI	Confidence interval
cm	Centimetre
COD	Change of direction
DUT	Durban University of Technology
H_0	Null hypothesis
IREC	Institutional Research and Ethics committee
Kg	Kilogram
KZN	Kwa-Zulu Natal
n	Sample size
ROM	Range of motion
s	Second
SD	Standard deviation
SMT	Spinal manipulative therapy
SSTB	Sport specific test battery
SST	Sport specific tests
Yrs.	Years

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Athletes competing in various sports are constantly trying to improve their performance and are seeking treatment options such as chiropractic assistance to achieve this goal (Wiggett 2015). In this context field hockey players are no exception. Field hockey is an Olympic sport that enjoys a high level of popularity worldwide (Barboza *et al.* 2018) and is played both recreationally and competitively in 122 countries (Murtaugh 2009). However, there is limited research available regarding interventions for the improved performance of female field hockey players (Naicker, Coetzee and Schall 2016).

Chiropractic treatment has been shown to improve and maintain muscle balance, the speed of neuromuscular reflexes, and joint function (Costa *et al.* 2009). It was thus envisaged that, by applying chiropractic treatments, players might be able to optimise their performance. It had already been established that chiropractic SMT could immediately improve one single movement in field hockey (Wiggett 2015), but it was unknown if chiropractic SMT would improve players' overall hockey performance, and therefore further investigation was warranted. It is important to improve athletes' performance not only for the purpose of playing a competitive sport but also for the prevention of injuries as sport injuries are inherently linked to performance (McGregor 2017).

The effect of chiropractic SMT on field hockey players' performance needed to be determined and the best combination of tests that would potentially provide the necessary information was the use of a sports-specific test battery (SSTB) (Botelho *et al*. 2017). Testing batteries can be used to distinguish between varying standards of a female hockey players' performance (Justin *et al*. 2003). Players who perform better overall in tests that are included in the battery are more likely to perform better during a field hockey game (Justin *et al*. 2003).

The available literature suggests that field hockey players will benefit from optimising their performance (Justin *et al.* 2003) and there is some evidence that SMT improves

sport performance (Botelho *et al.* 2017). It was for this reason that the paucity in existing literature that describes the effects of SMT on the performance of female recreational hockey players had to be augmented. The argument is that if SMT has a positive effect on players' performance in recreational field hockey, it may promote and encourage the inclusion of chiropractors in multidisciplinary sport teams along with doctors, physiotherapists, sport scientists, and biokineticists.

1.2 AIMS AND OBJECTIVES

1.2.1 Aim of the study

To determine the immediate effect of spinal manipulative therapy on performance of female club field hockey players.

1.2.2 Objectives of the study

Objective 1: To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post SMT.

Objective 2: To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post control.

Objective 3: To compare the results of objective 1 to objective 2 in terms of SSTB.

1.3 HYPOTHESES

1.3.1 Null hypotheses

The null hypothesis (H_0) was set in respect of the objective and are as follows:

H_0 1: Lumbar SMT will not have a significant immediate effect on sit and reach in female recreational field hockey players.

H_0 2: Lumbar SMT will not have a significant immediate effect on vertical jump in female recreational field hockey players.

H_0 3: Lumbar SMT will not have a significant immediate effect on 40 m sprint in female recreational field hockey players.

H_0 4: Lumbar SMT will not have a significant immediate effect on 5-0-5 agility in female recreational field hockey players.

1.3.2 Hypotheses

Hypothesis 1: Lumbar SMT will have a significant immediate effect on sit-and-reach in female recreational field hockey players.

Hypothesis 2: Lumbar SMT will have a significant immediate effect on vertical jump in female recreational field hockey players.

Hypothesis 3: Lumbar SMT will have a significant immediate effect on 40 m sprint in female recreational field hockey players.

Hypothesis 4: Lumbar SMT will have a significant immediate effect on 5-0-5 agility in female recreational field hockey players.

1.4 RATIONALE

Recreational sport is commonly played by South Africans and has become a large part of people's lives as participation in such sport activities will improve fitness, health, fun, and social interaction (Kenefick and Cheuvront 2012). One such sport is field hockey. Most schools and universities in South Africa partake in field hockey and it has become the second most popular sport played by female learners in South African schools (Venter 2018). However, an intensive literature review revealed that limited research has been conducted to determine what might improve performance in female field hockey players (Naicker, Coetzee and Schall 2016).

An SSTB is an integral part of training as it addressed the movements and demands of a specific sport (Winter 2006). The SSTB for field hockey includes sit-and-reach, vertical jump, 5-0-5 agility, and 40 m sprint (Wood 2008). This test is important for prescribing appropriate exercises as well as monitoring and improving the performance of hockey players (Singh, Singh and Singh 2010). It is argued that, if hockey players improve one or more of these components, their overall performance will improve (Wood 2008).

Lower back (lumbar) injuries are common chronic musculoskeletal injuries among female hockey players (Ellapen, Van Heerden and Bowyer 2014). According to Murtaugh (2009), the semi-crouched position that hockey players adopt can contribute to lower back injuries. Spinal manipulative therapy (SMT) may then be applied to restore the areas of dysfunction in the spine and improve the player's biomechanics (Bleekers 2015). If the spine is functioning optimally, the body will be able to move effectively and improve one or more of the components in the SSTB. In a review by (Botelho *et al.* 2017) of the effects of SMT on sport performance, 57% of the studies included in the review indicated that SMT enhanced performance. Unfortunately field hockey was not included in this review and thus the effects of SMT on the performances of field hockey players needed to be investigated, as proposed by Wood (2008). Recent studies revealed that SMT improved the sit-and-reach test (Cardinale *et al.* 2014), the vertical jump test (Humphries *et al.* 2013), the 5-0-5 agility test, and the 40 m sprint test (Shrier, Macdonald and Uchacz 2006).

More specifically, the immediate effect of lumbar chiropractic SMT on the SST in recreational female hockey players in the eThekwini Municipality had yet to be determined. Field hockey is a competitive sport, and the players compete in high performance competitions among clubs, provincial programs, universities, and national teams. Field hockey players will benefit from improving their performance and it was, therefore, necessary to perform these tests to determine if chiropractic SMT would be an appropriate treatment option to improve field hockey players' performance.

1.5 BENEFITS

The following parties stand to benefit should the results of the study confirm that the immediate effect of SMT can improve the performance of recreational hockey players: hockey players, coaches, the South Africa Hockey Association, and chiropractors.

- The overall personal performances of hockey players will be improved if each component of the SST is improved.

- Coaches can improve their teams' total performance by improving each of the components of the SST – flexibility, strength, speed, and agility.

- The South African Hockey Association stands to benefit if the performances of South African hockey players are improved.

- Chiropractic treatments will be promoted among hockey players as their demand for chiropractic manipulation will increase in their quest to improve their overall performance.

1.6 DISSERTATION STRUCTURE

This dissertation is presented in dissertation format as approved by the Durban University of Technology (DUT). The dissertation consists of seven chapters.

Chapter 1 presents the problem, states the aims and the hypotheses, and provides a summary of the structure of the dissertation. The literature review that focused on the immediate effect of chiropractic SMT on SST of recreational hockey players is presented in **Chapter 2**. **Chapter 3** is the methodology section where the methods that were used in this study are described. **Chapter 4** reveals the results in table and graph format. The results are discussed in **Chapter 5** while **Chapter 6** presents the conclusion, limitations, and recommendations for further research. The seventh and ultimate chapter presents the article that was written in accordance with the

requirements for manuscripts submitted to biomedical journals for publication in a peer reviewed journal. **Chapter 7** is followed by the reference list and the appendices.

All the references are presented alphabetically at the end of the dissertation. The references are presented in accordance with the DUT Harvard style.

1.7 CONCLUSION

Chapter 1 has provided the introduction for the study, determined the basis for the problem identified and set the hypotheses. In the next chapter, chapter 2, the literature concerning the problem that was investigated will be discussed.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

Chapter 2 presents an intensive review of literature related to the study and offers the reader insight into chiropractic SMT and the benefits thereof in sport and, more specifically, in field hockey. SSTB that consists of SST can be used to measure performance and this chapter will explain the tests relevant to field hockey.

2.2 FIELD HOCKEY

Field hockey is played by two teams of 11 players each. The goal of the game is to hit a small hard ball into the opponent's goal using a specialised hockey stick that is curved at the bottom end (Anders and Myers 2008). On average, a hockey player covers a running distance of 6.6 km during a match with 97.3% of total play time spent in low to moderate intensity activities with frequent high intensity bouts of running for a distance of 20 m (Gabbett 2010). Field hockey thus demands great physiological capability as the players need good aerobic system capacity as well as muscle power for sprints (Elferink-Gemser *et al.* 2006).

2.2.1 Biomechanics in field hockey

Field hockey players need to sustain forces that are generated for sharp turns and fast running using their lower bodies while using their upper bodies and arms to strike and control the ball (Feeley *et al.* 2019). Movements in hockey are predominantly unilateral and asymmetric and common movements in hockey include jogging, walking, and sprinting with or without dribbling the ball on the ground with the curved end of the hockey stick (Krzykała *et al.* 2018). Field hockey requires the athlete to maintain a semi-crouched position and this may contribute to the risk of musculoskeletal disorders (Krzykała *et al.* 2018).

A study conducted on field hockey players concerning the structural and functional changes in the lumber spine revealed that the lumbar lordosis linearly increased with

training over years (Ogurkowska and Kawałek 2017). According to Ogurkowska and Kawalek (2007), hockey players should have a large side bending ability with flexion and rotation to the right. Furthermore, radiological density analysis suggests that the vertebral bodies of hockey players become more fragile with time (Ogurkowska and Kawałek 2017).

Low back injuries and muscle strains are frequent injuries in females who play field hockey (Jooste 2015). According to a systematic review on injuries in field hockey players, Barboza *et al.* (2018) found that the most common injuries in field hockey are sustained to the lower limbs. The semi-crouched position combined with rotation and side bending generates loads and stress on these athletes' bodies and could lead to lumbar problems (Yard and Comstock 2006). Lumbar pain is a real risk factor in field hockey as a 60% prevalence was demonstrated in a 12-month trial among young elite athletes aged between 14 – 25 years (van Hilst *et al.* 2015).

2.3 THE LUMBAR SPINE

The vertebral column consists of 33 vertebrae divided into five regions: seven cervical, twelve thoracic, five lumbar, five sacral and four coccygeal (Moore, Dalley and Agur 2014). The size of the vertebrae increases as the vertebral column descends to the sacrum. This change in size occurs to accommodate the increase in body weight as each successive vertebra bears more weight (Moore, Dalley and Agur 2014). The vertebra reaches its largest size superior to the sacrum where the weight is transferred through the sacroiliac joints to the pelvic girdle (Moore, Dalley and Agur 2014). The successive vertebrae articulate at a synovial facet joint that controls and facilitates the vertebral column's flexibility (Moore, Dalley and Agur 2014).

There are five lumbar vertebrae between the thorax and the sacrum (Moore, Dalley and Agur 2014). The lumbar spine has a singular lordosis curvature that develops secondary as the toddler starts to stand and walk (Moore, Dalley and Agur 2014). Greater movement can be produced in the cervical and lumbar spine compared to the other regions (Moore, Dalley and Agur 2014). These movements include: flexion, extension, lateral flexion, and rotation (Moore, Dalley and Agur 2014).

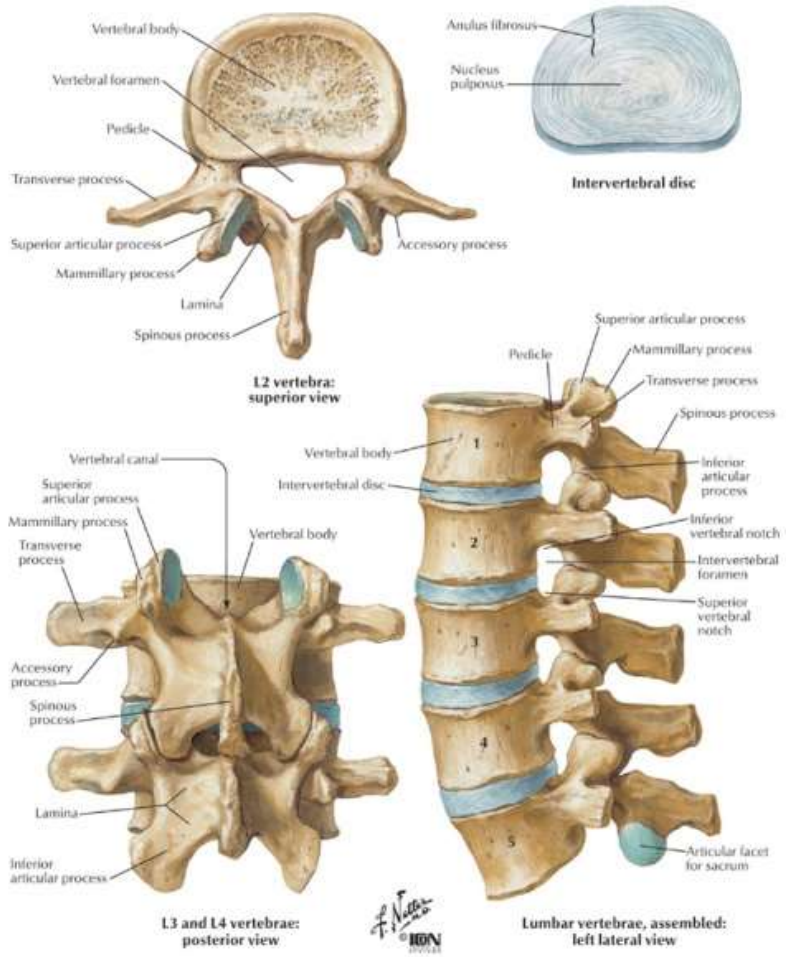


Figure 2.1: Lumbar spine anatomy (Physiopedia 2015)

The lumbar plexus arises from T12, L1 to L4 spinal nerves. The femoral nerve, the lateral femoral cutaneous nerve and the obturator nerve are the main nerves formed by the plexus (Moore, Dalley and Agur 2014). A restriction in the lumbar region can affect the motor functioning of the hip flexors and iliopsoas via the femoral nerve (L2 to L4), hip adductor and adductor longus via the obturator nerve (L2 to L4), and dorsiflexors of the ankle muscles (L5) (Basit, Eovaldi and Varacallo 2019). These muscles generate flexion, extension, abduction, and adduction of the femur at the hip and extension as well as flexion of the tibia at the knee and dorsiflexion of the foot (Moore, Dalley and Agur 2014).

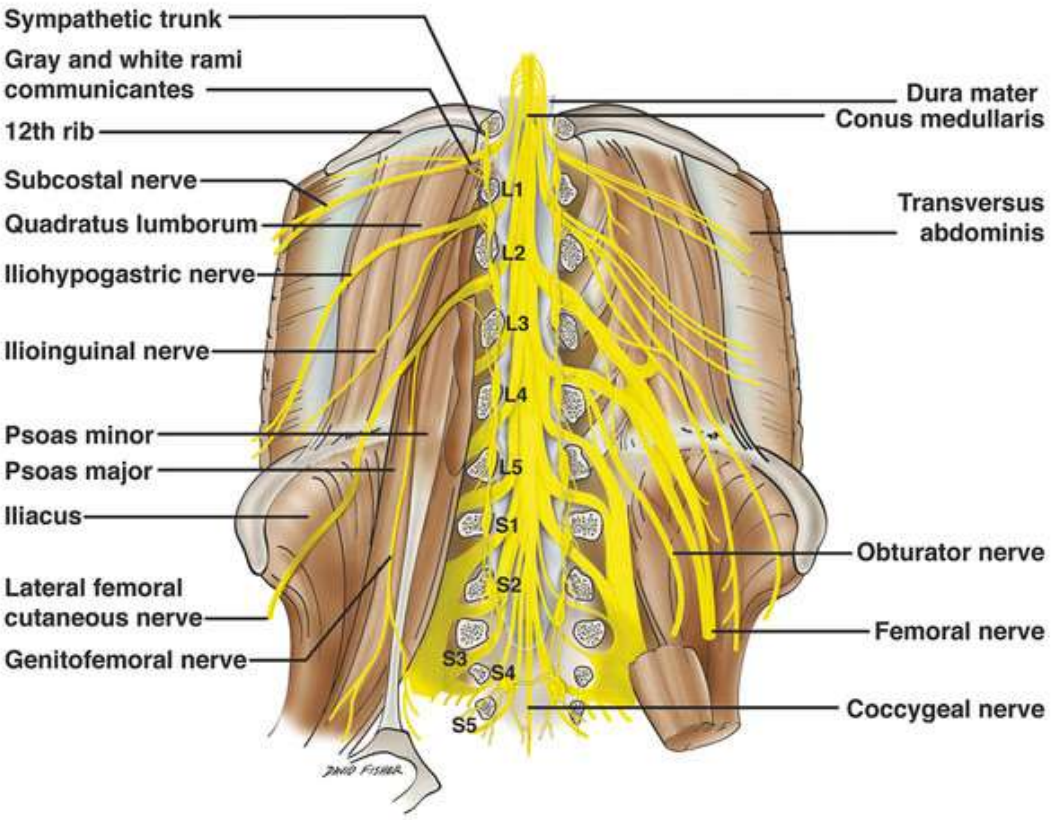


Figure 2.2: Lumbar nerves (Fisher 2021)

The lumbar spine impacts the lower limbs' exercise performance as multiple nerves exit the lumbar spine and innervate the ligaments, tendons, and muscles of the lower extremities (Ward *et al.* 2012). Thus adequate treatment for lumbar conditions is important for all people, including patients and clinicians (Rubinstein *et al.* 2019). SMT is a common approach used by chiropractors to treat lumbar issues (Vaillant *et al.* 2012), especially as SMT is effective in restoring the flexibility of the lumbar spine (Zhao and Tian 2009). It is therefore logical to suggest that chiropractic SMT of the lumbar spine can improve spinal mechanics and gait (Ward *et al.* (2012).

