The immediate effect of spinal manipulative therapy on drag flicking performance of field hockey players

By

Michael Wiggett

Dissertation submitted in partial compliance with the requirements for the Masters Degree in Technology: Chiropractic
Durban University of Technology

I, Michael Wiggett, do declare that this dissertation is representative of my own work in both conception and execution.

______________________ Date________________

Michael Wiggett

Approved for final submission

______________________ Date________________

Dr H Kretzmann
MDip Chiro CCFC (SA)

Dedication

This is dedicated to my family for their never-ending love and support.

To my parents, Di and Iain, for saying I can…

To my brothers, Andrew and Stephen, for saying I can't.

Acknowledgements

To Dr H. Kretzmann: Thank you for being my supervisor, and for your expert guidance during execution of this research project. It would not have been possible without you.

To Dr C Korporaal: Thank you for all the early mornings and late evenings in your office and for offering advice and pushing me to finish this dissertation on time.

To Dr Bruce Grant: Thank you for giving up your free time, especially during such a busy period in your life, to help with the data collection. Thank you for your friendship and inspiration to become a great chiropractor.

To Darryn Gallagher: Thank you for your friendship and for all your input into this thesis.

To Josh Cowell: Thanks for being such a good friend, all the chill sessions at your place, Friday night Comics take away and for being the drag flick model for my thesis.

To Taine Bird, Sacha De Marigny and Tylo Remke: Thank you for helping with all the data collection. It was not a fun job and you did it without complaining and with a smile on your face.

To the Fouche, Reed and Bird families: Thank you for taking me in as one of your own. Without your support I would never be where I am today. Words cannot express how grateful I am.

To the rest of my family – The Wiggett's, Bosman's, Rice's, Roux's, Gilmour's, Foster's, Coetzee's, De Beer's and Reed's: I am grateful for your support and interest in everything I do. Thank you for always being there.

To Matt Richardson: Thank you for putting up with me in our flat. It’s been a good few years.

To Linda, Pat, Wendy and Kershnee: Thanks for all your help over the years. You are all the heart and soul of the chiropractic programme. A chiropractic student would not get any where without your help.

To my statistician, Michael McCaul and to my proofreader, Bronwyn Jones: Thank you for your all your input to my thesis.

To KZN Hockey and Riverside Sports: Thank you for permission for the use of the facilities.

Abstract

Background

In sport, competitive athletes are required to perform to the best of their ability, with some athletes seeking the use of chiropractic treatment to improve performance. For example, hockey players are required to perform at peak physical function whilst executing a drag flick. The action of a drag flick involves a player hunched over low down in front of the ball and the hook of the hockey stick makes contact with the ball, which is then ball is pushed along the ground with the ball moving slightly up the shaft of the stick. The player then performs 'slinging' action, which means they 'flick' the ball towards the goal posts. The drag flick is an explosive sequential movement involving the player's pelvis, trunk and upper limbs, requiring the use of the spine to generate the speed of the stick and ball.

As a result any decreased spinal movement could reduce performance. Therefore this study attempted to assess the use of spinal manipulative therapy (SMT) in improving the drag flicking performance of hockey players. SMT has been shown to be a safe and effective way of increasing spinal joint mobility

Objectives

To determine and compare the effect of placebo and spinal manipulative therapy in terms of subjective and objective measurements on drag flicking performance of premier league field hockey players.

Methods

A comparative, experimental study of forty asymptomatic premier league hockey drag flickers were divided into two groups of twenty each. Group A received SMT of fixated joints of the spine (cervical, thoracic and lumbar) as determined by motion palpation by an experienced qualified chiropractor. Group B received sham manipulation. Pre and post intervention ROM of the spine and drag flicking speed where measured using CROM, Inclinometer, BROM II and Speed TracX Speed Sport Radar. The subject's perception of a change in drag flicking speed post intervention was also recorded. SPSS version 21 was used to analyse the data. A *p* value of 0.05 was considered statistically significant.

Results

Significant differences in ROM were noticed in the inter-group analysis in cervical: extension; LLF; RR PA, thoracic: extension; LLF, RLF, lumbar: extension, LLF, RLF. There was a significant increase in drag flicking speed post SMT, but between the SMT and sham manipulation groups were not significantly different. A significant correlation was seen between subjects' perception of change in drag flicking speed post intervention and the objective results obtained.

Conclusion

The immediate effect of SMT on drag flicking performance of hockey players was inconclusive. The outcomes of this study suggests that SMT results in an increase in the average speed of drag flicking, however further larger studies are required to confirm this.

Key words

Hockey, Field Hockey, Drag flicking, SMT, Chiropractic, Adjustment, Spine.

Table of Contents

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

List of Appendices

List of Tables

Chapter 2

Chapter 4

Chapter 5

List of Figures

Chapter 2

Chapter 4

Abbreviations

ANOVA	Analysis of variance
BROM II	Back range of motion
CROM	Cervical range of motion
C1-C7	Cervical vertebra with corresponding number
CI	Confidence interval
cm	Centimeters
FIH	Fédération Internationale de Hockey
kg	Kilograms
KZN	Kwa-Zulu Natal
LR PA	Left rotation posterior to anterior
LLF	Left lateral flexion
L1-L5	Lumbar vertebra with corresponding number
m	Meters
N/A	Not available
n	Sample size
QMHS	Queensmead Hockey Stadium
RR PA	Right rotation posterior to anterior
RLF	Right lateral flexion
ROM	Range of motion
SD	Standard deviation
SMT	Spinal manipulative therapy
T1-T12	Thoracic vertebra with corresponding number

Definitions

Hockey:

A game played between two teams of eleven players who use hooked sticks to drive a small hard ball toward goals posts at opposite ends of a field (http://www.fih.ch, 2012).

Drag flick:

The drag flick is a specialty shot used on penalty corners to take lifted shots on goal. There is no backswing used on a drag flick, so it is technically classified as a type of push (http://www.fih.ch, 2012).

Set play:

A prearranged maneuver carried out from a restart or after a timeout by the team that has the advantage (Gallagher, 2013).

Activator gun:

A activator gun is used by chiropractors. It is a small hand-held gun used to realign bones. The activator gun was designed to be an alternative method to the manual techniques chiropractors employ to manipulate the spine. (http://www.activatorgun.com, 2014).

Angular velocity:

Angular velocity is defined as 'rate of change of angular displacement' and is measured in degrees per second (McGinnis, 1999).

Joint play:

This term describes the 'degree of end movement or distention allowed passively that cannot be achieved through voluntary effort of the patient' (Schafer and Faye, 1990).

CHAPTER ONE

INTRODUCTION

1.1 Introduction

In sport, competitive athletes are required to perform to the best of their ability, with some athletes seeking the use of chiropractic treatment to improve performance (Stump and Redwood, 2002; Costa and Chibana *et al* 2009; Miners, 2010). Hockey players are required to perform at peak physical function whilst executing specialised skills. The drag flick that takes place during a penalty corner (set play) is considered a specialised skill (Gallagher, 2013).

The action of a drag flick involves a player hunched over low down in front of the ball and the hook of the hockey stick makes contact with the ball, which is then ball is pushed along the ground with the ball moving slightly up the shaft of the stick. The player then performs 'slinging' action, which means they 'flick' the ball towards the goal posts (McLaughlin, 1997). The drag flick is an explosive sequential movement involving the player's pelvis, trunk and upper limbs, requiring the use of the spine to generate the speed of the distal segment (Lopez *et al* 2010). The distal segment in this context is the stick and its resultant speed on the ball.

Normal biomechanical nature of the drag flicking action, its success and the resultant speed of the drag flick is dependant on the body and limb momentum that can be created by muscular contractions and joint motions (Young *et al*., 2004; Costa and Chibana *et al*., 2009). Therefore, it is necessary for there to be maximum possible range of motion of the involved joints to perform a drag flick (Bergmann and Peterson, 2011).

Abnormal biomechanics therefore could result in an impediment to the player achieving optimum drag flick performance (Stump and Redwood, 2002; Costa and Chibana *et al*., 2009; Miners, 2010). A common cause for abnormal biomechanics is joint dysfunction (Lantz, 1995; Edmondston and Singer, 1997; Bergmann and

Peterson, 2011). Joint dysfunction can also be created by the repetitive nature of the drag flick due to the unilateral biomechanical action involved in the drag flick technique (Sahrmann, 2001; Stamos-Papastamos *et al.*, 2011).

As a result any decreased spinal movement could reduce performance (Deutschmann, 2015). Therefore this study attempted to assess the use of spinal manipulative therapy (SMT) in improving the drag flicking performance of hockey players. SMT has been shown to be a safe and effective way of increasing spinal joint mobility (Leach, 2004; Gatterman, 2005; Bergmann and Peterson, 2011).