2.4 THE CHIROPRACTIC FIELD

Chiropractic is an important field in complementary and alternative medicine (Mącznik *et al.* 2014) and is described as "a system of healing that is based on the theory that a lack of normal nerve function results in disease in the human body". The profession is therefore concerned with musculoskeletal structures and the nervous system in the

maintenance and restoration of health (Stubenrauch 2011). Chiropractic emphasises that the body has inherent recuperative powers to heal itself in the absence of surgery and drugs (Redwood, Cleveland and Micozzi 2003).

Chiropractic principles focus on the relationship between the function of the nervous system and the structure of the spine and how this relationship affects the restoration and preservation of health (Redwood, Cleveland and Micozzi 2003). Wellness is the process of achieving the best health possible within a given genetic makeup. This occurs by pursuing the optimal level of functioning and strategies such as chiropractic treatment that can optimise these levels (Hawk *et al.* 2012).

Joint restriction is a chiropractic term that describes a complex of structural, pathological and/or functional articular changes that negatively affect the neural integrity of patients and influence their general health (Redwood, Cleveland and Micozzi 2003).Therefore, if the restriction is corrected it can enhance the restoration and preservation of health (Redwood, Cleveland and Micozzi 2003). Chiropractors' primary manual intervention is adjustment or spinal manipulation therapy (SMT) (Redwood, Cleveland and Micozzi 2003) which is aimed at correcting the joint restriction.

2.4.1 Spinal manipulative therapy (SMT)

SMT is a hands-on treatment that uses manipulation that is a high velocity low amplitude thrust to a synovial joint (Stubenrauch 2011). This manipulation is often accompanied by an audible click as a result of cavitation of the joint (Rubinstein *et al.* 2019). SMT is intentionally applied at a specific angle to the underlying vertebrae with the aim that the vertebrae (or the one vertebra) will move in the same direction (Kawchuk and Perle 2008). SMT is commonly used in many countries and its use has increased over the past several decades (Hurwitz 2012).

There are numerous hypotheses on the working of SMT that can crudely be divided into neurophysiological and biomechanical hypotheses (Rubinstein *et al.* 2019). The neurophysiological hypothesis suggests that the primary afferent neurons from pain processing, motor control system and paraspinal tissue are mainly affected by SMT

(Coronado *et al.* 2012). The biomechanical hypothesis suggests that SMT affects the functional or manipulable spinal lesion, thereby reducing internal mechanical stresses (Wong *et al.* 2015). From a mechanical perspective it is believed that SMT passively enforces a coupled motion in order to unlock a joint that is fixated, thereby restoring range of motion (Han *et al.* 2015).

Colloca, Keller and Gunzburg (2004) conducted a study to determine biomechanical and neurophysiological responses to SMT in patients with radiculopathy. Nine patients that were undergoing lumbar decompression surgery were recruited for this clinical trial study (Colloca, Keller and Gunzburg 2004). Chiropractic SMT was administered to the lumbar spine facet joints as well as the spinous processes during a laminarthrectomy and the outcome was measured using a triaxial accelerometer (Colloca, Keller and Gunzburg 2004). This was a ground-breaking study as previous studies to quantify spinal motions during SMT had typically been limited to cadaver studies due to the invasiveness of the procedure (Colloca, Keller and Gunzburg 2004). Colloca, Keller and Gunzburg (2004) concluded that the immediate effect of chiropractic SMT induced spinal motion (biomechanical) and nerve root responses (neurophysiological). Since the latter study SMT has been widely recognised and used successfully as a conservative treatment modality for pain and spinal joint dysfunction in health care fields (Herzog *et al.* 1993).

2.4.2 Benefits of SMT

Available evidence suggests that SMT is beneficial for a wide range of health problems that include cervical pain (Maiers *et al.* 2014), thoracic pain (Schiller 2001), lumbar pain (Rubinstein *et al.* 2019), lumbar disc herniation (Peterson *et al.* 2013), migraine (Tuchin 2014), cervicogenic headache (Fernández-de-las-Peñas *et al.* 2005), and colic, asthma, enuresis and scoliosis in children (Gleberzon *et al.* 2012). The most common indication for SMT is musculoskeletal conditions of which lower back and neck pain are the most common (Hurwitz 2012). Patient satisfaction is extremely high with SMT (Hurwitz 2012).

The focus of research on SMT has recently shifted from pain relief to motor and sensory response (Lo *et al.* 2019). It is argued that healthy, asymptomatic individuals

can also benefit from SMT, as was stated in a review of the effectiveness of SMT in healthy individuals (Lo *et al.* (2019). In the latter study three randomised controlled trials had been conducted and were included in the review. The study found that there was a significant increase in lower trapezius strength in 40 participants (N = 40 with females n = 21 and males n = 19 with a mean age of 33.1 years). Significant change in maximum voluntary isometric contraction of the quadriceps occurred immediately after intervention (n = 41). The study found no significant change between the treatment group and the sham group in any of the strength tests as measured by maximal voluntary contraction in 21 participants (female n = 12, men = 9 with a mean age of 33.6 years) (Lo *et al.* 2019). The study concluded that muscle strength was increased in asymptomatic subjects.

2.5 CHIROPRACTIC SUPPORT IN SPORT

Professional as well as non-professional athletes experience a high demand for performance enhancement (Botelho and Andrade 2012). Increasing numbers of athletes who compete in a variety of sports have been seeking chiropractic treatment in order to assist them in maintaining optimal competitive conditions (Costa *et al.* 2009). Chiropractic care has also become more sought after in national and international sporting events and is a well-used and accepted treatment option for athletes (Nook, Nook and Nook 2016). For instance, at the 1995 All African Games a total of 1 957 chiropractic treatments were performed on 1 135 athletes (Botelho and Andrade 2012). These rates are similar to those that were reported at the 2009 World Games where 1 514 chiropractic treatments were recorded. It was reported that these treatments benefited both athletes and non-athletes such as field marshals (Nook and Nook 2011). The lumbar spine was the region with the highest rate of treatment during the Games and chiropractic manipulation was the most utilised treatment option, followed by mobilisation (Nook and Nook 2011). More recently, at the 2013 World Games 1 463 athletes were treated with the thoracic spine being the most frequently treated area, followed by treatments of the lumbar spine (Nook, Nook and Nook 2016). Chiropractic manipulation and myotherapy were the treatments that were most frequently used (Nook, Nook and Nook 2016). The majority of athletes who had competed in international sporting events and who had received chiropractic care reported improvement post treatment (Nook, Nook and Nook 2016).

Chiropractic treatment has resulted in a dramatic reduction in lower limb injuries and improved injury preventions with significant reduction in weeks missed and lower limb muscle strains (Hoskins and Pollard 2010). After a six-week chiropractic treatment intervention program involving Australian football players (n = 59) with lower limb injuries, the protocol was individually determined with manipulation, mobilisation, and soft tissue therapies as the best possible treatment options (Hoskins and Pollard 2010). According to Costa *et al*. (2009), chiropractic treatment in athletes is directed at increasing performance rather than treating injuries. It is argued that performance may be optimised due to the improvement and maintenance of muscle balance, enhancement in the speed of neuromuscular reflexes, and improvement in joint function (Costa *et al.* 2009).

2.5.1 Immediate benefits of SMT in sport

SMT influences varies neurophysiological parameters that are associated with sport performance (Botelho *et al.* 2017). For instance, in the World Games 94% of the participants who were treated with SMT reported an immediate improvement in performance (Nook, Nook and Nook 2016). As SMT reduces pain and enhances spinal mobility, it is a sought-after treatment for high-level amateur golfers in the United States who wish to prevent disorders that can threaten their careers (Costa *et al.* 2009).

According to Botelho *et al.* (2017), four out of the seven clinical trials that they reviewed revealed that sport performance was improved by SMT. These studies included increased hip extension in male junior runners (n = 17), increased full swing in male golf players (n = 43), increased strength in male and female elite judoka (n = 18), and increased kicking speed in male elite soccer players (n = 40) (Botelho *et al.* 2017). However, the remaining three studies concluded that SMT did not improve sport performance (Botelho *et al.* 2017). These latter studies included male and female sprinters (n = 19) who respectively experienced no change in jump height and 40 m sprinting, recreational male basketball players (n = 24) who experienced no change in grip strength and free throw, and male and female cyclists (n = 20) who had no change in hip flexibility and cycling sprints (Botelho *et al.* 2017).

Conversely, a study conducted by Conradie (2013) found that chiropractic SMT to sacroiliac joints (SIJ) and to the lumbar spine in asymptomatic rugby players improved sprinting times as well as vertical jumps. The participants received a single treatment and experienced immediate benefits as a result of the treatment. These athletes reported that it provided a biomechanical advantage (Conradie 2013).

2.5.2 SMT in field hockey

According to the researcher's knowledge there have only been two studies that researched the effect of SMT on field hockey players. These studies reported contradictory results. Wiggett (2015) researched the immediate effect of SMT on drag flicking as a technique used by male field hockey players. The study found that the average drag flicking speed increased as the ROM of the cervical-, thoracic- and lumbar spine improved. The perception of the players concerning their drag flicking speed was that it improved after the control group had received SMT (Wiggett 2015). SMT was administered to the spinal region or a combination of regions where restrictions had been found.

Coston (2016) researched the effect of SMT on the speed of a hockey ball hit by hockey players with lumbo-sacral facet joint dysfunction. Thirty club, provincial and national hockey players were divided into a treatment group that received manipulation to restrictions in the lumbar and sacroiliac joints and a control group that received no treatment (Coston 2016). The treatment group received four manipulations over a two-week period. The study concluded that there was no significant effect on ball speed even though there was an effect on the lumbar spine ROM (Coston 2016).

Both these studies focused on a single skill in field hockey, namely the drag flick and ball speed respectively, with contradictory results. Field hockey demands great physiological ability that requires both muscle power and aerobic capacity (Elferink-Gemser *et al.* 2006), and it is therefore crucial to test all the physiological components that this sport demands. The current study was thus the first to test the effect of SMT on the primary physiological components that are crucial in field hockey. SMT has been shown to improve the performance of runners, soccer players, judoka and golf

players (Botelho *et al.* 2017) but it has hitherto not been assessed in terms of the performance of field hockey players.

2.6 PERFORMANCE IN SPORT

Athletes competing in various sports are constantly trying to improve their performance and are seeking approaches such as chiropractic treatment to achieve this goal (Wiggett 2015). Performance is important to athletes as it improves their game and decreases the probability of injuries on and off the field (McGregor 2017).

Sport performance is a combination of unique procedures or physical routines by an individual that is trained in a sport and is influenced by sociocultural, psychological, and physiological factors (Botelho *et al.* 2017). According to Beedie and Foad (2009), psychological variables such as expectancy, conditioning and motivation as well as the interaction with physiological variables can predict positive outcomes in sport. Physiological components include aspects such as speed, strength, agility, flexibility, power, endurance, and coordination (Wood 2008). Moreover, sport performance can be quantified by means of sport-specific testing (Wood 2008).

2.7 SPORT SPECIFIC TESTING

Testing is an integral part of training and should be conducted frequently and regularly (Winter 2006) using test batteries that should reflect the demands and movements of the sport in which the athlete partakes. According to Winter *et al.* (2006), testing is used to evaluate the effectiveness of any interventions and to determine if the intended and desired physiological adaptions have occurred. It is also an invaluable resource to answer research questions.

Test batteries can be used to distinguish between varying standards required of female hockey players (Justin *et al*. 2003). For instance, Justin *et al.* (2003) state that regional representative field hockey players attained higher scores in the sport-specific field hockey tests than local club players. Thus sport-specific testing in field hockey can successfully distinguish between less successful and successful female players. This was concluded in a study by Nieuwenhuis, Spamer and Rossum (2002) who compared

two top teams that were highly successful and two less successful teams in the under 14 and 15 age groups in the North West Province field hockey league.

Testing should mimic the sport and the following factors should be considered when developing a sport-specific test battery: energy systems recruited, duration and intensity of activity, resistive force and muscle groups, and range of motion required (Winter 2006). The field hockey sport-specific test (Table 3.1) consists of the sit-and-reach test, handgrip strength test, 40 m sprint test, and the 5-0-5 agility test (Wood 2008).

2.7.1 Flexibility – sit and reach:

Hamstring flexibility is mainly measured by the sit and reach test, but it is reliant on back and hip mobility as well (Mikkelsson *et al.* 2006). Good lower back and hamstring flexibility is crucial for hockey players to play the ball, back injuries in field hockey are common (Wood 2008). The sit and reach test is reliable and valid (Mayorga-Vega, Merino-Marban and Viciana 2014).

The participant sits on the floor with legs stretched out and shoes removed. The soles of the bare feet are placed against the sit and reach box.The knees should be pressed flat to the floor and the tester may assist by holding the knees down. With hands on top of each other and palms facing down slide the hands as far as possible down the measuring tape on top of the box. The participant holds this position for two seconds and the distance is recorded (Wood 2008).

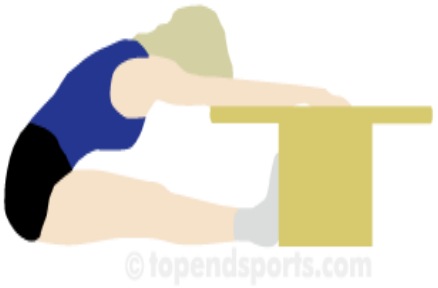


Figure 2.3: Sit and reach (Wood 2008)

2.7.2 Strength – vertical jump:

Power and strength tests, such as handgrip strength and vertical jump, is done to determine the strength levels and changes (Wood 2008). Mikkelsson et al. (2006) conclude and agreed with studies that were previously done, that strength is not a strong predictor of lower back pain and encourages the use of strength and flexibility as rehabilitation in chronic low back pain. Reliability and validity have been established with the vertical jump (Moir, Shastri and Connaboy 2008).

In this test the participant stands next to a wall and reaches up with the dominant hand. The first mark is recorded where the fingertips reach (standing reach). The participant then stands away from the wall and jumps vertically as high as possible using both legs and touches the wall at the highest point where the second mark will be recorded (jump height). Vertical jump height is calculated by subtracting the standing reach from the jump height. The best of three attempts is recorded (Wood 2008).

Figure 2.4: Vertical jump (Wood 2008)

2.7.3 Speed – 40 m sprint:

The target population for the 40 m sprint test is sports players whose speed is important over a similar distance (Wood 2008). This test is aimed at testing the players' acceleration and speed which are important in field hockey (Wood 2008). Glaister *et al.* (2009) applied this test and concluded that the 40 m sprint is valid and reliable.

The participant starts with the dominant foot behind the starting line. In her own time, the participant begins to sprint 40 m to the finish line. The time is recorded over the 40 m distance (Wood 2008).

Figure 2.5: 40 m sprint (Wood 2008)

2.7.4 Agility – 5-0-5 agility:

The 5-0-5 agility test determines the player's 180 degree turning ability. The test is simple, accurate and the most popular test to determine agility (Wood 2008). Hockey players should be able to quickly change direction (Wood 2008). Sayers and Killip (2010) evaluated this test and found it to be reliable and valid.

The participant sprints to the 15 m line, turns on the line and sprints back to the 5 m line. The time is taken from the 5 m line to the 15 m line and back to the 5 m line. The total distance covered is 10 m. The best of two trials is recorded (Wood 2008).

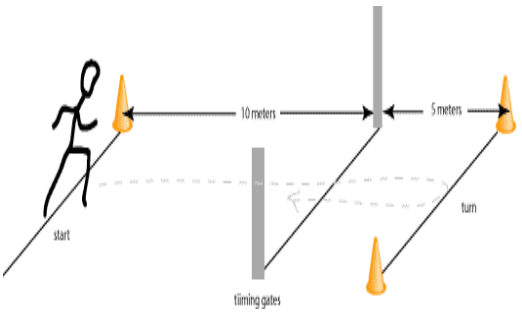


Figure 2.6: 5-0-5 agility (Wood 2008)

2.8 CONCLUSION

A paucity of literature exits in terms of the immediate effect of SMT on female field hockey players. Wiggett (2015) researched the immediate effect of SMT on male hockey players' drag flicking capacity. Although the latter study focused on only one movement in hockey, it is significant in that it was found that the average speed of the drag flick was increased with SMT. Drag flicks are only used during the penalty corner and effective drag flicking is considered a specialised skill (Gallagher 2013). The current study aimed to determine if SMT could be administered to improve multiple components in female field hockey players using SSTB, and therefore their overall performance potential was considered. The argument was that if SMT could be shown to improve female field hockey players' overall performance, it would highlight the need to employ chiropractors as members of the multidisciplinary teams that manage field hockey players.

CHAPTER 3: METHODOLOGY

3.1 INTRODUCTION

The methodology section describes the rationale for the procedures used in this study. The chapter outlines the methods that were used to collect the data and includes a discussion of the study design, the treatment approach, objective data collection, the data analysis procedure, and ethical considerations.

3.2 STUDY DESIGN

This study used the quantitative study paradigm in order to quantify any changes that were caused by the experimental intervention (Reed Johnson *et al.* 2013). The design was a randomised crossover design. This design was selected because it would overcome differences by comparing within-patient differences as each patient would receive the treatment and be part of the control in a random order with a washout period in between (Levin 2007). Senn (2002) argues that this randomised crossover design yields an efficient comparison of treatments as each participant serves as their own control. Groups were compared using paired t-tests if the outcomes were normally distributed, or paired Wilcoxon signed ranks tests if the data were not normally distributed. A p-value of <0.05 was considered statistically significant (Esterhuizen 2020).

3.2.1 Participant recruitment

Twenty recreational field hockey players were recruited for this study. Females who were between 18 and 35 years of age were targeted. Another requirement was that they had to have played field hockey at club level in the year that the study was conducted. Recruitment was done by word-of-mouth and advertisements (Appendix A) that were placed at various hockey clubs (Appendix E) in the eThekwini Municipality area.

3.2.2 Permission

Ethical approval was obtained from the Institutional Research and Ethics Committee (IREC) (Appendix L) and gatekeeper permission was obtained form the DUT Research Director (Appendix B) who approved the study for research purposes at the DUT. Approval was also obtained from the Clinic Director (Appendix C) who permitted the researcher to make use of resources available at the Chiropractic day clinic (CDC). The Director of the DUT sports field (Appendix D) also allowed the practical component of the study to be conducted on the sports field.

3.2.3 Location

The testing was done at the DUT CDC and DUT sports field. The DUT CDC is located on the Ritson campus on the corner of Steve Biko Road and Ritson Road in Durban. The DUT sports field is an outdoor grass soccer field that is located on the corner of Steve Biko Road and Botanic Gardens Road in Durban.

3.2.4 Sample selection and size

A sample size of twenty (N = 20) participants was deemed adequate for this study (Esterhuizen 2020). This sample size resulted in 20 paired measurements for each outcome and allowed a moderate effect size of up to 0.66 determined as statistically significant at 0.05 level of significance and 80% power. Sampling was done at three clubs in the eThekwini Municipality (Appendix E), namely the Riverside Hockey club, Varsity College Hockey club, and the Northwood Crusaders Hockey club. Each club had at least three female hockey teams with 15 players per team. Convenience sampling was utilised in order to involve participants who met the inclusion criteria.

3.2.5 Inclusion criteria

- Participants currently playing field hockey at club level in the eThekwini Municipality area.
- Participants between 18 and 35 years of age. This criterion was set to minimise factors that could influence the results as older participants were considered

more likely to have injuries and younger participants were considered skeletally immature (Bleekers 2015).

- Female participants were chosen for homogeneity (Mouton 1996).
- Participants needed a minimum of one fixation in the lumbar spine. It was taken into consideration that the semi-crouched position that hockey players adopt can contribute to lower back injuries (Murtaugh 2009).
- Participants had to voluntarily sign the letter of information and the consent form (Appendix F and Appendix G).

3.2.6 Exclusion criteria

- Applicants younger than 18 and older than 35 years of age were excluded.
- Those applicants presenting with one or more contra-indications to SMT (Gatterman 2005) as determined by the case history and a physical and lumbar regional examination (Appendix I) were excluded. Contra-indications of SMT in the lumbar spine include pathologies that lead to bone weakening, nerve root, cord or cauda equina compression with increasing neurological deficit, aortic aneurism, lack of diagnosis, and patient positioning that cannot be achieved due to pain or resistance (Bergmann and Peterson 2011).
- Applicants who present with current musculoskeletal conditions such as muscle sprains and ligament strains that could influence the performance of the participant or the results of the study (Bleekers 2015) were also excluded.
- Goalkeepers were excluded as these players have unique SST (Wood 2008).
- Applicants who did not sign the letter of information and consent form (Appendix F and G) were also not included.

3.2.7 Group allocation

The participants (N = 20) were randomly allocated to either Group 1 (n = 10) or Group 2 (n = 10). A randomisation chart that was created on Random Lists© (Appendix H) was used to randomly assign each participant to Group 1 or Group 2.

3.3 RESEARCH PROCEDURE

Recruitment was done by word-of-mouth as well as advertisements (Appendix A) that were placed at hockey clubs in the eThekwini Municipality area (Appendix E). Potential participants conveyed their interest by contacting the researcher who explained the research procedure telephonically. Once a participant had agreed to partake in the study, she was screened for eligibility according to the inclusion and exclusion criteria. Applicants who did not meet the inclusion criteria were thanked and excluded from the study. The information letter and informed consent form (Appendix F and G) were e-mailed to the participants to read through prior to testing.

All COVID-19 protocols (Appendix K) were adhered to. Prior to entering the DUT Chiropractic day clinic (CDC), a strict protocol was followed as required by the DUT CDC to ensure that all necessary precautions were taken. This included a verbal screening for COVID-19 symptoms, completion of a declaration form, consent to be treated during the COVID-19 pandemic, temperature check, signing an attendance register for tracking, disinfecting of hands, and wearing a facemask upon arrival at the DUT CDC (Appendix K). The testing was conducted in two phases.

On the day of phase one testing the participant arrived at the DUT CDC and completed an informed consent form (Appendix F and G). The research and research procedure were explained to the participant and all questions were answered. Thereafter the researcher completed a case history and a physical and lumbar regional examination (Appendix I) was conducted in a private clinic room to maintain confidentiality. The applicants who did not have at least one restriction in the lumbar spine were thanked and excluded from the study. All the restrictions were noted (Appendix I). The participants were randomly assigned to Group 1 or Group 2 by using Radom Lists© (Appendix H). A qualified chiropractor was present as a clinician during the testing procedure.

All the participants that met the inclusion criteria were then asked to complete a hockey SSTB at the DUT sports field and the scores were recorded on the data collection sheet (Appendix J). Thereafter Group 1 received SMT according to the spinal restrictions found during the lumbar regional examination (Appendix I). All the

restrictions were adjusted and re-tested. Group 2 was set up for SMT but no thrust was administered. All the participants immediately repeated the SSTB to determine if there was any change in the measurements. These results were recorded on the data collection sheet (Appendix J).

After a seven-day wash-out period phase two commenced. The wash-out period was used to eliminate any carryover effect from the treatment (Wellek and Blettner 2012). A seven-day wash-out period was deemed sufficient to ensure that no carryover effect would occur (Christiansen *et al.* 2018). On the second testing day, the participant arrived at the DUT sports field. All the participants that met the inclusion criteria then completed a hockey SSTB and the scores were recorded on the data collection sheet (Appendix J). Thereafter Group 2 received SMT according to the spinal restrictions found in the lumbar regional examination (Appendix I). Group 1 was set up for SMT but no thrust was administered. All the participants immediately repeated the SSTB to determine if there was any change in the measurements. These results were recorded on the data collection sheet (Appendix J). The research procedure is set out in Figure 3.1:

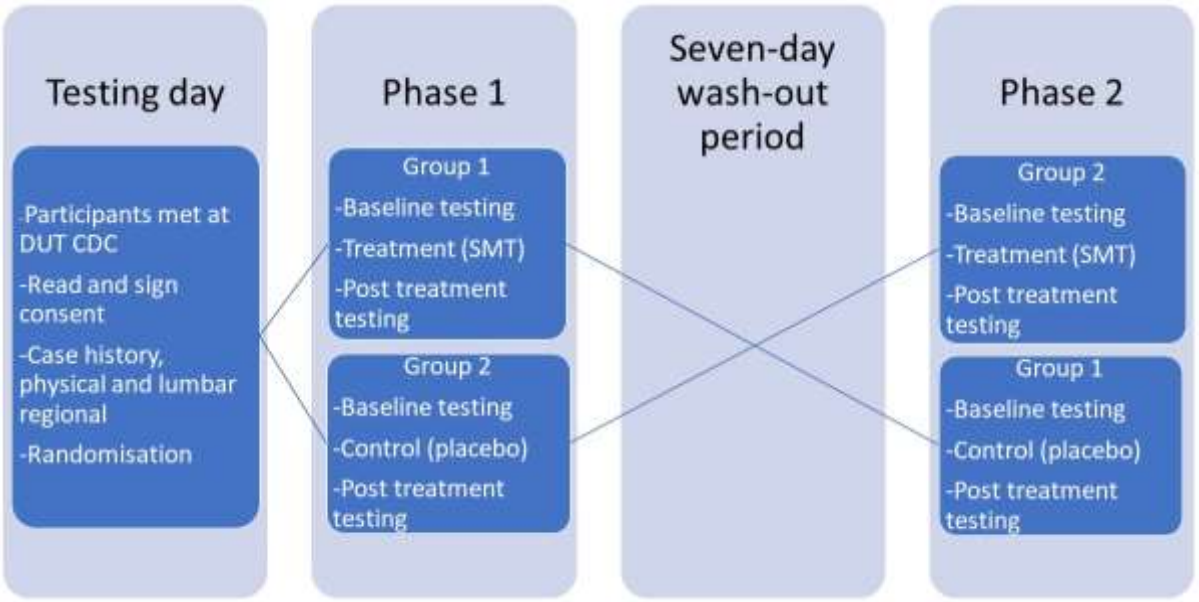


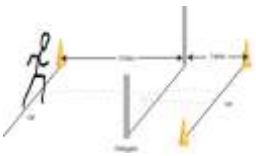
Figure 3.1: Flow diagram of research procedure

3.4 OBJECTIVE DATA

The field hockey sport-specific test consists of the sit-and-reach test, the vertical jump test, a 40 m sprint test, and the 5-0-5 agility test (Wood 2008). These tests have been proven to be valid and reliable by various authors: sit-and-reach test (Mayorga-Vega, Merino-Marban and Viciana 2014), vertical jump test (Moir, Shastri and Connaboy 2008), 40 m sprint test (Glaister *et al.* 2009) and the 5-0-5 agility test (Sayers and Killip 2010). These tests were completed identically pre and post intervention (Table 3.1).

Table 3.1: Field hockey sport specific tests

Order	Sport specific test	Method	Demonstration
1	Sit and reach test	The participant sits on the floor with legs stretched out and shoes removed. The soles of the bare feet are placed against the sit and reach box.The knees should be pressed flat to the floor and the tester may assist by holding the knees down. With hands on top of each other and palms facing down slide the hands as far as possible down the measuring tape on top of the box. The participant holds this position for two seconds and the distance is recorded (Wood 2008).	
2	Vertical jump	The participant stands next to a wall and reaches with dominat hand. The first mark is recorded where the fingertips reach (standing reach). The participant then stands away from the wall and jumps vertically as high as possible using both legs and touch the	

		wall at highest point where the second mark will be recorded (jump height). Vertical jump height is calculated by subtracting the standing reach from the jump height. The best of three attempts is recorded (Wood 2008).	
3	40 m sprint	The participant starts with the dominant foot behind the starting line. The participant begins in their time and sprints 40 m to the finish line. The time is recorded over the 40 m (Wood 2008).	
4	5-0-5 agility	The participant sprints to the 15m line, turns on the line and sprints back to the 5m line. The time is taken from the 5m line to the 15m line and back to the 5m line. The total distance covered is 10m. The best of two trials is recorded (Wood 2008).	

3.5 DATA ANALYSIS

IBM SPSS version 27 was used to analyse the data. A p-value op <0.05 was considered as statistically significant.

Within-treatment comparisons from pre to post testing for objectives 1 and 2 were achieved using paired t-tests. For this two-treatment two-period randomised cross-over trial the treatment effect for each outcome was measured as the difference between the pre and post measurement on that condition and modelled as a within-subjects effect (due to the pairing of the data) using repeated measures ANOVA. The Group (1 or 2) was added as a between-subjects effect to test for the presence of a carryover effect. Group 1 received treatment first and Group 2 received the placebo first. A statistically significant treatment main effect indicated a difference between the two treatments, while a significant group main effect indicated incomplete randomisation (baseline imbalances). A significant treatment x group interaction

indicated the presence of a carryover effect. The carryover effect is the effect of the treatment varied by the order of the treatments. Partial eta-squared values were reported as effect sizes.

3.6 ETHICAL CONSIDERATIONS

Ethical approval was obtained from the DUT IREC (Appendix L). The four principles of ethics include autonomy, justice, non-maleficence and beneficence (Kennelly 2011). The study upheld these principles as follows:

Autonomy:
All the participants were informed that they took part in the study at their own free will. An informed consent, explaining the procedure, was read, and signed by the participants before the commencement of the study. The informed consent form entailed the purpose of the study, benefits that might be gained by the study, possible discomforts or risks pertaining to the treatment and the procedures of the study.

Justice:
Recruitment of participants was done without taking religion, race, or nationality in consideration. The participants were able to withdraw at any point in the study without detrimental consequences to the participants. The participants that were recruited were asymptomatic, if a pathology is detected during the consultation the participant was excluded and referred to a health care professional. Adjustment of the cervical, thoracic and/or lumbar spine was not associated with any harmful consequences.

Non-maleficence
The participant's safety and health are of utmost importance and were protected at all times. The measurement tools and interventions were safe and approved with appropriate disciplines. The patients' confidential information will not appear in any research publications and will be kept confidential at the DUT Chiropractic day clinic for five years and thereafter destroyed. The study will be conducted at the DUT CDC and DUT sports field under the supervision of a qualified Chiropractic clinician.

Beneficence:

The participants benefited from SMT as treatment for lumbar restrictions as well as a full case history and physical examination as health screening. In addition, the participants were also be informed of their performance as determined by the SSTB.

3.7 CONCLUSION

The methodology described in this chapter was used to produce the results that is presented in chapter 4.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

Chapter 4 includes the presentation of the data obtained according to the methodology outlined in chapter 3. The results from this study is presented in accordance with the objectives set in chapter 1:

Objective 1: To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post SMT.

Objective 2: To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post control.

Objective 3: To compare the results of objective 1 to objective 2 in terms of SSTB.

4.2 RESULTS

4.2.1 CONSORT Flow diagram of participants

A number of applicants were assessed for eligibility and twenty (N = 20) were ultimately included in the study. The 20 participants were randomly allocated to Group 1 (n = 10) or Group 2 (n = 10). Zero participants (n = 0) were lost or discontinued treatment after phase one. All the participants (N = 20) completed phase two and the results of the entire sample were analysed. The flow diagram (Figure 4.1) shows the chronological sequence of events during the study:

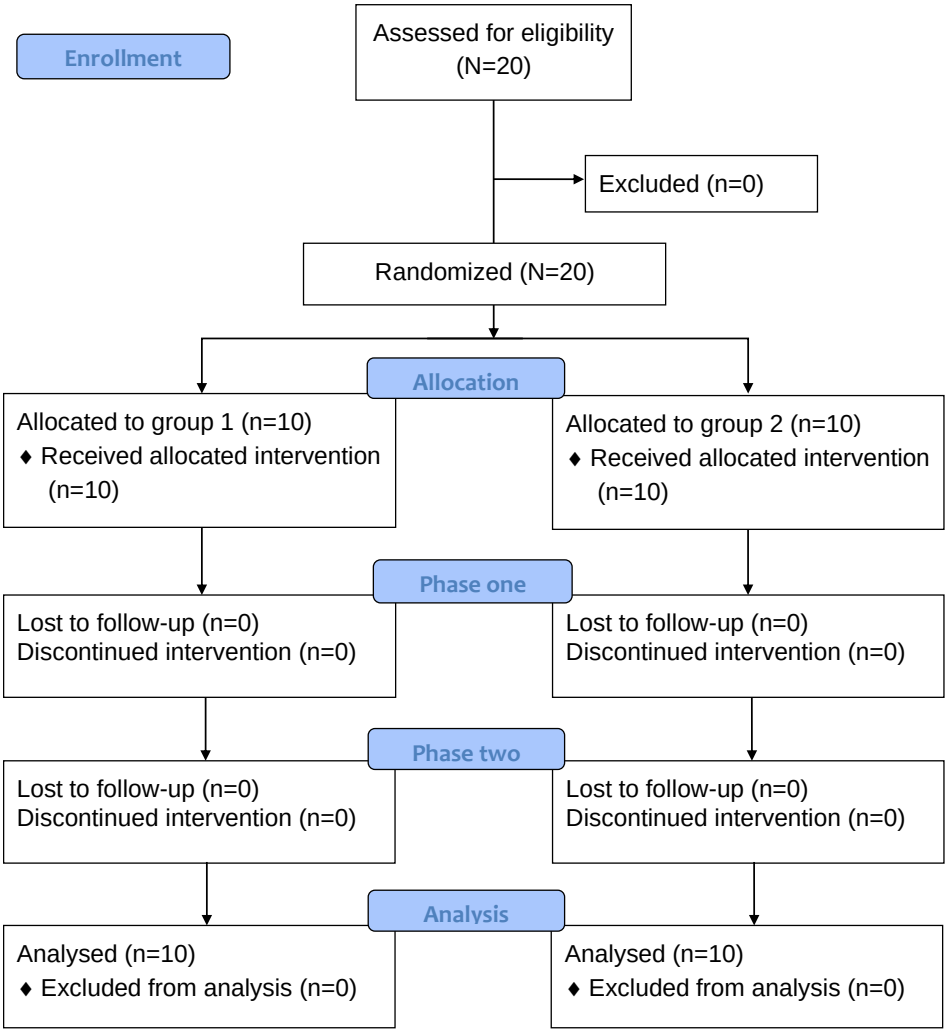


Figure 4.1: CONSORT flow diagram

4.2.2 Participant characteristics

The participant characteristics are represented in Table 4.1. A permutational multivariate Analyses of Variance (PERMANOVA) was used to test for a significant difference between the two groups based on age, weight, height, BMI, and experience.