1.2 Aims and objectives

The aim of this study was:

To determine the effect of SMT of the cervical, thoracic and lumbar spine compared to placebo intervention in terms of subjective (perception in change of speed) and objective measurements (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) on drag flicking performance of premier league hockey players.

The identified objectives were:

Objective One
To determine the effect of SMT of the cervical, thoracic and lumbar spine in terms of subjective (perception in change of speed) and objective (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) measurements on drag flicking performance of premier league field hockey players.

Objective Two
To determine the effect of placebo intervention of the cervical, thoracic and lumbar spine in terms of subjective (perception in change of speed) and objective (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) measurements on drag flicking performance of premier league field hockey players.

Objective Three

To compare results pre and post intervention between the SMT and the placebo intervention groups.

1.3 Hypothesis

In respect of the Objectives, the Null Hypothesis (Ho) were set as follows:

- There would be no statistically significant increase in drag flicking speed post intervention between the two groups.
- There would be no statistically significant increase in ROM post intervention for any of the two groups.
- There would be no statistically significant difference between change in drag flicking speeds immediately post intervention and the participants' perception of change in drag flicking speed.
- There would be no statistically significant difference between the groups in terms of drag flicking speed, range of motion and participants' perception of change.

1.4 Scope

The results of 40 asymptomatic premier league hockey players, who met all the inclusion criteria of the study, are presented in this dissertation. The participants were divided into two equal groups of twenty participants. Group A received spine manipulation where deemed necessary by an experienced chiropractor, which was done by means of motion palpation, (Bergmann and Peterson, 2011; Schafer and Faye, 1990). The whole spinal column (cervical, thoracic and lumbar spinal segments) was chosen, as the technique of drag flicking requires maximum trunk rotation (McLaughlin, 1997; Lopez *et al.*, 2010). There is a significant generation of force originating from the consecutive segmental rotation of the pelvis, lumbar spine and trunk (McLaughlin, 1997; Seaman, 1998; Le Roux, 1998; Lopez *et al.,* 2010), as well as the cervical spines' effect on the upper extremity (Vicenzino *et al*., 1996; Devitt, 2006; Costa and Chibana *et al.,* 2009). As a result any decreased spinal movement could reduce performance and SMT has been shown to be a safe and effective way of increasing spinal joint mobility (Leach, 2004; Gatterman, 2005; Bergmann and Peterson, 2011). A number of different manipulative procedures can be performed on the various regions of the spine. The type of manipulation used was dependent on the chiropractors preferred choice of manipulation, however their treatment approach is also dependant on assessment of the patient's spinal dysfunction, age, size and body shape (Bergmann and Peterson, 2011). Group B received sham manipulation: the patient was put into a similar position as if receiving SMT as in the patents in Group A. The sham manipulation was done by means of an activator gun.

ROM measurements of the lumbar, thoracic and cervical spine were performed pre and post intervention with a Saunders digital inclinometer (The Saunders Group, Chaska, MN), back range of motion (BROM II) and cervical range of motion (CROM) goniometers (Performance Attainment Associates, Roseville, MN 55110-4144). Drag flicking speed measurements were recorded pre and post intervention by use of the Speed Trac X Sport radar gun (EMG Companies, Wisconsin, USA). The participants' perception of their change in drag flicking speed post intervention was also recorded by asking each participant, 'Did you feel any change in your flicking speed after the chiropractic adjustment?' If the answer was a Yes, a second question was asked 'if it increased or decreased?'

1.5 Rationale

Field hockey is a growing sport in world (http://www.fih.ch, 2012). According to Gallagher (2013) (South Africa U21 Coach) there has been a significant increase in the number of schoolboys and girls playing hockey, and this is noticeable by the increase in number of teams that a school is able to field on a given day. A penalty corner where the drag flick skill is performed is one of the most important scoring methods in hockey, with one third of all goals arising from penalty corner set plays (Lopez *et al.*, 2010; Lopez *et al.*, 2011; Mclaughlin, 1997; Kerr and Ness, 2006). According to recent research by Yusoff *et al.* (2008), the drag flick is between 1.4 to 2.7 times more effective than hitting the ball in a penalty corner. Thus an increase in ball speed can increase the probability of a goal being scored and therefore the outcome of the game. Yusoff *et al*. (2008), Lopez *et al*. (2010) and Gallagher (2013) all state that an increase in ball speed will result in an increase in the probability of a goal being scored from a penalty corner. If the study finds an increase in flicking speed post intervention, this could increase the effectiveness and scoring ratio as described by Yusoff *et al.* (2008).

1.6 Benefits

Should the results of this study show that SMT is of benefit to drag flicking performance, multiple parties stand to benefit from understanding this. These include; the player, coach and chiropractors or manual therapists.

The player can improve their own personal performance, as well as, the life span of the player could be improved due to preventing biomechanical issue associated with high level demands on the body (Dagenais and Haldeman, 2012).

The coach can improve the teams' performance by increasing the goal scoring ratio of that team, and possibly the win ratio of that team.

Chiropractors or manual therapist possible employment to an international team or club, as well as the involvement in the treatment of hockey players and more specifically drag flickers to increase performance and decrease injury. This would decrease the need for players to spend money on other treatment options that may not deliver the same result (Langworthy *et al., 2002)*

1.7 Limitations

Fatique - The player may become tired after a few drag flicks and it may result in an decrease in ball speed post intervention. A rest period was allowed for each participant before the intervention took place so that the participant could recover.
Bias from the researcher and qualified chiropractor was removed as an independent observer recorded all speed results (Mouton, 1996).
The drag flick is a specialised skill that takes many hours of practise and thus there was a small sample size (Lopez *et al.*, 2010; Lopez *et al.*, 2011; Mclaughlin, 1997). Only those that fulfilled all inclusion criteria were included in this study.

1.8 Conclusion

This chapter has provided a basis for the problem identified, as well as an introduction to the study. Chapter Two highlights the literature surrounding the problem.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Sport has become a large aspect of some people's lives. Amateur and professional athletes alike aim to perform to the best of their ability (Miners, 2010). The physical demands on athletes (especially professionally) are high and combined with their inherent wish to reach peak performance, research currently shows that they seek chiropractic treatment for various sports for the maintenance of athletes (Stump and Redwood, 2002). The emphasis within sport chiropractic has been on SMT with the aim to increase players' sporting performance (Stump and Redwood, 2002; Costa and Chibana *et al.,* 2009; Miners, 2010). This study investigated if SMT can increase hockey players' performance with emphasis on a specific skill, namely the drag flick.

Hockey (field hockey) is a team sport that dates back to Egypt some 4000 years ago (http://www.fih.ch, 2012). The modern game evolved in England in the 18th century. In 1924 the Fédération Internationale de Hockey (FIH) (English: International Hockey Federation) was founded with a mission to 'encourage, promote, develop and control hockey at all levels throughout the world' (http://www.fih.ch, 2012).

Hockey was originally played only on grass but with the growth of the sport the game is now solely played on synthetic turfs or Astroturfs (http://www.fih.ch, 2012). The objective of the game is for players to manoeuvre the ball to score a goal past a goalkeeper (http://www.fih.ch, 2012). This is done by pushing, hitting, passing and dribbling. The ball is small and hard and similar to the size of a cricket ball (http://www.fih.ch, 2012). A hockey stick is 'hook' shaped where one side is rounded (right side) and the other side is flat (left side) (http://www.fih.ch, 2012). The ball can be played only with the flat, left side and the edges of the stick (http://www.fih.ch, 2012). Field players are not allowed to use any part of their body to play the ball (http://www.fih.ch, 2012). Only the goalkeeper is kitted with padding and a helmet and is permitted to use any part of their body to prevent a goal being scored when defending in his or her own ‘circle’ (http://www.fih.ch, 2012). The aim of the sport is for a team to achieve as many goals as possible and the winning team has the highest score (http://www.fih.ch, 2012). Currently, hockey is played in 112 countries worldwide and has been played in the Olympic Games since 1908 (http://www.fih.ch, 2012).

2.2 An overview of the game of hockey

2.2.1 Introduction

In the game of hockey, a match is played by two teams each consisting of ten outfield players and one goalkeeper (http://www.fih.ch, 2012). Each team allows seven players who may be brought into play for continuous substitutions (http://www.fih.ch, 2012). The field is a rectangular synthetic or grass surface which is 91.40m long and 55.00m wide (Figure 2.2) (http://www.fih.ch, 2012). The goal posts are rectangular in shape and measure 3.66m long and 2.14m high (Figure 2.1**)** (http://www.fih.ch, 2012). The rest of the field markings are as per Figure 2.2.