Table 4.1: Participant characteristics

Group	Mean age ± SD (yrs.)	Mean Weight ± SD (kg)	Mean Height ± SD (cm)	Mean BMI ± SD (kg/m^2)	Mean years' experience ± SD (yrs.)
1	23.2 ± 3.16	63.5 ± 5.60	163.9 ± 2.85	23.7 ± 2.32	5 ± 2.71
2	21.1 ± 2.85	58.8 ± 4.89	165.1 ± 4.95	21.6 ± 1.64	3.2 ± 2.35

There were no significant differences between Group 1 and Group 2 (df = 1, MS = 177.62, $p_{(Monte\ Carlo)} = 0.064$). The participants were randomly divided into the groups to ensure that the study could reflect the effect of the intervention.

4.2.3 Descriptive statistics

Twenty participants (N = 20) were randomised into two groups (Group 1 and Group 2). Group 1 (n = 10) received the treatment (SMT) followed by the control (placebo) and Group 2 (n = 10) received the control followed by the treatment. The summary statistics of all outcome measures are presented in Table 4.2 and Table 4.3.

Table 4.2: Descriptive statistics for groups 1 and 2 pre and post SMT treatment

			Valid N	Mean	Standard Deviation	Minimum	Maximum
group	1	Pre sitandreach 1 (cm)	10	27.6	10.1	11.0	40.0
		Post sitandreach 1 (cm)	10	29.9	10.0	14.0	42.0
		Pre vertjump 1 (cm)	10	32.5	6.7	22.0	42.0
		Post vertjump 1 (cm)	10	34.8	7.9	23.0	47.0
		Pre sprint 1 (s)	10	6.8	0.6	6.1	7.8
		Post sprint 1 (s)	10	6.6	0.6	6.1	7.9
		Pre 5-0-5 1 (s)	10	3.2	0.3	2.8	3.7
		Post 5-0-5 1 (s)	10	3.1	0.3	2.7	3.8
	2	Pre sitandreach 1 (cm)	10	28.9	10.6	7.0	44.0
		Post sitandreach 1 (cm)	10	31.1	11.2	4.0	44.0
		Pre vertjump 1 (cm)	10	32.7	7.5	23.0	44.0
		Post vertjump 1 (cm)	10	35.2	7.6	26.0	49.0
		Pre sprint 1 (s)	10	7.0	0.8	5.5	7.9
		Post sprint 1 (s)	10	6.4	0.8	5.1	7.2
		Pre 5-0-5 1 (s)	10	3.2	0.3	2.9	3.9
		Post 5-0-5 1 (s)	10	3.0	0.2	2.7	3.3

Table 4.3: Descriptive statistics for groups 1 and 2 pre and post placebo treatment

			Valid N	Mean	Standard Deviation	Minimum	Maximum
group	1	Pre sitandreach 2 (cm)	10	30.5	8.6	14.0	42.0
		Post sitandreach 2 (cm)	10	30.5	8.6	14.0	42.0
		Pre vertjump 2 (cm)	10	33.7	6.3	25.0	45.0
		Post vertjump 2 (cm)	10	31.9	7.0	22.0	45.0
		Pre sprint 2 (s)	10	6.9	0.5	6.2	7.6
		Post sprint 2 (s)	10	7.0	0.7	6.4	8.1
		Pre 5-0-5 2 (s)	10	3.0	0.2	2.7	3.4
		Post 5-0-5 2 (s)	10	3.1	0.3	2.7	3.5
	2	Pre sitandreach 2 (cm)	10	29.5	9.5	12.0	44.0
		Post sitandreach 2 (cm)	10	30.6	9.3	12.0	43.0
		Pre vertjump 2 (cm)	10	31.0	7.2	23.0	42.0
		Post vertjump 2 (cm)	10	31.4	6.9	24.0	42.0
		Pre sprint 2 (s)	10	6.8	0.7	5.7	7.7
		Post sprint 2 (s)	10	7.0	0.7	6.0	7.8
		Pre 5-0-5 2 (s)	10	3.1	0.3	2.7	3.7
		Post 5-0-5 2 (s)	10	3.2	0.4	2.7	3.9

4.2.4 Objective 1

To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post SMT. The results are represented in Table 4.4.

Table 4.4: Within treatment comparisons for each outcome under the SMT condition

Paired Samples Statistics						
		Mean	N	Std. Deviation	Std. Error Mean	p-value
Pair 1 (cm)	Pre sitandreach 1	28.25	20	10.094	2.257	<0.001
	Post sitandreach 1	30.50	20	10.349	2.314	
Pair 2 (cm)	Pre vertjump 1	32.60	20	6.901	1.543	<0.001
	Post vertjump 1	35.00	20	7.525	1.683	
Pair 3 (s)	Pre sprint 1	6.9145	20	0.69402	0.15519	0.001
	Post sprint 1	6.4905	20	0.69310	0.15498	
Pair 4 (s)	Pre 5-0-5 1	3.2230	20	0.30856	0.06900	0.002
	Post 5-0-5 1	3.0510	20	0.27511	0.06152	

All outcomes changed statistically significantly under the SMT condition. The results of the sit-and-reach ($p < 0.001$), vertical jump ($p < 0.001$), 40 m sprint ($p = 0.001$) and 5-0-5 agility ($p = 0.002$) tests improved post SMT for both Group 1 and Group 2.

4.2.5 Objective 2

To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post control. The results are represented in Table 4.5.

Table 4.5: Within treatment comparisons for each outcome under the control condition

Paired Samples Statistics						
		Mean	N	Std. Deviation	Std. Error Mean	P - value
Pair 1 (cm)	Pre sitandreach 2	30.00	20	8.820	1.972	0.164
	Post sitandreach 2	30.55	20	8.745	1.955	
Pair 2 (cm)	Pre vertjump 2	32.35	20	6.761	1.512	0.100
	Post vertjump 2	31.65	20	6.769	1.514	
Pair 3 (s)	Pre sprint 2	6.8650	20	0.59540	0.13314	0.068
	Post sprint 2	6.9735	20	0.63911	0.14291	
Pair 4 (s)	Pre 5-0-5 2	3.0590	20	0.28564	0.06387	0.026
	Post 5-0-5 2	3.1500	20	0.33150	0.07413	

Only the 5-0-5 agility outcome changed significantly under the control condition. The mean time for the test was 3.059 s pre intervention and 3.15 s post intervention ($p = 0.026$). There were no significant changes in the results of the sit-and-reach ($p = 0.164$), vertical jump ($p = 0.100$), and 40 m sprint ($p = 0.068$) tests.

4.2.6 Objective 3

To compare the results of objective 1 to objective 2 in terms of SSTB.

4.2.6.1 Sit and reach

Table 4.6 shows that there was a statistically significant treatment effect ($p = 0.005$) and no evidence of a carryover effect ($p = 0.272$) or baseline imbalances. Therefore, no effects from the previous treatment affected the experimental condition.

Table 4.6: Within subjects and between subjects effect for sit and reach

Effect	Statistic	p-value	Partial eta squared
Treatment	Wilk's lambda=0.636	0.005	0.364
Group	F=0.642	0.433	0.034
Treatment x group	Wilk's lambda=0.933	0.272	0.067

The profile plot (Figure 4.2) shows that SMT intervention difference values were higher than those for placebo, thus the change in sit and reach values were higher in the SMT group. The participants were immediately able improve their reaching distance (cm) post SMT.

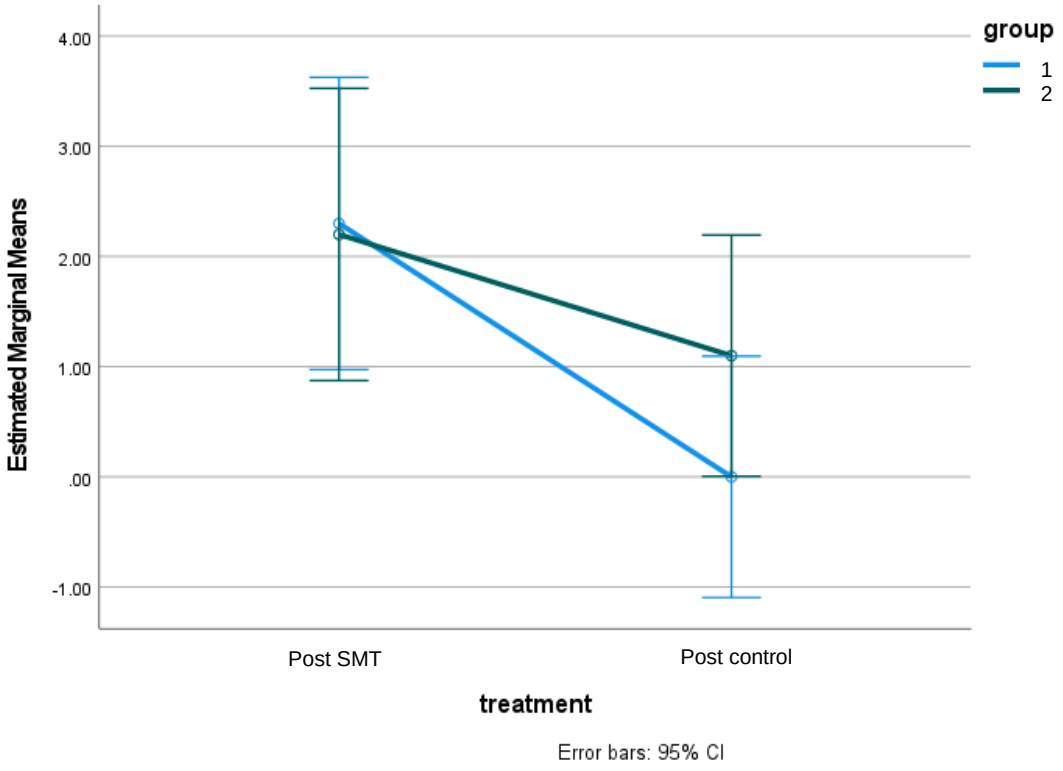


Figure 4.2: Sit and reach group 1 vs group 2

4.2.6.2 Vertical jump

Table 4.7 shows that there was a statistically significant treatment effect ($p < 0.001$) and no evidence of a carryover effect ($p = .0.71$) or baseline imbalances.

Table 4.7: Within subjects and between subjects effect for vertical jump

Effect	Statistic	p-value	Partial eta squared
Treatment	Wilk's lambda=0.337	<0.001	0.663
Group	F=3.681	0.071	0.170
Treatment x group	Wilk's lambda=0.830	0.071	0.170

The profile plot (Figure 4.3) shows that SMT intervention difference values were higher than those for placebo, thus the change in vertical jump values were higher in the SMT group. The participants were able to improve their mean jump height (cm) post SMT.

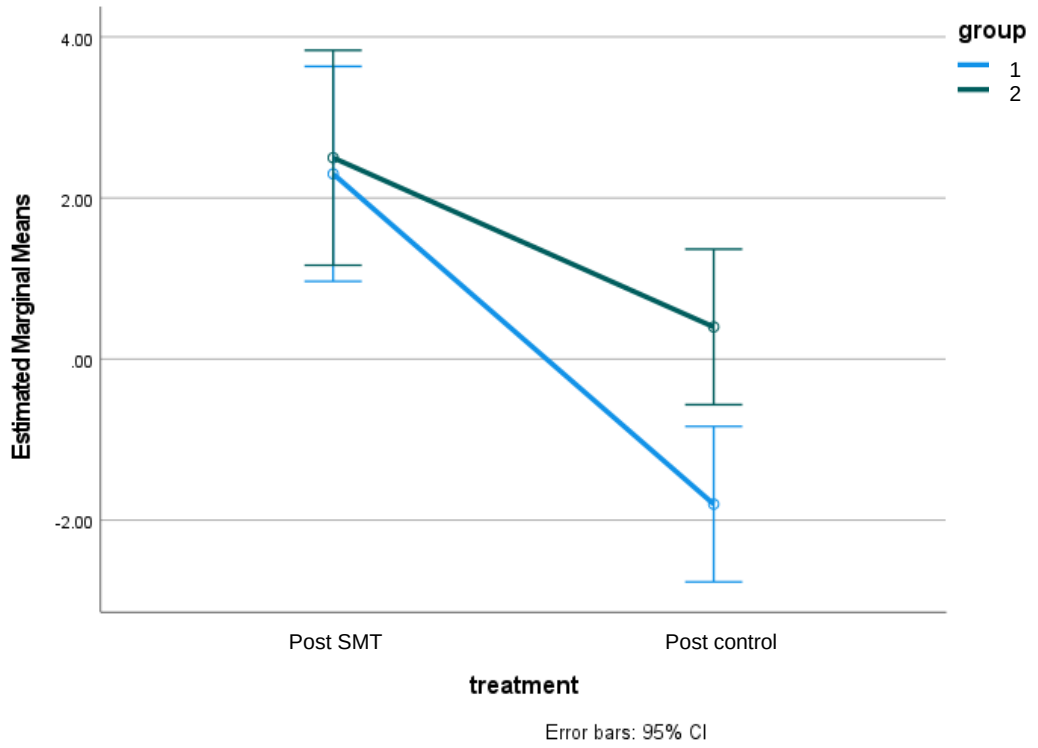


Figure 4.3: Vertical jump group 1 vs group 2

4.2.6.3 40 m sprint

Table 4.8 shows that there was a statistically significant treatment effect ($p < 0.001$) and but also evidence of a carryover effect ($p = 0.024$). Thus, the treatment effect cannot be interpreted since the effect of treatment depended on the order in which they received the treatments.

Table 4.8: Within subjects and between subjects effect for 40 m sprint

Effect	Statistic	p-value	Partial eta squared
Treatment	Wilk's lambda=0.474	<0.001	0.526
Group	F=4.271	0.053	0.192
Treatment x group	Wilk's lambda=0.748	0.024	0.252

The profile plot (Figure 4.4) shows that while placebo difference values were higher than those for treatment, the slopes of the two groups were not parallel, indicating that group 2 improved to a greater extent post SMT than group 1. Both groups improved their mean sprinting time (s), but group 2 had a greater immediate improvement.

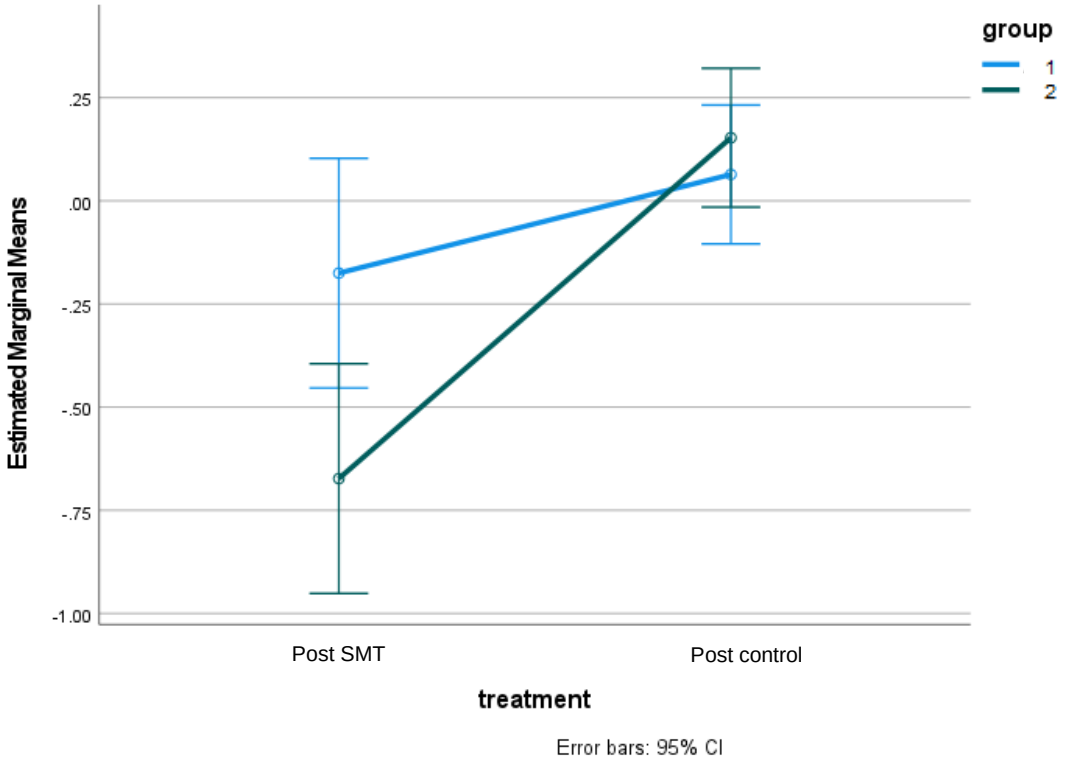


Figure 4.4: 40 m sprint group 1 vs group 2

4.2.6.4 5-0-5 agility

Table 4.9 shows that there was a statistically significant treatment effect ($p < 0.001$) and no evidence of a carryover effect ($p = 0.973$) or baseline imbalances.

Table 4.9: Within subjects and between subjects effect for 5-0-5 agility

Effect	Statistic	p-value	Partial eta squared
Treatment	Wilk's lambda=0.478	<0.001	0.522
Group	F=1.154	0.297	0.060
Treatment x group	Wilk's lambda=1.00	0.973	0.000

The profile plot (Figure 5.4) shows that SMT intervention difference values were lower than those for placebo, thus the change in 5-0-5 agility values were higher in the SMT group. The participants' mean time (s) decreased post SMT and therefore their agility improved.