Normal match time is 70 minutes, which is played in two equal halves of 35 minutes (http://www.fih.ch, 2012). The umpires, who manage the game, have the authority to stop time for any injury or while a card is being given to a player for an offence (http://www.fih.ch, 2012). Each umpire controls half of the field and they work co-operatively in the middle part of the pitch (http://www.fih.ch, 2012).

Within the time of play the aim of the game is to score as many goals as possible. A goal can only be scored from inside the 'circle', which is demarcated by a roughly semi-circular area located in front of the goals (http://www.fih.ch, 2012). If an attacking player plays the ball from outside this 'circle' and it goes directly into the goal or is touched by a defender, it does not count. There are no own goals, like in football, and an attacking player's stick must make contact with the ball within the 'circle' for a goal to be awarded (http://www.fih.ch, 2012).

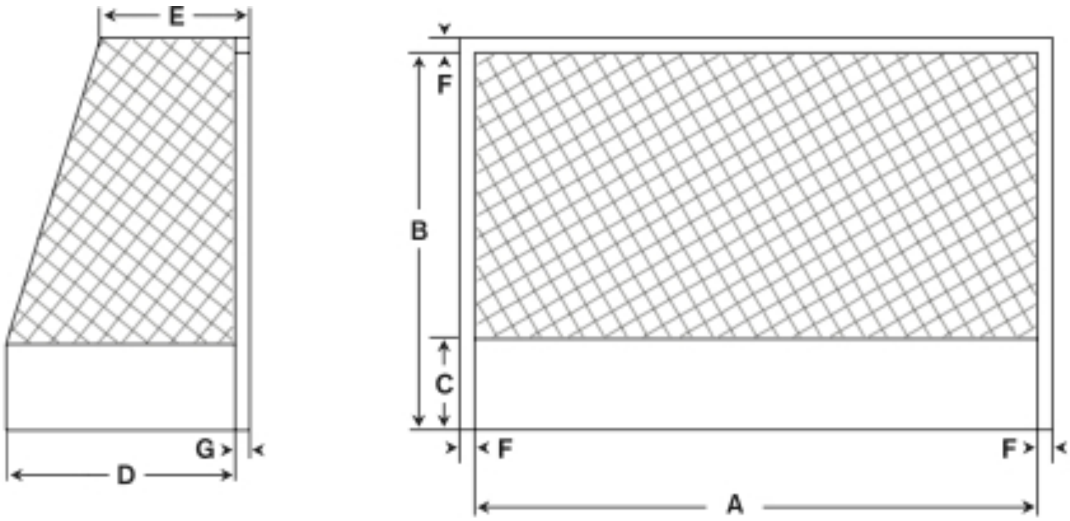

Figure 2.1
Diagram of hockey goals with dimensions
(Adapted from http://www.fih.ch, 2012)

Figure labels

A – 3.66m

B – 2.14m

C – 0.46m

D – 1.20m

E – 0.90m

F – 0.05m

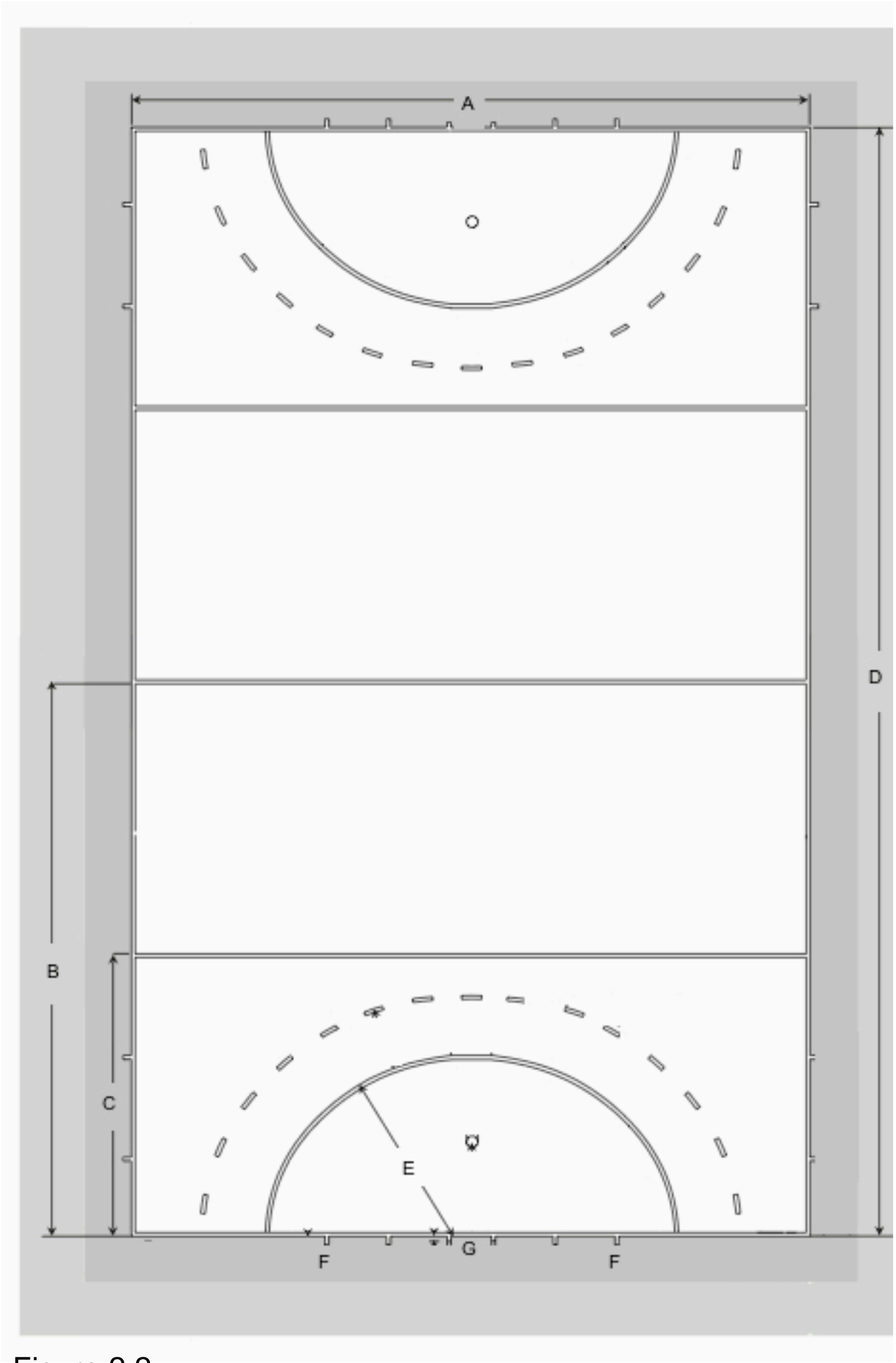

Figure labels

A – 55.00m

B – 45.70m

C – 22.90m

D – 91.40m

E – 14.63m

F – Penalty corner push in line

G – Goal area

Figure 2.2

Diagram of a Hockey Field with dimensions

(Adapted from http://www.fih.ch*, 2012)*

2.2.2 The penalty corner

The umpires may award a penalty corner to the attacking team if the defending team breaks certain rules (http://www.fih.ch, 2012). This usually occurs when the defending team commits a foul within their own/defending circle (label J in Figure 2.2) (http://www.fih.ch, 2012). Similarly, the umpire may award a penalty corner if a defending player commits a foul within their defensive quarter of the field (label C in Figure 2.2) (http://www.fih.ch, 2012).

A penalty corner, according to the FIH rulebook, takes place as follows (http://www.fih.ch, 2012):

- Play is stopped and the teams are allowed to take up their positions.
- The attacking team has one player, with the ball, along the back-line (label F in Figure 2.2 and label A1 in Figure 2.3).
- The rest of the attacking team position themselves around the 'circle' waiting for the ball to be pushed toward them (label A2 and A3 in figure 2.3).
- The defending team is allowed five defenders, which includes the goalkeeper, and they position themselves behind the goal line to defend the penalty corner (label D1 in figure 2.3).
- The rest of the defending team must wait behind the halfway line.
- Play begins when the ball is pushed out to the attackers positioned on the edge of the 'circle' (label A1 pushes to label A2 following red line in figure 2.3).
- The ball must travel outside the circle before any shot can take place.
- The attacking player that receives the ball usually pushes the ball back into the circle to take a shot or stops it for another attacker to perform a drag flick (label A2 in figure 2.3).
- Once the attacker pushes out the ball, the defending team may move to defend the goals.

According to FIH rulebook, if the first strike at goal is a hit then it may not enter the goals higher than the backboard of the goal (label C in Figure 2.1) (http://www.fih.ch, 2012). The backboard of the goal is 460mm high (Figure 2.1) (http://www.fih.ch, 2012). If the first strike at goal is a drag flick, the ball may enter the goal at any height (http://www.fih.ch, 2012).

The penalty corner is one of the most important scoring methods in hockey, with one third of all goals arising from penalty corner set plays (Lopez *et al*., 2011; Lopez *et al*., 2010; Kerr and Ness, 2006; McLaughlin, 1997). According to research by Yusoff *et al*. (2008), the drag flick is 1.4 to 2.7 times more effective than hitting the ball in a penalty corner.

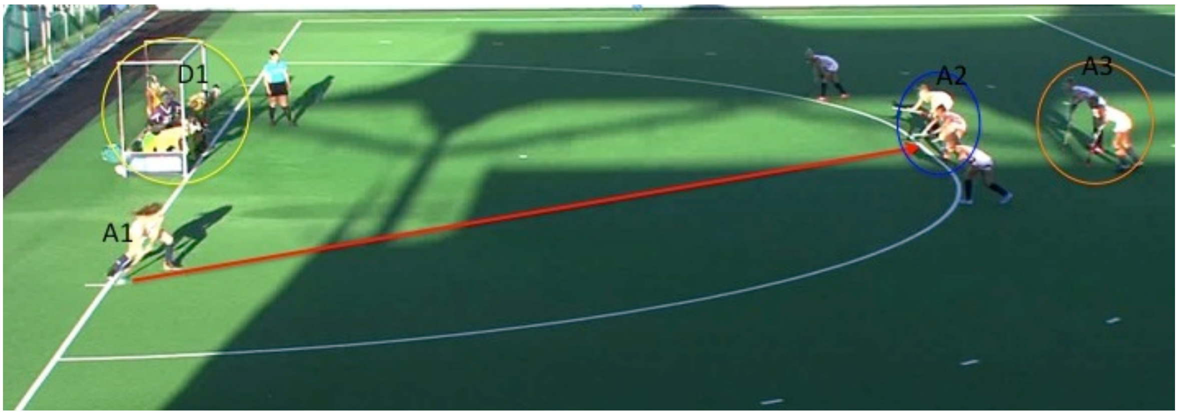

Figure 2.3

Penalty corner (Wiggett, 2014).

Figure labels

White team – Attacking team

Yellow team – Defending team

Red arrow – Direction of the ball to be pushed out by an attacking player

A1 – Attacker pushing the ball out

A2 – Attacker receiving the ball positioned on the edge of the circle

A3 – Attacker that will hit or drag flick the ball

D1 – Defenders (five players, including the goalkeeper)

2.3 Drag flicking in hockey

2.3.1 The drag flick technique

The action of a drag flick involves a player hunching low over in front of the ball and picking it up on the hook of the hockey stick (Yusoff *et al*, 2008). He or she then runs wth the ball, pushing it along the ground. The ball moves slightly up the stick. A 'slinging' action is performed as the player releases the ball towards the goal posts (McLaughlin, 1997). This slinging or whipping action of the stick is followed by "sequential movement of consecutive segments of the pelvis, trunk and stick" (McLaughlin, 1997).

These actions are not dissimilar to the throwing motion or the baseball pitching action (Enoka, 2002). They are all characterised by sequential movements of consecutive body segments in relation to an object, which results in projection of that object (McGinnis, 1999; Enoka, 2002; Lopez *et al*., 2010).

Lopez *et al*. (2010) identified key characteristics of a drag flick, which include:
1) Front foot contact.
2) Peak negative angular velocity of the stick.
3) Maximum angular velocity of the pelvis.
4) Maximum angular velocity of the upper trunk.
5) Release of the ball.
6) Peak positive angular velocity of the stick.

These characteristics result in generating power to maximise the speed of the distal segment at release, which is the stick and its resultant speed on the ball (Lopez *et al*., 2010). Angular velocity is defined as 'rate of change of angular displacement' and is measured in degrees per second (McGinnis, 1999). The results of Lopez *et al.* (2010) study showed that the drag flicker of international standard in comparison to amateur drag flickers produced a higher peak angular velocity from negative (rotation to the right) to positive (rotation to the left) of the pelvis, trunk, upper limbs and stick.

In order to show this, the stages of the drag flick as described by Gallagher (South Africa U21 Coach) (2013, pers. comm., 15 April) are as follows:

The run up:

The drag flicker (the person performing the drag flick skill) run up commences when the he / she walks or jogs toward the ball, gradually increasing his or her speed. Left foot contact alongside the ball marks the end of the run-up. The run-up length may vary between individual drag flickers due to personal preference (Figure 2.4).

Figure 2.4
The run up (Wiggett, 2014).

Left foot contact alongside the ball:

This phase occurs when the drag flicker's left foot is planted parallel to the ball with their toes pointing toward the ball. The right foot crosses either in front or behind the left foot (depending on individual preference) making contact with the ground. The player begins to crouch down lower. The peak of the negative angular velocity (rotation to the right) of the stick is reached (Figure 2.5).

Figure 2.5
Left foot contact alongside the ball (Wiggett, 2014).
(Right foot crosses in front of the left foot)

Ball pick-up:

Once the right leg has crossed behind / in-front of their left leg, they pick up the ball from the Astroturf on the bottom of the hockey stick. They then lower their body position even more resulting in the ball sliding up the shaft of the hockey stick (Figure 2.6).

Figure 2.6
Ball pick-up (Wiggett, 2014).

Rotation of the body:

Their left foot makes contact with the ground again, with the toes pointing toward the goal. The left foot is ahead of the right foot, resulting in the ball being dragged forward while remaining on the stick shaft. The rotation of the body begins proximally at the pelvis with consecutive rotation of the spine and upper trunk distally, with the result that the ball slides back down the shaft of the stick. Maximum angular velocity or rotation of the pelvis and the upper trunk occurs during this phase. The rotation is from right (negative) to left (positive) (Figure 2.7).

Figure 2.7
Rotation of the body (Wiggett, 2014).

Ball release and follow through:

The stick follows the rotation of the upper trunk in a whipping action and the ball is released from the stick toward the goal. This results in positive (rotation to the left) angular velocity of the stick until reaching a peak position. He / she keeps a low body position and carries on jogging a few more paces to slow down (Figure 2.8 and Figure 2.9).

Figure 2.8
Ball release and follow through (image 1) (Wiggett, 2014).

Figure 2.9
Ball release and follow through (image 2) (Wiggett, 2014).

2.3.2 Drag flick speed

The velocity and accuracy of drag flicking is considered vital on the outcome of scoring a goal within a penalty corner set play and potentially winning a game (Yusoff *et al.*, 2008). Gallagher (South Africa U21 Coach) confirmed that speed is an important factor in this skill. A faster drag flick speed gives the goalkeeper less time to react and thus reduces his or her chances of defending the goal (Gallagher, 2013). Drag flicking speeds, like any other skill in sport, will vary according to the age, skill level, performance ability and physical fitness of the player (Lopez *et al.,* 2010).

McLaughlin (2007) first described drag flicking speed with a ranged between 68km/h to 79km/h. But more recently, Yusoff *et al*. (2008) and Lopez *et al. (*2011) measured drag flick speeds in an international hockey competition and found that the average flicking speed is between 71km/h to 100km/h, with the highest speed recorded as 120km/h.

There are various factors that affect the resultant speed of the ball following the drag flick (Yusoff *et al*., 2008). These factors can be divided into two categories, namely: external/environmental and internal/player related. Internal factors include: physical fitness, amount of practice, drag flicking technique, player preparation and range of motion of the full biomechanical chain. External factors include: rain, wind, humidity, altitude, saturation of the turf and how and where the ball is stopped during the penalty corner play (Lopez *et al*., 2011; Lopez *et al*., 2010; Yusoff *et al*., 2008; McLaughlin, 1997).

2.4 An overview of the bony anatomy of the lumbar, thoracic and cervical spine with emphasis on how it relates to biomechanics and their range of motion

2.4.1 Biomechanical considerations of the cervical, thoracic and lumbar spine

The movement involved in a drag flick action can be applied to a study conducted by Young *et al*. (1996), which investigated the role of the spine during baseball pitching. The spine is an important component of the kinematic chain, that enable force to be transferred from the lower to the upper limbs as well as functioning as a force generator capable of accelerating the stick and thus the ball.

Young *et al*. (1996) hypothesized that a practitioner cannot be restricted to evaluating the glenohumeral joint alone when analysing shoulder dysfunction in throwing e.g. baseball, cricket or tennis players who throw or hit balls. This is because the shoulder (on its own) is not capable of generating the force necessary to throw for example, a baseball at speeds of 145-160km/h. The same principle could be applied to the drag flicking action and the resultant speed of the ball (Young *et al*., 1996; Lopez *et al*., 2010).