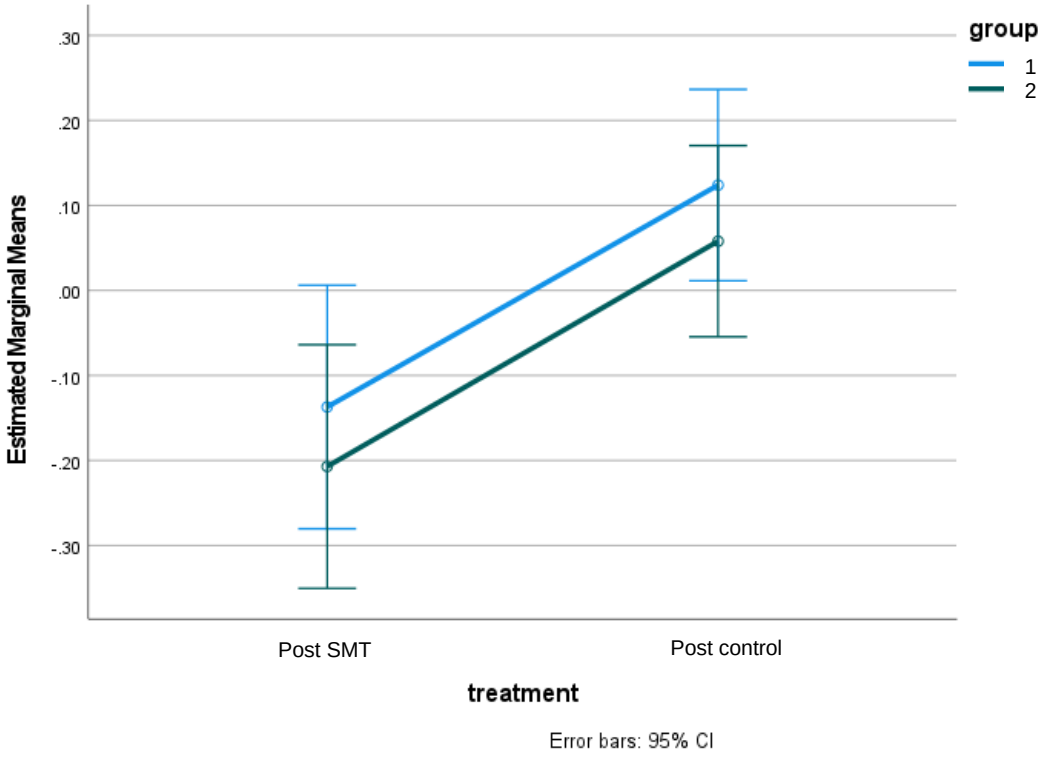


Figure 4.5: 5-0-5 agility group 1 vs group 2

4.3 CONCLUSION

Based on the results that were presented in Chapter 4, statistically and clinically significant results will be discussed and compared with previous research results in Chapter 5.

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

Chapter 5 presents a discussion on the clinically significant findings that were presented in tables and graphs in Chapter 4. The discussion will be presented in accordance with the objectives and null hypotheses as presented in Chapter 1. The null hypotheses (H_0) were proposed in respect of the objectives as set out in Chapter 1, and are as follows:

H_0 1: Lumbar SMT will not have a significant immediate effect on sit and reach in female recreational field hockey players.

H_0 2: Lumbar SMT will not have a significant immediate effect on vertical jump in female recreational field hockey players.

H_0 3: Lumbar SMT will not have a significant immediate effect on 40 m sprint in female recreational field hockey players.

H_0 4: Lumbar SMT will not have a significant immediate effect on 5-0-5 agility in female recreational field hockey players.

5.2 DISCUSSION

5.2.1 Participant characteristics

There were no significant differences between Group 1 and Group 2 when compared collectively for age, height, weight, BMI, or years of experience. Earlier studies on female field hockey players concerning discrimination between successful and less successful players (Kruger 2010), physiological profiles (McGuinness *et al.* 2019), effects of heat stress and dehydration on cognitive function (MacLeod *et al.* 2018), and gluteus medius coactivation response (Bussey, Kennedy and Kennedy 2016) had similar participant demographics relating to age, height, weight, and BMI. It is thus

argued that the demographics of the club hockey players who participated in the current study and who were between 18 to 35 years of age were similar to those of the participants in earlier studies, which renders the data relevant and valid. One difference was that other studies involved males, which this study did not.

5.2.2 Objective 1

To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post SMT.

The outcome of the SSTB post treatment was statistically significant which indicates that all the SSTs were improved after receiving chiropractic SMT. (Rubinstein *et al.* 2019) confirm that neurophysiological and biomechanical changes occur during SMT and therefore the observed improvements in the tests are warranted. This finding is in accordance with the systematic review conducted by Botelho *et al.* (2017) who found that four out of the seven clinical trials that were included in the review revealed that sport performance was improved by SMT. These studies included increased hip extension in male junior runners (n = 17), increased full swing in male golf players (n = 43), increased strength in male and female elite judoka (n = 18), and increased kicking speed in male elite soccer players (n = 40) (Botelho *et al.* 2017).

5.2.3 Objective 2

To determine the change in performance in terms of SSTB of female club hockey players compared to pre and post control.

The only outcomes that significantly changed post intervention were the results the 5-0-5 agility test. The mean outcome was slower after the participants had received the placebo treatment. The 5-0-5 agility test was the last test in the test battery and was performed directly after the 40 m sprint test. The participants could thus not have rested sufficiently after the sprint before attempting the agility test as it was the final test of the day.

The other tests, namely sit-and-reach, the vertical jump, and the 40 m sprint did not indicate a statistically significant change. The placebo treatment consisted of setting the participant up for an adjustment but not administering the thrust. No neurophysiological or biomechanical changes occurred (Rubinstein *et al.* 2019) and therefore no change in the tests occurred.

5.2.4 Objective 3

To compare the results of objective 1 to objective 2 in terms of SSTB.

5.2.4.1 Sit and reach

The results for the sit-and-reach test significantly improved post SMT treatment. The participants were able to improve their mean reaching distance (cm) post SMT. Mechanically it is believed that SMT passively enforces a coupled motion in order to unlock a joint that is fixated and thereby restoring range of motion (Han *et al.* 2015). Therefore, by restoring full range of motion using SMT, the participants were enabled to reach further vertically.

This finding of the current study is in contradiction to the outcomes of a study by Olson *et al.* (2014) who found that lumbar SMT did not significantly improve flexibility as measured by the sit-and-reach test. The earlier study was a crossover study design that used SMT as treatment and sham acupuncture and no treatment as the control treatment. The participants (n = 12) in that study were cyclists that were equally randomised into AB:BA (Olson *et al.* 2014).

5.2.4.2 Vertical jump

The vertical jump ability was significantly improved post SMT treatment. The participants were able to improve their mean jumping height (cm) post SMT. Muscle strength is a key factor in increasing vertical jump height. Lo *et al.* (2019) have already shown muscle strength in asymptomatic athletes and therefore the vertical jump ability can be improved by SMT manipulation as the vertical jump test is a test for muscle strength.

Similar outcomes were obtained in asymptomatic rugby players (Conradie 2013). In the latter study Conradie (2013) found that lumbar SMT improved sprinting times as well as vertical jump ability. The participants received a single treatment and experienced immediate benefits as a result of the treatment that provided a biomechanical advantage (Conradie 2013).

Shrier, Macdonald and Uchacz (2006) conducted a crossover study to determine if SMT improved 40 m sprint speed and countermovement jump height ability. Nineteen elite athletes involved in sprint sports took part in the study. These participants tended to perform better after SMT but, as a result of greater than expected variability, the results were not statistically significant (Burnstein, Steele and Shrier 2011).

5.2.4.3 40 m sprint

The 40 m sprint test was significantly improved after SMT treatment as the participants were able to improve their mean sprinting time (s) post SMT. As previously mentioned, both the studies of Shrier, Macdonald and Uchacz (2006) and Conradie (2013) found that the lumbar SMT improved 40 m sprint and vertical jump ability, although the findings were only significant in the study of Conradie (2013).

It is noteworthy that a carryover effect was present only in the 40 m sprint test in the current study. This indicates that the size of the effect depended on the order in which treatment was received. The group that received the placebo first and the SMT second had a greater improvement post intervention. Curtin, Elbourne and Altman (2002) argue that a carryover effect may occur when the effects of the treatment in phase one are carried over and affect the experimental condition in phase two. The carryover effects can be prevented by extending the washout period between phases (Mills *et al.* 2009). The current study used seven days as a washout period and observed a carryover effect, whereas a study by Fachinatto *et al.* (2015) used a 14-day washout period in the crossover study that consisted of SMT and transcutaneous electrical nerve stimulation and no carryover effect was present. Therefore, it is acknowledged that the 7-day washout period was too short in the current study and a 14-day washout period is thus suggested to eliminate the carryover effect when using SMT.

5.2.4.4 5-0-5 agility

The 5-0-5 agility test was significantly improved post SMT treatment. The participants were able to improve their mean agility time (s) post SMT. Contradictory findings concerning the effect of SMT on agility have been reported. For instance, Botelho *et al.* (2020) found that there was no immediate improvement in the change of direction (COD) sprint test that was conducted on 20 elite soccer players, whereas the study that was conducted by Landman (2016) found that the participants improvement in the Illinois test immediately after SMT. Both the COD sprint test and the Illinois test measure the same component as the 5-0-5 agility test. The current study indicated that the 5-0-5 test results were improved post SMT and thus demonstrated that this treatment can improve agility.

5.3 NULL HYPOTHESES

5.3.1 Null hypothesis 1

H_0 1: Lumbar SMT will not have a significant immediate effect on sit and reach in female recreational field hockey players.

H_0 1 is rejected as lumbar SMT had a significant immediate effect on sit and reach in female recreational field hockey players.

5.3.2 Null hypothesis 2

H_0 2: Lumbar SMT will not have a significant immediate effect on vertical jump in female recreational field hockey players.

H_0 2 is rejected as lumbar SMT had a significant immediate effect on vertical jump in female recreational field hockey players.

5.3.3 Null hypothesis 3

H_0 3: Lumbar SMT will not have a significant immediate effect on 40 m sprint in female recreational field hockey players.

H_0 3 is rejected as lumbar SMT had a significant immediate effect on 40 m sprint in female recreational field hockey players.

5.3.4 Null hypothesis 4

H_0 4: Lumbar SMT will not have a significant immediate effect on 5-0-5 agility in female recreational field hockey players.

H_0 4 is rejected as lumbar SMT had a significant immediate effect on 5-0-5 agility in female recreational field hockey players.

5.4 CONCLUSION

Chapter 5 presented an in-depth discussion on the clinically significant results that were obtained and compared these results to those of previous studies. The objectives were discussed and the null hypotheses were rejected. To conclude, all the outcomes were significantly improved post treatment while a carryover effect was present in the 40 m sprint test.

CHAPTER 6: CONCLUSION AND RECOMMENDATIONS

6.1 INTRODUCTION

Chapter 6 concludes the discussion on the findings as presented in Chapter 5. The limitations that impacted the study are highlighted and recommendations to improve future studies are offered while suggestions for further research are made.

6.2 CONCLUSION

The aim of this study was to determine the immediate effect of SMT on performance of female club field hockey players.

The results were presented in terms of the objectives that were set out in Chapter 1. All the SSTs had a statistically significant change after the administration of SMT treatment, whereas only the 5-0-5 agility test indicated a significant change after control treatment as the mean time of the participants was higher and therefore their performance in the 5-0-5 agility test decreased post placebo.

The SMT treatment was superior compared to the placebo treatment (no thrust) in all the outcomes. The 40 m sprint test appeared to show the benefit of treatment only if the order of intervention was first placebo and then SMT treatment, as in this case the SMT values were lower and the mean time was faster than when the order of treatment was SMT first and control second, as was the case for Group 1. The treatment effect could therefore not be interpreted as the effect of treatment was dependent on the order in which the treatments were administered.

In conclusion, SMT can improve performance in female field hockey players. This conclusion was reached on the basis that SMT was superior to control (no thrust) treatments for all the tests in the field hockey SSTB that consisted of the sit-and-reach, the vertical jump, the 40 m sprint, and the 5-0-5 agility tests. A statistical significance was observed in all the SSTs although evidence of carryover was present in the 40 m sprint test.

6.3 LIMITATIONS AND RECOMMENDATIONS

The following limitations were encountered. The recommendations that are offered may improve results in similar research in the future:

- The study utilised a relatively small sample size of only 20 participants. Therefore, by increasing the sample increased statistical significance may be observed.
- A carryover effect was noted in the 40 m sprint test and therefore a longer wash-out period (at least 14 days) is suggested to prevent it.
- There were extensive differences among the participants in terms of activity and competition levels that could have influenced the results as the players were not equally skilled. Recruiting players who are at similar activity or competition levels will ensure that the players are more homogenous for comparative results.
- Future researchers should use a placebo method that is more effective. In the current study the participants who had received chiropractic treatment prior to the study might have been able to distinguish between actual treatment and placebo treatment. The use of an activator gun or placebo patches is suggested.
- Future studies could also include symptomatic athletes as they might manifest greater improvements. Comparisons between symptomatic and asymptomatic athletes can also be analysed for greater in-depth results.
- It is also recommended that future studies include cervical and thoracic spine manipulation to determine if this will contribute to performance post SMT.

6.4 FURTHER RESEARCH

There is a need for further research regarding the following:

- The immediate effect of SMT on the performance of male field hockey players should be assessed to determine if gender plays a role in SMT treatment.
- The immediate effect of SMT on different sporting codes should also be assessed.

- The immediate effect of SMT on athletes who participate at different levels, for instance professional vs recreational level, should be assessed.

CHAPTER 7: ARTICLE

7.1 INTRODUCTION

Chapter 7 is the article that was written in accordance with the requirements for manuscripts submitted to biomedical journals and may be published in a peer reviewed journal.

The immediate effect of lumbar spinal manipulative therapy on performance in female field hockey players

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Background: Athletes are continually seeking to improve their performance. Spinal manipulative therapy (SMT) has been proven to improve performance in some sports. In field hockey SMT is effective in improving a single movement but it is unknown if it can improve the overall performance of a recreational field hockey player.
Aim: To determine the immediate effect of spinal manipulative therapy on performance of female club field hockey players.
Methods: A quantitative control crossover study design of 20 recreational female field hockey players was chosen for this study and was randomly assigned into Group 1 or two. The participants completed a field hockey sport specific test battery (SSTB) consisting of the sit and reach, vertical jump, 40 m sprint and the 5-0-5 agility test. In phase one Group 1 received SMT of fixated joints in the lumbar region, as determined by lumbar regional assessment. Group 2 received a control treatment entailing setting up the participant for and adjustment and not administering the thrust. In phase two, group 1 received the control treatment and SMT was administered to group 2. A 0.05 p value was considered statistically significant.
Results: There was a significant improvement in the sit and reach, vertical jump, 40 m sprint and 5-0-5 tests. A carryover effect was detected in the 40 m sprint test.
Conclusion: Lumbar spinal manipulation therapy can improve the performance of female recreational field hockey players in terms of sport specific tests (SST).
Keywords: chiropractic, sport, athletes

Field hockey is an Olympic sport that has a high level of popularity worldwide [1] and is played both recreationally and competitively in 122 countries [2] .However, there is, limited research available in the domain of female field hockey players [3]. Athletes competing in various sports are constantly trying to improve their performance and are seeking treatment options such as chiropractic to achieve this goal [4].

Chiropractic treatment has shown to improve and maintain muscle balance, speed of neuromuscular reflexes and joint function [5], and by doing this, it may be able to optimize performance. It is already established that chiropractic SMT can immediately improve one single movement in field hockey [4], but it is unknown if chiropractic SMT can improve overall hockey performance and therefore further investigation is warranted. It is important to improve performance as it is not only crucial for competitive sport but also in injury prevention as injuries can be inherently linked to performance [6].

The effect of chiropractic SMT on sports performance in field hockey players is still to be determined and the combination of tests that may provide information to this is the sports specific test battery [7]. Testing batteries can be used to distinguish between varying standards of a female hockey players [8]. Players that perform better overall in the tests that are found in the battery are more likely to perform better during a field hockey game [8].

From the available literature, it can be noted that, field hockey players can benefit from optimizing performance [8] and there is some evidence that SMT improves sport performance [7]. However, paucity in literature exists describing the effects of SMT on the performance of female recreational hockey players. If it is found that SMT has a positive effect on performance in recreational field hockey players, it may promote and encourage the inclusion of chiropractors in the multidisciplinary sport team

along with doctors, physiotherapists, sport scientists and biokineticists.

Methods

Study design

This study has a quantitative randomised crossover design. Permission to conduct research was obtained from field hockey clubs in the eThekwini municipality, KwaZulu-Natal, South Africa, and ethical clearance was granted by the Durban University of Technology's (DUT) Institutional Research and Ethics committee (IREC 048/20).

Participants

The study was conducted at the DUT Chiropractic Day Clinic (CDC) and sport field in KwaZulu-Natal, South-Africa. Twenty recreational field hockey players were recruited to participate in this study. All the participants were required to be between female, 18 and 35 years of age, injury free and were currently playing at club level.

Test procedures and protocol

Recruitment was done by means of word-of-mouth as well as advertisements that took place at the hockey clubs in the eThekwini Municipality. Potential participants conveyed their interest in participating by contacting the researcher, who explained the research procedure telephonically. Once the participant agreed to partake in the study, they were screened for eligibility according to the inclusion and exclusion criteria. Participants who did not meet the inclusion criteria, were thanked, and excluded from the study. The information letter and informed consent was e-mailed to the participant to read through prior to testing.

All COVID19 protocols were adhered to and therefore prior to entering the DUT Chiropractic day clinic (CDC) a strict protocol was followed as set out by the DUT CDC to ensure that all necessary precautions were taken. This included a verbal screening for COVID19 symptoms, declaration form, consent to treat during COVID 19 pandemic, temperature check, signing attendance register for tracking, disinfecting of hands and wearing a facemask upon arrival at the DUT CDC. The testing was conducted in two phases.

On the day of the testing phase one the participant arrived at the DUT CDC and completed an informed consent form. The research and procedure were explained to the participant and all questions were answered. Thereafter the researcher completed a case history, physical and lumbar regional examination in a private clinic room to maintain confidentiality. The participants who did not have at least one restriction in the lumbar spine was thanked and excluded from the study. All the restrictions were noted. The participants were randomly assigned to group 1 or group 2 by using Radom Lists©. A qualified Chiropractor was present as a clinician during the testing procedure.

All the participants that met the inclusion criteria completed a hockey SSTB at the DUT sports field and the scores was recorded on the data collection sheet. Thereafter the group 1 received SMT dependent on spinal restrictions found in the lumbar regional examination. All the restrictions were adjusted and re-tested. Group 2 was set up for SMT, but no thrust was administered. All the participants immediately repeated the SSTB to determine if there was any change in the measurements, these results were recorded on the data collection sheet.

After a minimum of a seven-day wash-out period phase two commenced. The wash-out period was used to eliminate any carryover effect from the treatment [9]. A seven-day wash-out period is sufficient to ensure that no carryover effect will occur [10]. On the second testing day, the participant arrived at the DUT sports field. All the participants that met the inclusion criteria then completed a hockey SSTB and the scores was recorded on the data collection sheet. Thereafter the group 2 received SMT dependent on spinal restrictions found in the lumbar regional examination. Group 1 was set up for SMT, but no thrust was administered. All the participants immediately repeated the SSTB to determine if there was any change in the measurements, these results were recorded on the data collection sheet. The research procedure is set out in fig. 1:

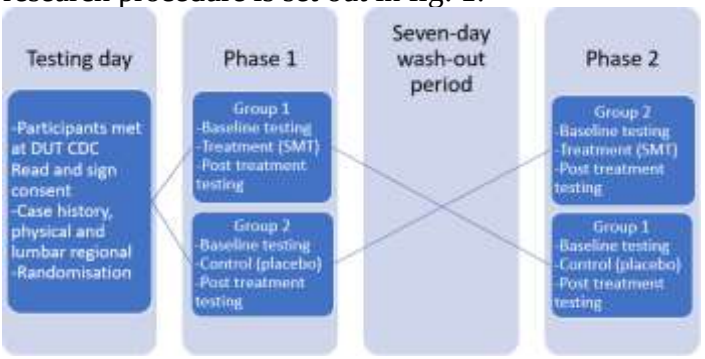

Fig. 1. Flow diagram of research procedure

Instrumentation

Field hockey SSTB was used to measure performance. The field hockey sport specific test consists of the sit and reach test, vertical jump test, 40 m sprint and 5-0-5 agility tests [11]. These tests have been proven to be valid and reliable: sit and reach test [12], vertical jump test [13], 40 m sprint [14] and 5-0-5 agility test [15]. These tests were completed identically pre- and post-intervention.

Data management

All participants were allocated a unique code. All the information and data from the participants were assigned to the unique code to ensure confidentiality.

Statistical analysis

IBM SPSS version 27 was used to analyse the data. A p-value <0.05 was considered as statistically significant.

Within-treatment comparisons from pre to post for objectives one and two were achieved using paired t-tests. For this two treatment, two period, randomised cross-over trial, the treatment effect for each outcome was measured as the difference between the pre and post measurement on that condition and modelled as a within-subjects effect (due to the pairing of the data) using repeated measures ANOVA. The group (one or two) was added as a between-subjects effect to test for the presence of a carry-over effect. Group 1 received treatment first and group 2 received the placebo first. A statistically significant treatment main effect indicated a difference between the two treatments, while a significant group main effect indicated incomplete randomisation (baseline imbalances). A significant treatment x group interaction indicated the presence of a carryover effect. The carryover effect is the effect of the treatment varied by the order of the treatments. Partial eta-squared values were reported as effect sizes.

Results

Twenty club field hockey players aged between 18 and 35 years were tested. There were no statistical differences between group 1 (23.2±3.16 yrs., 63.5±5.6kg, 163.9±2.85 cm, 5±2.71 yrs.) and group 2 (21.1±2.85 yrs., 58.8±4.89 kg, 165.1±4.95, 3.2±2.35 yrs.) in terms of age, weight, height and experience (df = 1, MS = 177.62, $p_{(Monte\ Carlo)}$ = 0.064). The flow diagram (Fig. 2) shows the chronological sequence of events for the study:

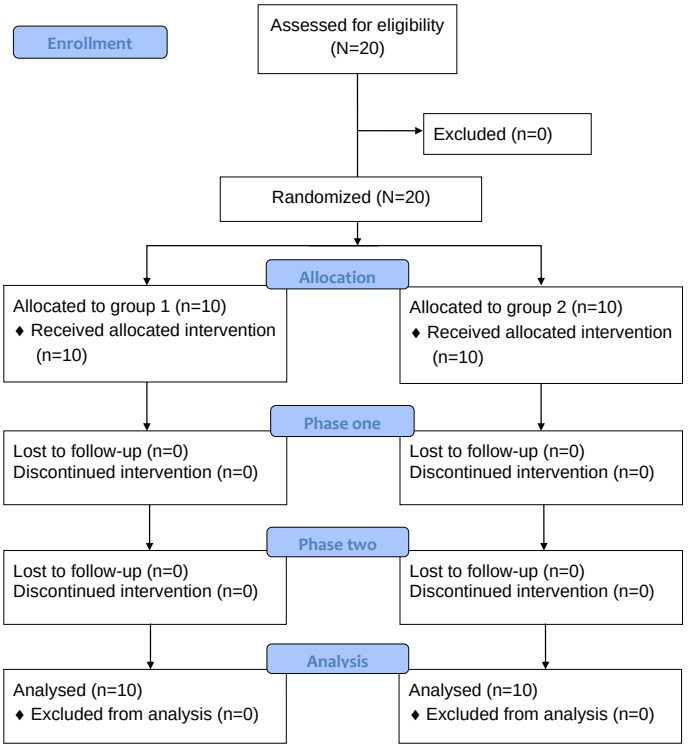

Fig. 2. CONSORT flow diagram

All outcomes changed statistically significantly under the SMT condition. The tests, that include the sit and reach ($p < 0.001$), vertical jump ($p < 0.001$), 40 m sprint ($p = 0.001$) and 5-0-5 agility ($p = 0.002$), were improved post SMT for both group 1 and group 2.

The data in terms of SST were compared pre and post test in group 1 and two with the following results:

Sit and reach (cm)

There was a statistically significant effect of treatment on the sit and reach test ($p = 0.005$) with no evidence of carryover effect ($p = 0.272$). The profile plot shows that SMT intervention difference values were higher than those for placebo, thus the change in sit and reach values were higher in the post SMT.

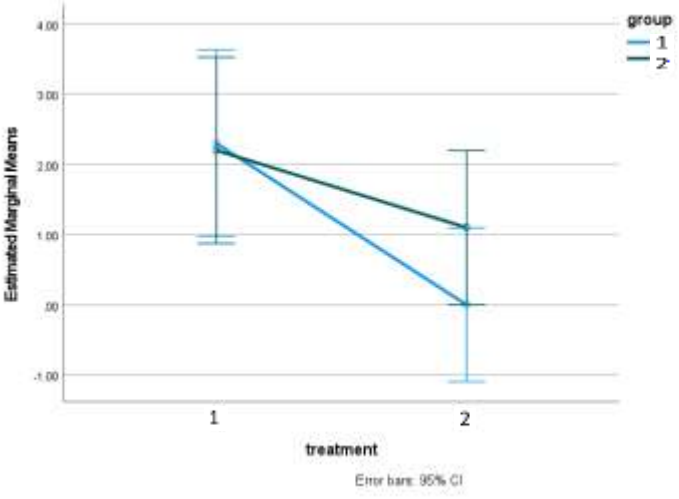

Fig. 3. Sit and reach group 1 vs group 2

Vertical jump (cm)

The vertical jump was statistically improved ($p < 0.001$) post treatment and no evidence of carryover effect ($p = 0.71$). The profile plot shows that SMT intervention difference values were higher than those for placebo, thus the change in vertical jump values were higher in the SMT group.

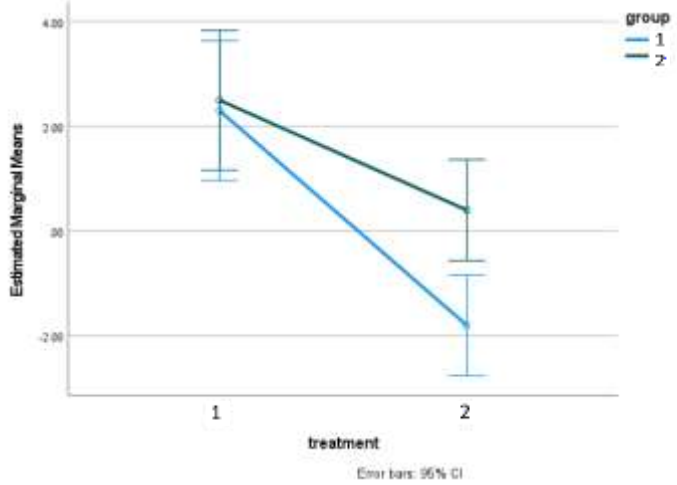

Fig. 4. Vertical jump group 1 vs group 2

40 m sprint (s)

There was a statistically significant improvement ($p < 0.001$) in times of the 40 m sprint post treatment and evidence of carryover effect ($p = 0.024$). Thus, the treatment cannot be interpreted since the effect of treatment depended on the order in which they received the treatments. The profile plot shows that while placebo difference values were higher than those for treatment, the slopes of the two groups were not parallel, indicating that group 2 improved to a greater extent on SMT than group 1.

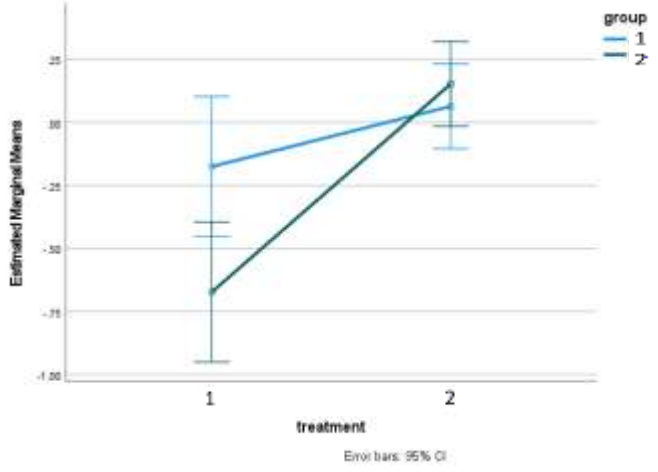

Fig. 5. 40 m sprint group 1 vs group 2

5-0-5 agility (s)

The profile plot shows that SMT intervention difference values were lower than those for placebo, thus the change in 5-0-5 agility values were higher (greater decrease) in the SMT group ($p < 0.001$) with no evidence of carryover effect ($p = 0.973$).

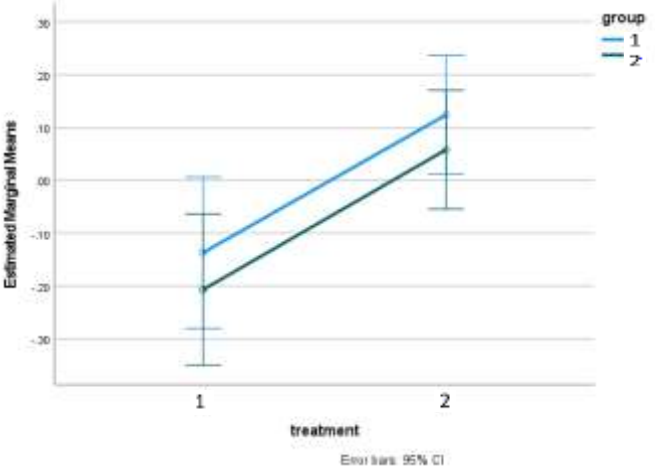

Fig. 6. 5-0-5 agility group 1 vs group 2

Discussion

The outcome for the tests post treatment was all statistically significant indicating that all the SST were improved after receiving chiropractic SMT. This finding is in accordance with the systematic review conducted by Botelho et al [7]. The study found that 4 out of the 7 clinical trials that were included in the review revealed that sport performance was improved by SMT. These studies included increased hip extension in male junior runners (n = 17), increased full swing in male golf players (n = 43), increased strength in male and female elite judoka (n = 18) and increased kicking speed in male elite soccer players (n = 40) [7].

Sit and reach

The sit and reach test were significantly improved post SMT treatment. These findings are in contradiction to the outcomes of Olson et al [16] that found that lumbar SMT did not significantly improve flexibility as measured by the sit and reach test. The study was a crossover study design that used SMT as treatment, sham acupuncture and no treatment as control treatment, the participants (n = 12) were cyclists that were equally randomised into AB:BA [16].

Vertical jump

The vertical jump was significantly improved post SMT treatment. Similar outcomes were obtained in asymptomatic rugby players [17]. A study conducted by Conradie [17] found that lumbar SMT improved sprinting times as well as vertical jump. The participants received a single treatment and

experienced immediate benefits as a result of the treatment that provided a biomechanical advantage [17].

Shrier, Macdonald and Uchacz [18] conducted a crossover study to determine if SMT improved the 40 m sprint and the countermovement jump height. Nineteen elite athletes involved in sprint sports took part in the study, the participants tended to perform better after SMT but the as a result of greater than expected variability the results were not statistically significant [19].

40 m sprint

The 40 m sprint test was significantly improved after the SMT treatment. As previously mentioned, both in the studies of Shrier, Macdonald and Uchacz [18] and Conradie [17] found that the lumbar SMT improved the 40 m sprint and vertical jump although the findings were only significant in the study of Conradie [17]. It is noteworthy to mention that a carryover effect is present, this indicates that the size of the effect depends on the order in which treatment was received. The group that received the placebo first and the SMT secondly had a greater improvement post intervention.

5-0-5 agility

The 5-0-5 agility test was significantly improved post SMT treatment. There have been contradictory findings concerning the effect of SMT on agility. Botelho et al [20] found that there was no immediate improvement in the change of direction (COD) sprint test that was conducted on 20 elite soccer players. A study that was conducted by Landman [21] found that the participants had improvement in the Illinois test immediately after SMT. Both the COD sprint- and the Illinois test measure the same component as the 5-0-5 agility test.

Conclusion

The aim of this study was to determine the immediate effect of SMT on performance of female club field hockey players.

The results were set out in terms of the objectives that were set in chapter 1. All the SST had a statistic significant change after the treatment of SMT was administered whereas only the 5-0-5 agility test had a significant change after the control of placebo treatment was administered. The mean time of the participants were higher and therefore their performance in the 5-0-5 agility test decreased post placebo.

The SMT treatment was superior compared to the placebo treatment in all the outcomes. The 40 m sprint test appeared to be a benefit of treatment only if the order of intervention is first placebo, then SMT treatment, whereby SMT values were lower, faster mean time, than if the order of treatments were SMT firstly and control secondly as in the case of group 1. The treatment effect cannot therefore be interpreted as the effect of treatment is dependent on the order in which the treatments were administered.

In conclusion SMT can improve the performance in female field hockey players. This was concluded on the basis that SMT was superior to control for all the tests in the field hockey SSTB that consisted of the sit and reach, vertical jump, 40 m sprint and 5-0-5 agility tests. A statistical significance was observed in all the SST although evidence of carryover was present in the 40 m sprint.

Conflict of interest and source of funding: The authors declare no conflict of interest with respect to authorship and/or publication of this article.

Acknowledgements: The authors would like to acknowledge and thank the participants who willingly participated in the study.

Author contributions:

AM designed the study, collected the data, analysed the data and interpreted it, wrote the draft and final paper. GM and CP contributed to the design of the study and critically assessed the draft and final paper. All authors approved the final paper.

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APPENDICES

Appendix A: Advertisement

Attention all female hockey players

Are you a healthy female, between 18 and 35 years, and interested in testing your hockey performance?

Taking part in the study may affect your hockey performance.

Please contact Arline Muller 082 455 0488 if you are interested in participating in the study.

Appendix B: Letter to the Research Director

2020/02/20

Director: Research and Postgraduate Support

Request for Permission to Conduct Research

Dear Professor,

My name is Arline Muller, a MTech Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves the immediate effect of spinal manipulative therapy on performance in female field hockey players.

I am hereby seeking your consent to conduct research using DUT staff and participants.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (082 455 0488 or arline.muller@yahoo.com). Thank you for your time and consideration in this matter.

Yours sincerely,

Arline Muller
Durban University of Technology

Appendix C: Letter to the Clinic Director

2020/02/20

Clinic Director: Chiropractic Day Clinic: Chiropractic

Request for Permission to Conduct Research

Dear Clinic Director,

My name is Arline Muller, a MTech Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves the immediate effect of spinal manipulative therapy on performance in female field hockey players.

I am hereby seeking your consent to access and conduct my research at the DUT Chiropractic Day Clinic.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (082 455 0488 or arline.muller@yahoo.com). Thank you for your time and consideration in this matter.

Yours sincerely,

Arline Muller
Durban University of Technology

Appendix D: Letter to the Fred Crooks Sport centre Director

2020/02/20

Fred Crooks Sport centre Director

Request for Permission to Conduct Research

Dear Director,

My name is Arline Muller, a MTech Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves the immediate effect of spinal manipulative therapy on performance in female field hockey players.

I am hereby seeking your consent to access and conduct my research at the DUT Fred Crooks Sport centre.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (082 455 0488 or arline.muller@yahoo.com). Thank you for your time and consideration in this matter.