According to the key events of the drag flick identified by Lopez *et al*. (2010), where peak right rotation (negative angular velocity) of the pelvis is reached before peak right rotation of the trunk and stick. The left rotation (positive angular velocity) of the pelvis initiates left rotation of the trunk and stick. Peak positive angular velocity of the pelvis is reached before that of the trunk, followed by the stick (Enoka, 2002; Lopez *et al*., 2010). This is consistent with Young *et al*. (1996), who states an increase in ball velocity from a baseball pitch is created by the trunk and arms, which involves the progressive increase in the angular velocity of the body segments in the following order; pelvis, upper trunk, forearm, and hand (Enoka, 2002).

The sequential movement of consecutive body segments occurs when the proximal segments begin to rotate before the distal segments and the proximal segments begin to slow down before distal segments have reached peak angular velocity (Enoka, 2002).

Normal biomechanical nature of the drag flicking action, its success and the resultant speed of the drag flick is dependant on the body and limb momentum that can be created by muscular contractions and joint motions (Young *et al*., 2004; Costa and Chibana *et al*., 2009). Therefore, it is necessary for there to be maximum possible range of motion of the involved joints to perform a drag flick (Bergmann and Peterson, 2011).

Abnormal biomechanics therefore could result in an impediment to the player achieving optimum drag flick performance (Stump and Redwood, 2002; Costa and Chibana *et al*., 2009; Miners, 2010). A common cause for abnormal biomechanics is joint dysfunction (Lantz, 1995; Edmondston and Singer, 1997; Bergmann and Peterson, 2011). This is described as a joint or motion segment with movement dysfunction and neuropathophysiological compromise, muscle changes (myopathology),as well as cellular and histological changes (pathophysiological changes) (Leach, 2004; Gatterman, 2005; Bergmann and Peterson, 2011).
Therefore, it is important to note that when considering joint dysfunction, that the spine and surrounding anatomy functions as motion segments and intersegmental units where the proximal segments begin to rotate before the distal segments (Redwood, 2003).

Research has found that manipulation and motion palpation techniques are used to address such dysfunction in a number of different ways (Lantz, 1995; Edmondston and Singer, 1997;Bergmann and Peterson, 2011; Gatterman, 2005). This will be discussed in section 2.5.

2.4.2 The cervical spine

The cervical spine maintains head posture while allowing for a large ROM (Table 2.1) (Bergmann and Peterson, 2011). A typical vertebra (C3-C6) is wider than it is high with large transverse foramina (Gatterman, 2005). Its superior surface is concave and raised laterally to form the uncinate processes (Gatterman, 2005). These have corresponding articular surfaces on the inferior lateral plateau of the vertebra above (Gatterman, 2005). The anteroinferior surface of the vertebral body shows a lip that projects downward and fits together with the concave superior surface of the vertebra below, which gives rise to the saddle effect that limits lateral flexion and guides anterior-posterior movement in flexion and extension (Bergmann and Peterson, 2011). The spinous processes are short and bifid in nature (Bergmann and Peterson, 2011). The superior articular facet joints are oval and flat. They are directed backward and upward. The inferior articular facets face downward and forward (Gatterman, 2005).

The upper cervical segments of C1 and C2 (atypical vertebra) are known as the atlas and axis respectively (Bergmann and Peterson, 2011). The atlas has pedicles that are enlarged to form the lateral masses, while the facets are concave and face superior medially (Bergmann and Peterson, 2011). The atlas lacks a vertebral body as it fuses with C2/axis to form the dens of that foramina (Bergmann and Peterson, 2011). There is no true spinous process attached to C1 (Bergmann and Peterson, 2011). The axis pedicles are enlarged to form articular surface facets (Bergmann and Peterson, 2011). The traverse foramina of the axis makes a right angle bend in the transverse process to emerge from the lateral aspects between the anterior and posterior tubercle (Bergmann and Peterson, 2011). This is because the transverse foramina in the atlas is placed further laterally than in the axis and the vertebral artery must therefore loop laterally to allow for a wide range of motion between the atlas and axis during head rotation (Bergmann and Peterson, 2011).

The C7 vertebra (Figure 2.10 and Figure 2.11) is also atypical as it has a longer spinous process and its transverse foramina do not transmit vertebral arteries (Gatterman, 2005). The vertebral body shape is similar to that of a typical cervical vertebra as well as the direction and shape of the facet joints (Gatterman, 2005).

Table 2.1 - ROM of the cervical spine

Reference	Flexion	Extension	Lateral Flexion	Rotation
Bergmann and Peterson, 2011	60-90º	75-90º	45-55º	80-90º
Petersen *et al*, 2001	60-75º	60-70º	45-55º	80-90º
Feipel *et al*, 1999	65º	55-75º	44º	70º

Figure 2.10 - C7 Vertebral body (image 1)

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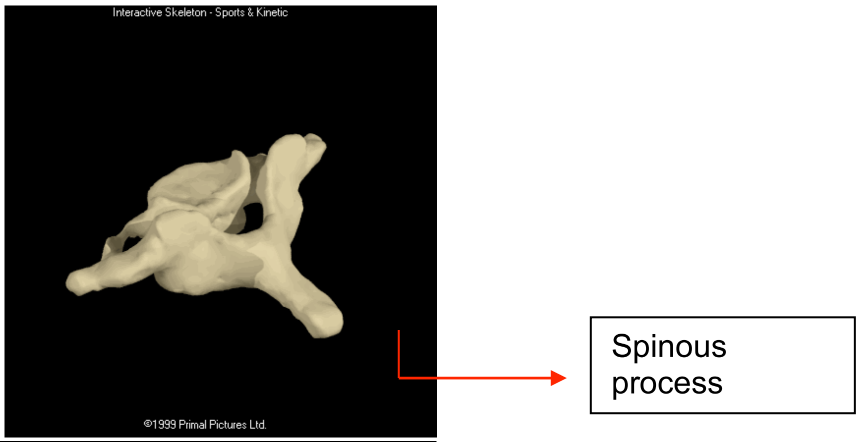

Figure 2.11 – C7 Vertebral body (image 2)

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2.4.3 The thoracic spine

The thoracic spine starts immediately after the cervical spine and ends at the thoracolumbar area just before L1 (Gatterman, 2005). The thoracic spine consists of 12 vertebra (Figure 2.12) (Gatterman, 2005). According to Gatterman (2005) a typical thoracic vertebra (Figure 2.6) consists of the following:

- Heart shaped body
- Two transverse processes
- Articular processes
- Spinous process

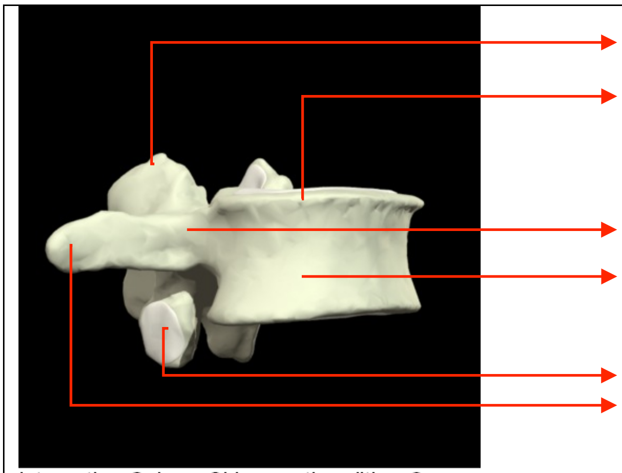
An atypical thoracic vertebra has a long, almost horizontal spinous process that is very prominent (Gatterman, 2005). It also has tubercles similar to the mamillary and accessory processes of a typical lumbar vertebra (Gatterman, 2005).

The pedicles of a thoracic vertebra are short and have inferior vertebral notches deeper and larger than in any other part of the spine (Gatterman, 2005). The spinous processes are long and slender and point obliquely downward, overlapping in the midthoracic spine, which limits extension (Gatterman, 2005). The intervertebral foramina differ in the thoracic spine as they are circular in shape and fairly small (Gatterman, 2005). The articular facets are angled 60º from the transverse to the coronal plane and 20º from the coronal to the sagittal plane (Gatterman, 2005). The inferior articular process arise from the laminae and have an inferomedioanteriorly orientation (Gatterman, 2005). The superior articular processes arise from the laminae-pedicle junctions and face superolaterally and posteriorly (Gatterman, 2005).