Yours sincerely,

Arline Muller
Durban University of Technology

Appendix E: Letter to the Hockey Clubs

2020/02/20

Manager: Hockey club

Request for Permission to Conduct Research

Dear Manager,

My name is Arline Muller, a MTech Chiropractic student at the Durban University of Technology. The research I wish to conduct for my Masters dissertation involves the immediate effect of spinal manipulative therapy on performance in female field hockey players.

I am hereby seeking your consent to approach the female field hockey players at this hockey club.

I have provided you with a copy of my proposal which includes copies of the data collection tools and consent and/ or assent forms to be used in the research process, as well as a copy of the approval letter which I received from the Institutional Research Ethics Committee (IREC).

If you require any further information, please do not hesitate to contact me (082 455 0488 or arline.muller@yahoo.com). Thank you for your time and consideration in this matter.

Yours sincerely,

Arline Muller
Durban University of Technology

Appendix F: Letter of information and informed consent (English)

LETTER OF INFORMATION

Dear participant

Title of the Research Study:

The immediate effect of lumbar spinal manipulative therapy on performance in female field hockey players

Principal Investigator/s/researcher:

A Muller, BTech Chiropractic

Co-Investigator/s/supervisor/s:

Dr G Matkovich, MTech Chiropractic and Dr C Prince, MTech Chiropractic

Brief Introduction and Purpose of the Study:

Field hockey is a widely popular sport that is frequently played in South Africa. Sportsmen are continuously seeking to improve performance and decrease injuries. Performance can be measured with sport specific tests. The sport specific tests for field hockey are sit and reach, vertical jump, 40 m sprint and 5-0-5 agility test.

Field hockey players are prone to get restrictions and injuries in their lower backs because of the semi-crouched position they maintain most of the game. This can have an effect on the performance of a player. Spinal manipulative therapy (SMT) is a hands-on treatment that

includes manipulation that is a high velocity low amplitude thrust to the restrictions found in the spine.

The study aims to research the effect of SMT on the performance of female field hockey players that have restrictions in their lower backs.

Outline of the Procedures:

The first step in participating in this study is to read the letter in order to ask questions and give full informed consent. The testing will take place in two phases:

Phase one a Case history, Physical examination and Lumbar regional examination will be done at the DUT Chiropractic Day Clinic. You will be assessed by 5th year Chiropractic student under the supervision of a clinician for restrictions in your lower back. You will then complete a sport specific test battery that will consist of the sit and reach, vertical jump, 40 m sprint and 5-0-5 agility test. Thereafter you will receive spinal manipulative therapy or lay on a chiropractic table dependent on the group that you were assigned to and then complete the same sport specific test battery.

After a minimum of seven days phase two will commence. Phase two the same tests will be repeated, and you will receive the treatment that was not administered in phase one (spinal manipulative therapy or lay on a table). Lastly the sport specific test battery will be completed. The results will be noted, and you will be informed of the outcome of the study. The procedure will take 90min to complete.

Inclusion criteria:

- Participants between 18 and 35 years of age.
- Female.
- Fixations in the lumbar spine.
- Participants who sign the letter of information and consent form.

Exclusion criteria:

- The participants presenting with one or more contra-indications to SMT. Contra-indication of the lumbar spine includes pathologies that lead to bone

weakening, nerve root, cord or cauda equina compression with increasing neurological deficit, aortic aneurism, lack of diagnosis and patient positioning that cannot be achieved due to pain or resistance.

- Participants that present with current musculoskeletal conditions such as muscle sprains and ligament strains that could influence the performance of the participant or the results of the study.
- Goal keepers as these players have unique sport specific tests.

Risks or Discomforts to the Participant:

The risks involved with SMT are minor if they do occur. Side effects may include discomfort, headaches, autonomic phenomena such as dizziness and post treatment discomfort. Extremely rare complications are fractures, disc herniations, stroke and progression of neurological symptoms.

Benefits:

The participants will directly benefit from the intervention as the restrictions in the lumbar spine will be treated with SMT. The researcher expects to publish the findings in a Journal.

Reason/s why the Participant May Be Withdrawn from the Study:

Should the participant choose to withdraw there will be no adverse consequences.

Remuneration:

No remuneration will be given to the participants.

Costs of the Study:

There are no costs involved for the participants.

Confidentiality:

Confidential information will be kept confident by using a coding system for the reporting and analysis of information. You may withdraw at any stage of the study and no coercion will occur.

Research-related Injury:

The protocol set by the general health clinic will be followed and the injury will be reported to the Institutional Research Ethics committee. Please advise the researcher of any such problems.

Persons to Contact in the Event of Any Problems or Queries:

Please contact the researcher Arline Muller (082 455 0488), my supervisors Dr G Matkovich (031 201 8204) and Dr Prince (031 373 3005) or the Institutional Research Ethics Administrator on 031 373 2375. Complaints can be reported to the DVC: Research, Innovation and Engagement Prof S Moyo on 031 373 2577 or moyos@dut.ac.za

Yours sincerely

Arline Muller
Researcher

CONSENT

Statement of Agreement to Participate in the Research Study:

- I hereby confirm that I have been informed by the researcher, Arline Muller, 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, Arline Muller,herewith confirm that the above participant has been full 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 G: Letter of information and informed consent (IsiZulu)

INCWADI YEMININGWANE NGOCWANINGO

Isihloko socwaningo:

The immediate effect of lumbar spinal manipulative therapy on performance female in field hockey players

Umqondisi womcwaningi:

A Muller, BTech Chiropractic

Umlekeleli womqondisi womcwaningi:

uDtkl G Matkovich, MTech Chiropractic and uDtkl C Prince, MTech Chiropractic

Isingeniso kanye nenhloso yesifundo socwaningo:

Umdlalo we-Hockey umdlalo ojwayelekile okanye odumile eningizumu Afrika. Abemidlalo bahlezi bebheka izindlela abangavimba ngayo ukulimala nokuthuthukisa ikhono labo lokudlala. Izinga lokudlala lingakalwa ngokuhlolwa okuqondene nqo nezemidlalo.

Abadlali be-Hockey basencupheni yokulimala okanye ukujama kwamathambo ngenxa yendlela abama ngayo emidlalweni yabo. Lokhu kungaba nomthelela omukhulu ezingeni lendlela yokudlala kwabo. Ukuqondisa komgogodla ngezandla ngamandla aphezulu nokuqhumisa uma kubuyiselwa amathambo endaweni yawo kungaba nomthelela ekujameni kwamathambo.

Inhloso yalesifundo socwaningo ukubheka imiphumela yokulungisa umgogodla ngezandla kubadlali be-Hockey.

Uhlaka lwezinqubo:

Isigaba sokuqala ekubambeni iqhaza kulolucwaningo ukuba ufunde incwadi yemininingwane ukuze uzokwazi ukubuza imibuzo usayine ukuba uzobamba iqhenye kulesifundo socwaningo. Ukuhlolwa kuzothatha izigaba ezimbili.

Isigaba sokuqala ukuthatha imininingwane yalo obambe iqhaza, ukuhlolwa kwemoilo, nokubhekwa ngokucophelela iqolo okuyokwenzelwa emtholampilo wase- DUT. Uyohlolwa umcwaningi egadwe umelekeleli emtholampilo. Uyobe usugcwalisa okuqondene nqo nezemidlalo ukuze uzohlolwa okuyofaka ukuhlala uthinte, ukugxuma, uku-sprinta. Emuva kwalokho uyobe usulashwa iqolo ulele etafuleni elisetshenziswa kulomtholampilo.

Emuva kwezinsuku eziyisikhombisa isigaba sesibili siyoqala. Isigaba sesibili kuyohlolwa ngokufanayo nakwesokuqala, mase uthola ukwelashwa okungenzeka kwisigaba sokuqala (ulele etafuleni). Okokugcina ukuhlolwa okuqondene nezemidlalo kuyoqhutshezwa. Imiphumela iyogcina obebambe iqhaza aziswe ngayo. Lokhu kuyothatha isikhathi esingamaminithi awu 90.

Ongabamba iqhaza:

- Abaneminyaka ephakathi kuka-8 no 35.
- Abesifazane.
- Izinhlungu eqolo noma emhlane.
- Abavumile basayina incwadi yemininingwane neyemvume yokubamba iqhaza.

Ongeke abambe iqhaza:

- Ongaba nezimpawu ezingavimba ukubuyisela umgogodla endaweni, njengokulahlekelwa inqondo, i-depression, okanye esinye isifo senqondo, izifo ezimayelana nemithambo yegazi.
- Onenkinga engaba ukuphuka, ukunyela okungaba nomthelela ekudlaleni komdlali okanye imiphumela yalolucwaningo.
- Onozinti ngoba baneqhaza elihlukile.

Ubungozi okanye ukungaphethi kahle kobambe iqhaza:

Ubungozi obumayelana nokubuyiselwa komgogodla esimweni mincane, uma kwenzeka yenzeka. Ama-side effects angafaka unzululwane okanye ukungapheki kahle. Okunye kungaba

ukuphuka, kepha amathuba mancane, ukufa kwezinhlangothi kanye nokuqhubeka kwezimpawu zemizwa.

Inzuzo

Ababambe iqhaza bayozuza ngokungenelela kulesifundo socwaningo ngokuba imikhawulo eqolo iyolashwa. Umcwaningi ufisa ukushicilela okutholakele ocwaningweni kwiphephabhuku.

Izizathu kungani ungahoxiswa ukubamba iqhaza kulolucwaningo:

Kungenzeka obambe iqhaza akhethe ukuhoxisa, azikho izinyathelo ezizothathwa.

Inkokhelo:

Akukho nkokhelo eyotholwa oyobe embambe iqhaza kulesifundo socwaningo solwazi.

Izindlelo zocwaningo:

Akukho zindleko mayelana nalesi Sifundo socwaningo.

Ubumfihlo

Imininingwane eyimfihlo iyogcina ngasese ngokusebenzisa uhlelo lokufaka amakhodi ukuze kuzobikwa , kuhlaziywe imininingwane. Ungahoxa ukubamba iqhaza nanoma ukuyiphi inxenye yocwaningo.

Ukulimala mayelana nalesi Sifundo socwaningo:

Umthetho obekwe umtholampilo wasenyuvesi yasethekwini yamakhono uyolandelwa kanye nokulimala okungenzeka kuyobikwa kubaphathi bokuqondisa. Kuyomele umcwaningi abikelwe ngezehlakalo.

Ongamuthinta mayelana nezinkinga or imibuzo ongaba nayo:

Ungathinta umcwaningi U-Arline Muller ku-082 455 0488, umqondisi womcwaningi uDokotela G Matkovich Ku-031 201 8204 kanye nomelekeleli womcwaningi uDktl Prince ku-031 373 3005 okanye umphathi wesikhungu socwaningo oluphakeme kwezemfundo the ku-031 373 2375. Izikhalazo zingabikwa kuDVC onguProfesa S Moyo ku-031 373 2577 or moyos@dut.ac.za

Ozithobayo

Arline Muller

Umcwaningi

ISIVUMELWANO

Isitatimente semvumelwano yokuthatha ingxenye kwisifundo socwaningo:

- Ngilapha ngiyaqinisekisa ukuba umcwaningi, Arline Muller ungichazele wangicacisela ngayo yonke imininingwane mayelana nesihloko, nobungozi, nosizo oluzoza nokwenzeka kwesifundo sakhe.- Ucwangingo nezimilo kanye nemvume, inombolo: _____,
- Ngiyaqinisekisa ngitholile, ngafunda ngaphinda ngaqondisisa imininingwane engaphezulu (Incwadi yemininingwane mayelana nesifundo socwaningo) mayelana nalesi Sifundo socwaningo.
- Ngiyaqonda ukuthi imiphumela, kanye nemininingwane mayelana nobulili, iminyaka, imininingwane yokuzalwa kwami, amagama ami kanye nokugula kwami akuyodalulwa kwisifundo socwaningo.
- Ngokubheka okudingekayo mayelana nalesi sifundo socwaningo, ngiyavuma ukuba imininingwane etholakale ngokuqhubeka kwesifundo ingagcinwa.
- Nginelungelo, kunoma yisiphi isigaba, ngaphandle ngokubuzwa okanye ukuthola imvume ukuhoxisa ukubamba iqhaza kulolucwaningo.
- Ngibe nesikhathi esanele nethuba ukuba ngibuze nanoma yimiphi imibuzo ngaphambi kokuba ngivume ukubamba iqhaza kulolucwaningo.
- Ngiyaqonda ukuthi nanoma yimiphi imiphumela ezotholakala kulolucwaningo mayelana nami, ngiyokwaziswa ngayo.

_____ _____ _____ _____

Amagama aphelele lobambe iqhaza kwisifundo **Usuku** **Sayina**

Isithupha

Mina, Arline Muller, ngiyaqinisekisa ukuba lona ongenxa ubambe iqhaza eliphelele kwisifundo socwaningo sami, uchazele ngezinqinamba nenhlobo yocwaningo.

Amagama aphelele omncwaningi **usuku** **Sayina**

Amagama ofakazi	**Usuku**	**Sayina**
Amagama omzali	**Usuku**	**Sayina**

Appendix H: Randomisation plan

A Randomization Plan

from

http://www.randomization.com

1. Treatment
2. Treatment
3. Treatment
4. Placebo
5. Treatment
6. Placebo
7. Placebo
8. Placebo
9. Treatment
10. Placebo
11. Treatment
12. Treatment
13. Placebo
14. Treatment
15. Placebo
16. Placebo
17. Treatment
18. Treatment
19. Placebo
20. Placebo

20 subjects randomized into blocks of
10 10
To reproduce this plan, use the seed 2441
along with the number of subjects per block/number of blocks
and (case-sensitive) treatment labels as entered originally.
Randomization plan created on 29/10/2020, 08:43:32

Appendix I: Case history and Physical and Lumbar regional examination

DUT DURBAN UNIVERSITY OF TECHNOLOGY — DEPARTMENT OF CHIROPRACTIC

CHIROPRACTIC DAY CLINIC CASE HISTORY

Patient: _____ Date: _____

File #: _____ Age: _____

Gender: _____ 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:

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

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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:**

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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

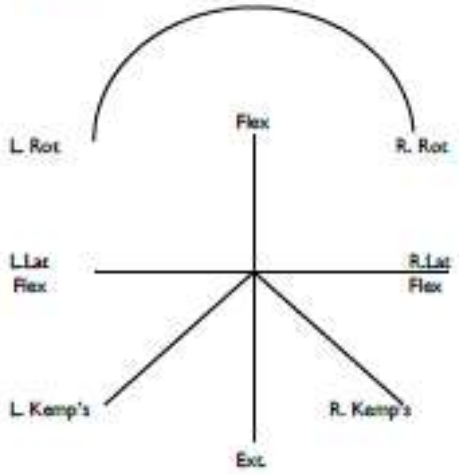
Minor's Sign
Muscle tone
Spinous Percussion
Schober's Test (6cm)
Bony and Soft Tissue Contours

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

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

SLUMP / 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

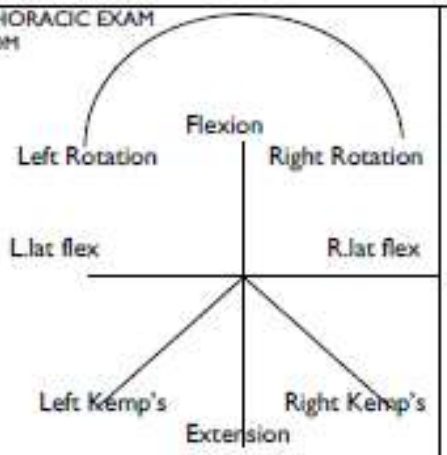
Fasciculations						
Plantar reflex						
level	**Tender?**	**Dermatomes**		**DTR**		
		L	**R**		**L**	**R**
T12				Patellar		
L1				Achilles		
L2						
L3				Proprioception		
L4						
L5						
S1						
S2						
S3						

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		

Appendix J: Data collection sheet

Data collection sheet

Participant number:		Group:
Position:		Team:
Phase one		
	Pre-test	Post-test
Sit and reach		
Vertical jump		
40 m Sprint		
5-0-5 Agility		
Phase two		
	Pre-test	Post-test
Sit and reach		
Vertical jump		
40 m Sprint		
5-0-5 Agility		

Appendix K: COVID 19 protocols

GUIDELINES FOR GOOD PRACTICE HYGIENE IN RELATION TO SARS-COV-2

Department of Chiropractic Chiropractic Day Clinic and Department Protocols

General considerations and signage for implementation of protocol

- Appropriate signage describing:
    - Information for staff, students, visitors and patients about screening and hygiene procedures.
    - Signs and symptoms of COVID-19.
    - How to cough, advising people not to touch their mouths, nose or eyes.

- All items in the waiting or consulting rooms which are not required or patients may come into contact with unnecessarily, such as books, magazines, children's toys, pens, models, etc. should be removed. This will also include the use of the water dispenser.

- Sanitisers have been placed in all areas where it is required such as front desks, reception areas, guard cubicles, clinic rooms, clinician offices, kitchens, toilets, etc.

- A protective shield to be put up at reception. This shield needs to be regularly disinfected.

- Appropriate floor marking has been done appropriately using blue tape in all offices and clinic areas (reception, clinicians' office, consultation rooms, shared toilet areas, photocopiers and board rooms).

- Cleaning solutions containing at least 70% ethyl or isopropyl alcohol or 0.5% sodium hypochlorite will be used to disinfect surfaces. Must check surface areas before use as they can damage surfaces.

- Avoid congregation in areas such as passages or reception areas.

- The use of the elevator should be restricted to people with a physical disability and/or the elderly. Only one person at a time permitted to use the elevator. Strictly off limits to students. All touch buttons need to be disinfected frequently.

- Temperature testing/scanning daily for staff and students at the main entrances and for patients at the clinic entrance.

- Stair case railings are to be disinfected frequently by the cleaning staff.

Admin staff

- Temperature testing/screening upon arrival at main campus entrance.
- Need to be sprayed with hand sanitiser upon arrival. Must sanitise up to the elbow.
- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.
- Sanitising of individual doorknobs and door surfaces upon arrival and prior to leaving.
- Sanitising of any front office sliding window, office telephone, equipment, surfaces (inclusive of computer screens and keyboards) upon arriving and prior to leaving. Clinic reception desk must be disinfected between patients and if there is a changeover of reception staff the telephone and computer must also be disinfected.
- Should remove all items in the reception area which are not required or visitors may come into contact with unnecessarily, such as books, magazines, pens, etc.
- Anyone entering the offices must be notified to sanitise adequately.
- To disinfect the photocopier and any other shared items after using it.

Academic staff

- Temperature testing/screening upon arrival.
- Need to be sprayed with hand sanitiser upon arrival. They must sanitise up to the elbow.
- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.
- Sanitising of individual office doorknobs and door surfaces upon arrival and prior to leaving.
- Sanitising of office telephone, equipment, surfaces (inclusive of computer screens and keyboards) upon arriving and prior to leaving. Staff should only use their own equipment which must then be sanitised before and after each day – all offices to have a bottle of sanitiser

- To ensure that anyone entering the offices have been notified to sanitise adequately.
- To disinfect the photocopier and any other shared items after using it.
- Must bring their own pen.
- A screen will be installed in the department reception area.

Clinic admin

- Temperature testing/screening upon arrival at main campus entry point.
- Need to be sprayed with hand sanitiser upon arrival. They must sanitise up to the elbow.
- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.
- Sanitising of individual office doorknobs and door surfaces upon arrival and prior to leaving.
- Sanitising of telephones, equipment, surfaces (inclusive of computer screens and keyboards) upon arriving and prior to leaving.
- Sanitising of counter tops and protective shield.
- Ensure that pens, clipboards, credit card machines or credit cards are cleaned between each patient.
- To ensure that any towels, gowns and shorts used by patients are appropriately laundered and tumble dried after use. Where possible patients to bring their own towels, gowns and shorts.
- Staff to each have a defined work station within the social distancing guidelines of 1.5m – only one staff member to man the reception desk.
- Files that are returned are to be placed in quarantine for 24 hours before being processed.

Cleaners

- Temperature testing/screening upon arrival at main campus entry point

- Need to be sprayed with hand sanitiser upon arrival. Must sanitise up to the elbow.

- Should wear gloves as is recommended by the AHPCSA as well as disposable aprons.

- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.

- Sanitising of doorknobs, door surfaces and gates of main entrance doors

- To disinfect the surfaces, telephone, computer screens, keyboards and desks in the clinicians' office.

- To disinfect the surfaces, kitchen equipment, kitchen floor and fridges in kitchens.

- To disinfect the toilets, wash basins, toilet walls and floors, door surfaces and doorknob. a spray bottle of disinfectant will be placed in the toilet along with a printed notice indicating that all surfaces that will be/have been come into contact with, must be disinfected before and after use.

- Must ensure that all mops and cleaning equipment remain in the detergent after disinfecting floors and surfaces and between uses.

Students

- Students will be screened at the main campus entry using the Higher Health app and their temperature will be taken

- Must wear a face mask all the time. Cloth face masks to be washed and ironed daily.

- Avoid wearing jewellery, watches.

- Avoid wearing long sleeves when treating patients, as one needs to sanitise/wash up to the elbow.

- Students need to be sprayed with hand sanitiser upon arrival. Must sanitise up to the elbow.

- Must wear clean and ironed clinic jacket.

- All clothing worn must be washed daily using high temperatures (where possible) using washing powder with a proper oxidizing agent and should be tumble dried or hung in the sun for UV disinfection.

- Equipment which are used during the consultation or for treatment should be thoroughly cleaned and/or disinfected as appropriate between each patient, e.g. BP cuffs, stethoscopes, diagnostic kits, wedges/blocks, activators, fascial release equipment etc. This also applies to any modality room used as well as the rehab room. This will be done by the student.

- Surfaces must be cleaned at the start of the day and after each patients. The entire bed needs to be disinfected by the student between patients (not only the head piece). Examination couch, desks, chairs and door handles also need to be disinfected between patients.

- To ensure that towels, gowns and shorts are removed from the treatment rooms after each patient and handed placed in the laundry basket which will be available in the clinic. Reception staff will collect the basket regularly. Reception attire will only be issued in instances where patients have forgotten to bring their own.

- Students to remain in their allocated treatment room during their shift. No swopping of rooms or congregating in treatment or common room. In addition, no congregating in the passage or clinician's office. The common room will be shut down during this period.

- Patients are to be advised to ice and/or use heat at home.

- Discontinue the use of TENS and EMS temporarily as we cannot disinfect the sticky electrodes and it's not financially feasible to use them on a once off basis. Discontinue IFC temporarily as the straps cannot be disinfected

- Students to only report to reception to collect a patient or to obtain files for case summaries or linen. Packs of paperwork will be provided to each student to be retained in their locker. This will be replaced if it runs out.

- Student observers in fourth year as well as any scholars will not be permitted to do any observations until such time is deemed safe.

- Each student treating in clinic to be sent an electronic copy of diagnostic and treatment codes and files to be coded in the treatment room and not in the reception waiting area, tables in the passages or in the clinicians' office.

- All booking of appointments for patients will be handled by Linda. In the event that she is unavailable a message must be taken and she will get back to them.

- Fifth year students will not be allowed to work at reception until such time that it is deemed safe to do so. Paid part time reception staff will be permitted to continue working the lock up shift as well as providing relief in respect of full time clinic staff that are on leave/sick leave.

- All students will be rostered on a rotational basis to screen incoming patients for symptoms of COVID-19.

- All students will be required to sign an agreement to adhere to the COVID-19 clinic protocols. Should any student be found to be in breach of these protocols, disciplinary action will be taken by the Chiropractic Department and DUT.

- Windows in treatment rooms to be opened at start of shift to improve ventilation. Students to ensure that all windows are closed before they leave the premises.

Patients

- No walk-ins, access to clinic is strictly by appointment.

- Patient booking must allow for time to clean surfaces and contact areas as well as for ventilation. The AHPCSA recommends a minimum of 15 minutes/patient.

- Patients need to be informed that they should refrain from wearing jewellery.

- It is advisable that patients carry their own pens to fill in any paperwork.

- A register must be kept of all patients presenting daily.

- Telephonic screenings to be done when booking appointments. Telephonic screening to involve the following:
  - Cough, fever (above 38 degrees), sore throat, malaise
  - Exposure to anyone with suspected or diagnosed with COVID-19 in the last 14 days
  - Worked or attended a clinic facility treating COVID-19 patients
  - Travel internationally or domestically in the last 14 days

- Patients will be contacted the day prior to OR ON THE DAY OF their appointment and screened.

- Patients need to be informed that they are required to wear a mask for the duration of the treatment. Patients are to be informed that they must carry their own gown and shorts.

- Higher risks patients (e.g. over the age of 60 years, asthma, chronic lung conditions such as COPD, cancer, immunocompromised, pregnant, diabetes, cardiac disease, organ transplant, hypertension) need to be informed that they do have/carry a higher risk. Patients will be informed if they are high risk and what the implications are and all patients will be required to sign an indemnity/consent to treatment during the COVID-19 pandemic.

- Patients need to be use the hand sanitiser upon arrival. Must sanitise up to the elbow.

- Temperature testing or screening of every patient must be done prior to entering the reception area.

- Upon arrival, patients must be screened for risk factors as well as sign that they do not have risk symptoms or history. They will be required to sign a declaration for entry in the chiropractic clinic form.

- Patients will not be permitted to wait at reception with other patients; therefore, using a staggered approach to bookings is necessary. In the instance that patients have to wait, there must be a distance of 1.5m between patients seated in the reception area. All friends and family must wait in their vehicle.

- It is recommended that patients do not touch anything inside the rooms unless absolutely necessary. The use of toilets needs to be monitored and signage and disinfectant will be available requesting that anyone using the facility must disinfect surfaces both before and after use.

- An appropriate area will be designated for any patients who display symptoms and they must be adequately referred for further testing.

- Patients are not to be accompanied by anyone (including minors) unless they require assistance.

Guards

- Temperature screening testing upon arrival at main campus entrance.

- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.

- Need to be sprayed with hand sanitiser upon arrival. Must sanitise up to the elbow.

- Sanitising of doorknobs, door surfaces and gates of individual office door upon arrival and prior to leaving.

- To control movement in and out.

- Ensure that everyone complies with the protocols being enforced.

Clinicians

- Temperature testing/screening upon arrival at main campus entrance.

- Need to be sprayed with hand sanitiser upon arrival. They must sanitise up to the elbow.

- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.

- To ensure that the appropriate distances of 1.5m is maintained at all times and that students do not congregate in the clinicians' office (only one student allowed per clinician at any given time).

- Clinicians to disinfect desks, chairs and pens used upon arrival for their shift and prior to leaving.

Visitors to the department (e.g. parents)

- Temperature testing/screening upon arrival.

- Need to be sprayed with hand sanitiser upon arrival. They must sanitise up to the elbow.

- Must wear a face mask at all times. Cloth masks to be washed and ironed daily.

- It is recommended that they do not touch anything in the reception area.

- To keep a distance of 1.5m at all times.

- Parents should be advised to rather email or consult telephonically when they call in

- requesting for an appointment. Email is better so that the "he said/she said" scenario is avoided.

What to do in the instance of exposure to a COVID-19 patient

- Close off the areas/treatment room that the patient has been in and increase ventilation in those areas.

- Do not clean or disinfect the area immediately as the AHPCSA recommends waiting for a period of 24 hours prior to cleaning and disinfecting. Any and all surfaces, equipment and areas which the person came into contact with needs to be disinfected.

- Refer the person for further investigations immediately.

Requirements to carry out the above protocols

- Hand held temperature scanners

- Cleaning solutions containing at least 70% ethyl or isopropyl alcohol or 0.5% sodium hypochlorite are recommended (or approved cleaning detergent).

- Cleaning staff need to be adequately trained and given appropriate PPE to use including disposable aprons.

- An additional cleaner to assist in the clinics as it is massive for two to cope on their own given the tasks required.

- Spray bottles for disinfectants. To be given to all staff and students to use for disinfecting surfaces (offices and clinic)

- Disposable paper towel to be used to disinfect areas. ALL MATERIAL – INCLUDING PAPER FOR THE BEDS NEEDS TO GO INTO THE BIOHAZARD BINS AND NOT THE NORMAL BINS !

- Face masks – two cloth masks will initially be issued to staff and students. Disposable masks will be available for patients who arrive without them.

- Blue tape to mark distances in all areas

- Protective shield for reception area both in clinic and departments

- Printed symptom check lists

- Signage with hygiene protocols

Factors to consider for face to face teaching:

- All desks and chairs must be disinfected prior to use and prior to leaving the venue by students using them

- The beds in the practical room/s need to be disinfected before use and once the prac session is done.

- All other surfaces need to be disinfected in lecture venues on a daily basis.

- Any computers and keypads or shared department laptops should be disinfected every time it is used.

- We need to consider face shields in addition to masks for any one doing the temperature testing/screenings.

- Some of the disinfectant may be too strong to use on the beds so we may need to consult with HiTech or any other supplier for ones that do not damage beds or wear the fabric down.

- The use of markers for topo needs be considered. Each student must have their own one to be used on them.

- Social distancing measures need to be set up in classrooms with appropriate markings as well.

NOTES:

AHPCSA Guidelines to disinfecting:

Hard (Non-porous) Surfaces

If surfaces are dirty, they should be leaned using a detergent or soap and water prior to disinfection.

For disinfection, most common household disinfectants should be effective. Follow the manufacturer's instructions.

Diluted household bleach will be effective against coronaviruses when properly diluted. Prepare a bleach solution by mixing 20 ml bleach per litre of water.

Soft (Porous) Surfaces

For soft (porous) surfaces such as carpeted floor, rugs, and drapes, remove visible contamination if present and clean with appropriate cleaners indicate for use on these surfaces.

If items can be laundered, launder items in accordance with the manufacturer's instructions using the warmest appropriate water setting for the items and the dry items completely. Do not shake laundry before cleaning.

Electronics

Remove visible contamination if present. Follow the manufacturer's instructions. Use of alcohol-based wipes containing at least 70% alcohol to disinfect touch screens. Dry surfaces thoroughly to avoid pooling of liquids.

CONSENT FOR CHIROPRACTIC TREATMENT DURING THE COVID-19 PANDEMIC

I,_____, knowingly and willingly consent for myself or for a minor_____, under my care, to receive elective Chiropractic or emergency Chiropractic treatment from the Durban University of Technology Chiropractic Day clinic during the COVID-19 pandemic.

I understand the COVID-19 virus has a long incubation period during which carriers of the virus may not show symptoms but still be highly contagious.

Chiropractic procedures/treatment take place with the patient in very close proximity to the practitioner. This potentially exposes the patient and the practitioner to the COVID-19 virus.

I understand that due to the frequency of other Chiropractic patients, the characteristics of the virus, and the characteristics of Chiropractic practice, that I have an elevated risk of contracting the virus simply by being in the Chiropractic clinic._____(Initial)

I confirm that I am not presenting with ANY of the following symptoms of COVID-19 listed below:

- Fever
- Shortness of Breath
- Dry Cough
- Runny Nose
- Sore throat
-

High risk patients relating to the severity of COVID-19 are persons of the age of 60 and persons who have pre-exiting medical conditions such as: asthma; chronic lung conditions; hypertension; autoimmune diseases; organ transplants; cancer; immunocompromised; obesity (BMI over 40) and liver or kidney conditions.

I confirm that I do not fall into any of these high risk categories_____(Initial)

Consultations and treatment will only be done for high risk patients if absolutely necessary and in emergencies.

I am aware of the risks involved with the spread of COVID-19 and the risks it may hold to my health and the health of others I come into contact with. I accept those risks and hereby indemnify and hold the Durban University of Technology Chiropractic Day Clinic and its students and staff blameless should I contract the disease at the clinic premises or from the clinic staff and/or students.

_____ _____

Patient's signature DATE

COVID-19

Declaration for entry into the Chiropractic Day Clinic

Name and Surname			
File No			
Contact number			
Reason for entry			
Body temperature reading at time of entry			
TICK AS APPLICABLE		**YES**	**NO**
Have you been in contact in the last 14 days with someone who is confirmed to have COVID-19?			
Have you been for a COVID-19 test in the last 14 days?			
Have you received test results for COVID-19 in the last 14 days?			
What was the outcome: _____		N/A	
Do you have any results pending for COVID-19 testing?			
Are you currently suffering with any of the following symptoms or have you had any of these symptoms within the past 14 days?			
• Cough			
• Fever			
• Sore throat			
• Shortness of breath (or difficulty of breathing)			
• Fatigue, weakness or tiredness			
• Aches and pains or headaches			
• Loss of smell			
• Loss of taste			
• Redness of eyes			
• Nausea			
• Vomiting			
• Diarrhoea			

Declaration

I hereby declare that the information I have disclosed is correct at the time of completion. To the best of my knowledge I have not had direct contact with any person who has tested positive for COVID-19 symptoms in the past 14 days, nor have I presented with any of the above COVID-19 symptoms within the past 14 days.

_____ _____

Signature Date

Appendix L: IREC approval

Institutional Research Ethics Committee
Research and Postgraduate Support Directorate
3rd Floor, Berwyn Court
Gate 1, Steve Biko Campus
Durban University of Technology

P O Box 1334, Durban, South Africa, 4001

Tel: 031 373 2375
Email: irecchair@dut.ac.za
http://www.dut.ac.za/research/institutional_research_ethics

www.dut.ac.za

30 October 2020

Ms A Muller
124 Ester Roberts Road
Glenwood
Durban

Dear Ms Muller

The immediate effect of lumbar spinal manipulative therapy on performance in female field hockey players
Ethical Clearance number IREC 084/20

The Institutional Research Ethics Committee acknowledges receipt of your gatekeeper permission letters.

Please note that FULL APPROVAL is granted to your research proposal. You may proceed with data collection.

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 Standard Operating Procedures (SOP's).

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

Yours Sincerely

Prof J K Adam
Chairperson: IREC

Appendix M: Plagiarism declaration

DUT DURBAN UNIVERSITY OF TECHNOLOGY

PLAGIARISM DECLARATION

I, Arline Muller (Full name of student) and
Dr Cleo Prince and Dr Grant Matkovich (full name of supervisor/s), do declare that in respect of the following dissertation/thesis:

THE IMMEDIATE EFFECT OF LUMBAR SPINAL MANIPULATIVE THERAPY ON PERFORMANCE IN FEMALE FIELD HOCKEY PLAYERS

As far as we know and can ascertain: (√ appropriate answer)

a. No other similar dissertation/thesis exists ✓

b. The only similar dissertation/s thesis/es that exist/s is/have been referenced in my dissertation as follows:

1. I know and understand that plagiarism is using another person's work and pretending it is one's own, which is wrong.

2. This dissertation/thesis/essay/report/project is my own work.

3. All references as detailed in the dissertation are complete in terms of all personal communications engaged in and published works consulted.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Signature

ARLINE MULLER

Name (in capital letters)

21533649

Student Number

Appendix N: Turnitin report