As a result, the function of the thoracic spine is mainly for protection of the thoracic viscera, and this takes priority over intersegmental spine mobility (Bergmann and Peterson, 2011). A special feature of the thoracic vertebra is the presence of costovertebral and costotransverse joints (Bergmann and Peterson, 2011). The costovertebral joints are located on either side of the vertebral body and articulate with the head of the ribs (Bergmann and Peterson, 2011). The costotransverse are located on the anterior part of the transverse processes and articulates with the tubercles of the ribs (Bergmann and Peterson, 2011).

Table 2.2 - ROM of the thoracic spine

Reference	Flexion	Extension	Lateral Flexion
Gehardt *et al*, 2002	50º	-	-
Magee, 2002	20-45º	20-45º	20-40º
Rothman and Thiel, 2005	45º	-	-
Bergmann and Peterson, 2011	25-45º	25-45º	20-40º



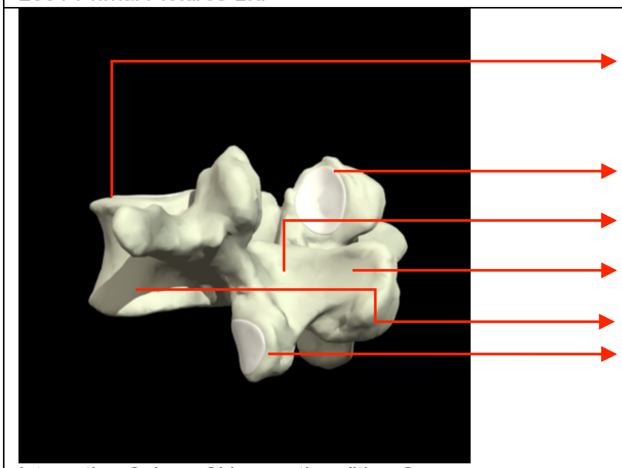


Figure 2.12 – Thoracic vertebra

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2.4.4 The lumbar spine

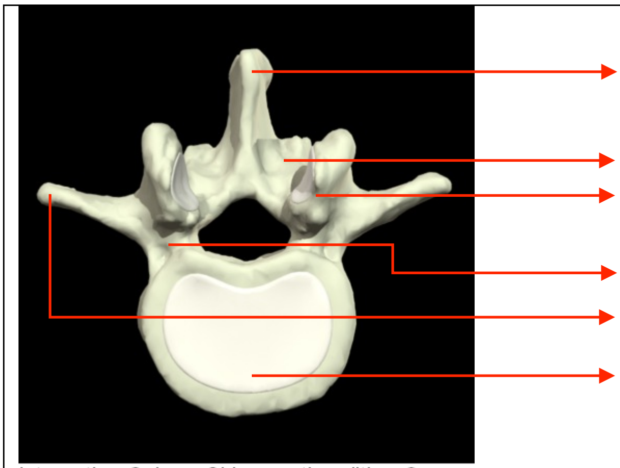
There are typically five lumbar vertebra in the lower lordotic area of the spine (Gatterman, 2005). The typical lumbar vertebra (Figure 2.13) is a large kidney shape and is designed to bear heavy loads (Gatterman, 2005). The typical lumbar vertebra consists of the following:

- spinous process
- transverse process
- laminae
- pedicles
- superior and inferior articular processes
- vertebral body

The lumbar vertebrae differ from thoracic vertebra as they have no transverse foramina or costal facets (Gatterman, 2005). The lumbar vertebra articulates together at the facets joints, which are also known as zygopophyseal joints (Gatterman, 2005). The superior articular processes are concave and face posteromedially, while the inferior articular convex and face anteriorly and laterally (Gatterman, 2005). The superior articular process is also wider and lies outside the inferior articular process (Gatterman, 2005). In the upper lumbar regions the facet joints are orientated close to the sagittal plane (Gatterman, 2005). As the lumbar vertebra progress downward the planes of the facets angle closer to parallel with the coronal plane (Gatterman, 2005). Thus this facet arrangement limits rotation but allows for maximum range of motion in flexion and extension (Gatterman, 2005).

Table 2.3 - ROM of the lumbar spine

Reference	Flexion	Extension	Lateral Flexion	Rotation
Saunders, 1998	60º	30º	30º	5-10º
Gehardt *et al*, 2002	60º	25º	25º	-
Magee, 2002	40-60º	20-35º	15-20º	3-18º
Rothman and Thiel, 2005	60º	30º	30º	-
Bergmann and Peterson, 2011	40-60º	20-35º	15-25º	5-18º
Petra *et al,* 1996	40-50º	10-20º		



Interactive Spine - Chiropractic edition © 2001 Primal Pictures Ltd

Figure 2.13 – Lumbar vertebra

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2.5 Motion palpation, spinal manipulative therapy (SMT) and range of motion

2.5.1 Motion palpation

Motion palpation is a diagnostic technique used by the chiropractor to locate joint dysfunction within the spinal column and extremities (Schafer and Faye, 1990). Motion palpation of the lumbar, thoracic and cervical spines are techniques which chiropractors use to identify if a motion segment is compromised prior to that motion segment being manipulated (Schafer and Faye, 1990). The procedure takes place with the patient, usually seated, with their back upright and arms crossed across their chest (Schafer and Faye, 1990). The chiropractor will use his/her hand to compare and feel for joint play, which indicates a dysfunctional segment (Schafer and Faye, 1990). Joint play is defined as that degree of end movement or distension allowed passively that cannot be achieved through voluntary effort of the patient (Schafer and Faye, 1990).

2.5.2 Spinal manipulative therapy and range of motion

Bergmann and Peterson (2011) define SMT or adjustment as 'uses of controlled force, leverage, direction, amplitude, and velocity, which is directed at specific joints or anatomical regions'. The use of SMT directed at alleviating the joint dysfunction has been linked to increase ROM (Gatterman, 2005; Haldeman, 2005)

There are varied clinical outcomes from the use of SMT, which include: relief of pain, oedema reduction, increased functioning and patient satisfaction, have been documented (Leach, 2004; Gatterman, 2005; Haldeman, 2005; Dagenais and Haldeman, 2011). Several studies related to SMT assessed the immediate biomechanical effects caused by manipulation (Leach, 2004; Haldeman, 2005; Bergmann and Peterson, 2012). Leach (2004), Haldeman (2005) and Bergmann and Peterson, (2011). These included: the effects in change of the orientation and/or positioning of various anatomical structures (Leach, 2004), increased in ROM of motion segments (Rogers *et al.*, 2003), increase of neurological input (Haldeman, 2005), unbuckling of ligaments and the release of trapped meniscoids (Bergmann and Peterson, 2011), breaking of adhesions (Leach, 2004) and return of normal motion segment function (Rogers *et al.*, 2003). This increased neurological input and the increased flexibility and mobility of the manipulated joints (Herzog, 2000; Gatterman, 2003) may result in increased speed of the rotation of the pelvis, trunk and arms and such increase may in turn improve a players performance in their drag flick motion ability and the resultant ball speed (Sood, 2008; Le Roux, 2008; Costa and Chibana *et al*., 2009; Miners, 2010; Deutschmann, 2015).

Costa and Chibana *et al*. (2009) stated that it has been “argued that the maintenance and improvement of joint function, muscle balance, and the speed of neuromuscular reflexes obtained through SMT may help optimise performance.” Studies have been done by Le Roux (2008) and Costa and Chibana *et al*. (2009) to determine the effect of SMT on golf swing performance. Le Roux’s (2008) results showed that players had limited improvement in performance but Costa and Chibana *et al*. (2009) revealed a significant increase in the players full swing performance. Costa and Chibana *et al*. (2009) performed SMT on golf player’s to joint dysfunctions (diagnosed by chiropractors) in the lumbar, thoracic and cervical spine. They concluded that SMT positively affected golf swing performance and thus improved their sports performance.

A fast bowler in a cricket team could increase the ability to win a game. A faster kicking speed in soccer players can result in the ball passing the goalkeeper more easily and that is why both Sood (2008) and Deutschmann (2015) performed randomised, placebo, controlled clinical trials in order to see the efficacy of SMT on forty cricket fast bowlers speed and forty soccer players kicking speed respectively. Sood’s (2008) study showed that players had a significant increase in ROM of the thoracic and lumbar spine after SMT as well as slight increase in bowling speed in participants that received thoracic or a combination of thoracic and lumbar manipulation. Deutschmann (2015) showed that manipulation of the sacroiliac joints significantly increased soccer players kicking speed (measured though the use of a radar gun) while manipulation of the lumbar spine significantly increased both ROM (measured through the use of a Saunders inclinometer) and kicking speed. From the studies done by Deutschmann (2015) and Sood (2008) it can be deduced that the SMT has a positive effect on both ROM of the lumbar and thoracic spine, which in turn increases the speed of fast bowlers and soccer players kicking speed.

Studies by Stamos-Papatamos (2011), Evans (2002) and Whittingham and Nilsson (2001) have shown that spinal manipulation increases the ROM of the lumbar, thoracic and cervical spinal segments respectively. Therefore SMT to spinal joint dysfunctions should increase not only the ROM but flexibility and neurological input of the segmental joints (Herzog, 2000; Suter and McMorland, 2002; Evans, 2002; Hillerman *et al.,* 2006; Deutschmann, 2015). SMT could result in a possible increase in speed of a drag flick that can be obtained from an optimally functioning biomechanical chain. The drag flicker should thus reach maximum angular velocity of the pelvis, trunk and stick, which could potentially increase drag flick performance in terms of speed (Yusoff *et al*., 2008; Le Roux, 2008; Lopez *et al*., 2010; Lopez *et al*., 2011).

2.6 The Hawthorne and placebo effects

2.6.1 The Hawthorne effect

The Hawthorne effect occurs when the participants of a study can tend to change their behaviour as they are aware of being observed (Mouton, 1996). McCarney *et al*. (2007) stated it may be an important factor affecting the generalisability of clinical research to routine practice. Many patients appear to respond better to treatment offered in a clinical trial than those in normal practice because of their participation in an observed setting (McCarney *et al*., 2007).
The Hawthorne effect was first observed in the 1920s when Hawthorne Works (an electrical company) performed extensive research on investigating methods to increase productivity (Roethlisberger and Dickson, 1939; Mayo, 1993). The results of the research showed that no matter what change was implemented, productivity increased. Franke and Kaul (1978) defined this phenomenon as “an increase in worker productivity produced by the psychological stimulus of being singled out and made to feel important”. This definition has subsequently been expanded to include participants in clinical trials by referring to their treatment response rather than their productivity (McCarney *et al*., 2007).

Special precautions need to be taken into consideration when performing a clinical trial, these include: increased levels of clinical surveillance and extra attention given to the participants by the researchers. Thus, both the treatment and control group received equal attention and treatment interventions. However, most clinical trials are unable to properly quantify the magnitude of the Hawthorne effect (McCarney *et al*., 2007).

2.6.2 The placebo effect

Placebo, according to Wall and Wheeler (1996), is derived from the term 'I shall please'. and is the result of a participant attempting to 'please' the researcher. McConnell and Philipchalk (1992) describe it is a "harmless, unmedicated treatment used for its psychological effect, often as a comparison with other treatments". The placebo effect is used as a control intervention to prove the efficacy of a drug or treatment being administered to the research participants. In addition the placebo participants are unaware as to whether they receive the active treatment or not (Draper, 2002). This also allowed the researcher to ascertain the physical effect independently to the participant's expectations of the treatment. As with all treatments, the placebo effect also occurs with spinal manipulation (Draper, 2002). A feeling that a misaligned vertebra has returned to its normal position, along with the audible cavitation produced by SMT and the manual contact (Maigne and Vautravers, 2003) in addition to the practitioners explanation may contribute to the placebo effect. In respect of this study, the placebo effect was achieved through sham manipulation and this was done by means of an activator gun. The activator gun was held a small distance away from the skin and at the same time a similar size and shape headpiece to the activator gun was placed on the skin of the patient. The activator gun was fired with the patient hearing the noise, but it was not applied directly to the skin of the patient.

2.6.3 Similarities and differences between the Hawthorne and placebo effects

These two effects both have an effect on the participants through psychological and physiological means. The Hawthorne effect results in participants changing their behaviour to please the researcher, while the placebo effect measure the efficacy of the intervention by the participant that they are receiving an active treatment. Placebo is derived purely from the participants' perceived physiological changes. The Hawthorne effect results in participants changing their behaviour to please the researcher, while the placebo effect is a measure the efficacy of the intervention expressed by the participant's belief that intervention. Therefore the researcher needs to avoid results that are not accurate. This deception by the researcher plays an important role in particular studies.

2.7 Conclusion

Based on the above, the aim of this study is to prove if SMT has an effect on drag flicking performance in hockey players. Chapter Three will present the manner in which this was achieved.

CHAPTER THREE

MEHTODOLOGY

3.1 Introduction

This chapter outlines the methods used to conduct the research.

3.2 Study design

This study was a placebo controlled, pre-test post-test experimental design study was appoved by the Institutional research and ethics committee (5/14) (Appendix P)

3.3 Study population

There are eight premier league hockey teams that participate in the Kwa-Zulu Natal (KZN) Premier League with an average of 14 players per team (112 players in total). Each team will have on average six players that are able to perform the drag flick skill. There were approximately 48 players (total sample) that could participate in this research. The research earnestly requested all of the 48 total sample to participate in the research to achieve the highest maximum participation. As a result of the small total population no *a priori* statistics could be completed to determine minimum sample sizes.

3.4 Advertising

Advertisements were placed at the Queensmead Hockey Stadium (QMHS) and Riverside Sports Club notice boards (Appendix A) and this included the reasearcher's telephone number for interested persons to contact for more information.

3.5 Study permission

KZN Hockey Association gave permission for the research on premier league hockey players to be conducted, as well as the authority to use its facilities at Queensmead Hockey Stadium (Appendix B). Permission was also given by Riverside Sports Club for use of its facilities (Appendix C).

Once permission was received from the QMHS and Riverside Sports Club as well as their relevant coaches, teams were addressed regarding the research, at which point interested players were able to ask questions about the research and interested players were asked to phone the researcher for a telephonic interview to asses their suitability for this research study. If the participants were found suitable they were asked to attended a consultation at Durban University of Technology Chiropractic Day Clinic. The research procedure was explained to each participant and the Letter of Information and Consent Form was signed (Appendix D).

3.6 Sampling recruitment

3.6.1 Telephonic screening

The researcher asked the following questions during the telephonic interview (required answers are provided in brackets after each question);

- Are you between the ages of 18-35 years? (Yes)
- Are you currently playing for a KZN Premier League Hockey team, and if so what club? (Yes, club name written down by researcher)
- Do you ever drag flick for your team? (Yes)
- Are you pain free before, during and after a game of hockey? (Yes)
- Have you ever had spinal surgery or are you currently on any medication/treatment related to your spine? (No)
- Can you commit to two consultations (one at Durban University of Technology and one at Queensmead Hockey Stadium/Riverside Sports Club)? (Yes)

All questions asked were recorded and were kept for referral if needed. Once the likelihood of potential participant suitability was ascertained, the researcher proceeded to schedule an initial consultation with the participant.

3.6.2 Sampling method

Participants were divided into Group A or B by purposive allocation (Mouton, 1996). The reason for the use of purposive allocation was to attempt to get full spinal and/or regional manipulation into each group for homogeneity. Thus to allow for equal number of cervical, thoracic, lumbar and/or combinations of the regions in Group A and Group B. The purposive allocation was done after motion palpation, which was done by an experienced qualified chiropractor. Group allocation was done by the experienced qualified chiropractor and researcher.

For example, the first participant presented with only cervical dysfunction/s, between C0-C7, then it would be necessary for the researcher to place a participant in Group B who also had dysfunction/s between C0-C7 the same.

Group A received spinal manipulations.
Group B received sham manipulations.

3.6.3 Sample size

A sample size of 40 premier league drag flickers was used.

3.6.4 Sample characteristics

3.6.4.1 Inclusion criteria

- Participants had to be male between the ages of 18 to 35 years.
- All participants had to be male hockey players to keep the sample homogeneous (Mouton, 2006).
- All participants had to be currently playing in the KZN Hockey Premier League.

- All participants had to have signed the Letter of Informed Consent (Appendix D).
- Participants had to have the clinical signs of a joint dysfunction (Bergmann and Peterson, 2011) in their spine as detected by motion palpation. Joint dysfunction comprises of one or more decreased range of motion (regionally), decreased joint play, hard or blocked end feel (segmentally), muscle hypertonicity, soft tissue bogginess and / or pain (Leach, 2004; Bergmann and Peterson, 2011).
- Participants had to be asymptomatic with regards to low back pain, thoracic spine pain and/or neck pain, as detected by orthopaedic examination by the researcher (Bergmann and Peterson, 2011; Schafer and Faye, 1990).

3.6.4.2 Exclusion criteria

- Participants with any contra-indications to spinal manipulation excluded the participant as stated by Bergmann and Peterson (2011), which included but not limited to spinal fractures, hypermobility of functional segmental unit, tumours or bone infections.
- Participants that had a history of spinal surgery and who were suffering from debilitating illness.
- Participants who did not read and/or sign the Letter of Information and Informed Consent (Appendix D).
- Participants who had any low back pain, thoracic spine pain and/or neck pain as detected by orthopaedic examination by the researcher (Bergmann and Peterson, 2011; Schafer and Faye, 1990).

3.7 Interventions

3.7.1 Spinal manipulative therapy

Group A received SMT where deemed necessary by an experienced chiropractor (Appendix E). This was done by means of motion palpation, (Bergmann and Peterson, 2011; Schafer and Faye, 1990). The whole spinal column (cervical, thoracic and lumbar spinal segments) was chosen as the technique of drag flicking requires maximum trunk rotation with a significant generation of force originating from the consecutive segmental rotation of the pelvis, lumbar spine and trunk (McLaughlin, 1997; Seaman, 1998; Le Roux, 1998; Lopez *et al*., 2010). This also included the cervical spines effect on the upper extremity (Vicenzino *et al*., 1996; Devitt, 2006; Costa and Chibana *et al*., 2009). A number of different manipulative procedures can be performed on the various regions of the spine, which was dependent on the researcher's assessment of the patient's spinal dysfunction, age, size, body shape and the chiropractors personal preference of adjustment (Bergmann and Peterson, 2011). A diversified technique was used by the chiropractor performing the spinal manipulation. The manipulation was done to the dysfunctional segments found by the experienced chiropractor, and thus would be different in each participant.

3.7.2 Sham manipulation

Group B received sham manipulation: the patient was put into a similar position as if receiving SMT as in the patents in Group A. The sham manipulation was done by means of an activator gun (http://www.activatorgun.com, 2014), which was held a small distance away from the skin. Without the patient observing the chiropractor, a similar size and shape head piece to the activator gun was placed on the skin of the patient. The activator gun was fired with the patient hearing the noise, to give the impression that it was the activator gun applied directly to the patients skin (Yates *et al*., 1988; Hawk *et al*., 1999). The sham manipulation was done to dysfunctional segments found by the experienced chiropractor, and thus would be different in each participant.

3.8 Measurement tools

All readings were recorded in Appendix F.

3.8.1 Objective measurement tools

3.8.1.1 Speed Trac X Sport radar gun

The Speed Trac X Sport radar gun (EMG Companies, Wisconsin, USA) was used to measure the speed (velocity) of the hockey ball in its trajectory. A radar speed gun is a tool used to measure the speed of moving objects by transmitting radar signals. A frequency is transmitted to the moving object and then back from the moving object. The radar gun utilises the Doppler effect to calculate the speed of an object. This is done by calculating the difference of the transmitted waves to and from the object thus a velocity measurement is seen on the display. The signal transmitted is able to pass through materials such as netting, white mesh fencing, or backdrops without being affected. Therefore, a protective barrier was placed between the moving object and the radar to prevent any damage, without affecting the accuracy of the measurements (Deutschmann 2015).

The reliability and validity of the speed gun has been shown in numerous studies where velocity has been measured (Sood 2008; Deutschmann 2015; Rebelo 2011). The accuracy of the radar is within 2-3 km/h (Sood 2008). The diagram in Appendix G shows the setup of the radar speed gun.

The radar gun was placed 7.5 meters away from the flicking point to get the most accurate readings. The flicking point is around 1m from ball pick up (Gallagher, 2013).

Three measurements were recorded and averaged by an independent observer and kept blinded from the researcher and experienced qualified chiropractor to avoid any bias (Mouton, 1996). The process for reading measurements were simple as the independent observer only had to read the LED lights generated by the Speed Trac X Sport radar gun.

3.8.1.2 Digital inclinometer

The digital inclinometer (The Saunders Group, Chaska, MN) consists of a sensor with a digital display, and on/off button, a zero button, a hold button and two velcro straps. If the sensor is tilted e.g. 20 degrees in any direction, then it will read 20 degrees. If the sensor is held at 22 degrees and then zeroed and then moves e.g. to 40 degrees in any direction, then it will read 40 degrees. The measurements were taken immediately before and after the intervention. The reliability and validity has been shown in both Sood (2008) and Deutschmann’s (2015) studies One measurement per motion was recorded by the researcher and kept blinded from the independent observer and experienced qualified chiropractor to avoid any bias (Mouton, 1996).

3.8.1.2.1 Assessment of flexion, extension and lateral flexion of the thoracic spine

- The participants were asked to sit, the researcher made a mark over the skin overlying the T6 spinous process.
- The inclinometers sensor was placed with its midpoint directly overlying the mark made on the skin at T6, the researcher firmly secured the inclinometer around the participants torso with Velcro straps.
- The inclinometer was switched on and zeroed.
- The participants were asked to bend backwards as far as possible, whilst the inclinometer was held firmly to prevent any movement off the T6 point.
- At the participant’s extension limit, the reading was taken and this indicating the degree of extending backwards.
- The participants were then asked to sit straight up again and the inclinometer was zeroed.
- The participants were then asked to bend forwards as far as possible, whilst the inclinometer was held firmly to prevent any movement off the T6 point.
- At the flexion limit, the reading was taken and this indicated the degree of flexing forward.
- The participants were then asked to sit straight up again and the inclinometer was zeroed.

- The participants were asked to laterally bend to the left as far as possible without rotation of the shoulders.
- At the participants left lateral limit, the reading was taken and this indicating their degree of flexing laterally to the left.
- The participants were asked to straighten up again, the inclinometer zeroed.
- The participants were asked to laterally bend to the right as far as possible without rotation of the shoulders.
- At the participants right lateral limit, the reading was taken and this indicating their degree of flexing laterally to the right (Sood, 2008).

3.8.1.3 BROM II and CROM Goniometer

The BROM II and CROM goniometers (Performance Attainment Associates, Roseville, MN 55110-4144) are instruments used to measure range of motion (ROM) of the lumbar and cervical spines respectively. The measurements were taken immediately before and after the intervention

The following ROM was assessed in both the lumbar and cervical spine:

a) Flexion.

b) Extension.

c) Lateral flexion (left and right).

d) Rotation (left and right).

The procedure for use of the BROM II and CROM are found in Appendix H and I respectively. Williams *et al.* (2010) demonstrated the reliability of the CROM goniometer in their systematic review titled: ‘A Systematic Review of Reliability and Validity Studies of Methods for Measuring Active and Passive Cervical Range of Motion’. Breum *et al.* (1995) demonstrated the reliability of the BROM II goniometer in there journal article titled: ‘Reliability and concurrent validity of the BROM II for measuring lumbar mobility’. One measurement per motion was recorded by the researcher and kept blinded from the independent observer and experienced qualified chiropractor to avoid any bias (Mouton, 1996).

3.8.2 Subjective measurement tools

3.8.2.1 Participants perception of Speed change

At the end of the research process, the researcher asked each player, ‘Did you feel any change in your flicking speed after the chiropractic adjustment?’ If the answer was a Yes, a second question was asked ‘if it increased or decreased?’ This was recorded on Appendix F. This will be done by the researcher to avoid any bias from the independent observer who measured their drag flicking speeds.

3.9 Research procedure

Participants were screened by a telephonic interview (as described in section 3.6.1)
A consultation at Durban University of Technology Chiropractic Day Clinic was made to determine their suitability for the study.
The research procedure was explained to each participant and the Letter of Information and Consent Form was signed (Appendix D).
A case history, full physical, cervical regional, thoracic regional, lumbar regional exams were done by the researcher (Appendix J,K, L, M and N).
The participants were given a date and time to report to Queensmead Hockey Stadium/Riverside Sports Club for testing.
A consultation at Queensmead Hockey Stadium/Riverside Sports Club was undertaken.
The researcher assessed if any injury to the participant had occurred or exclusion criteria was present since previous consultation.
Each participant was required to engage in a warm-up routine (as described in Appendix O).
Thereafter the participant was asked to perform three drag flicks toward the goal, with the following instructions; 1) Maximum of a three step run up. 2) Perform 3 drag flicks at maximum power toward the goal. 3) The drag flick must enter the goal to be considered.
ROM of cervical, thoracic and lumbar spines was measured by the researcher (as described in sections 3.8.1.2 and 3.8.1.3).
The participants flick speed was measured by an independent observer (as described in section 3.8.1.1).
Motion palpation was used to determine the presence of joint dysfunction (as described in section 3.7). This took about 5min to complete. This was done by an

<table>
<tr><td colspan="2">experienced qualified Chiropractor.</td></tr>
<tr><td colspan="2">Participants were divided into Group A or Group B using purposive allocation by the experienced qualified chiropractor after motion palpation had been performed (as described in section 3.6.2).</td></tr>
<tr><td><u>Group A</u>
Participants received SMT as as determined by motion palpation. was performed by the experienced Chiropractor (as described in section 3.7.1).</td><td><u>Group B</u>
Participants received sham manipulation determined by motion palpation. This was performed by the experienced Chiropractor (as described in section 3.7.1).</td></tr>
<tr><td colspan="2">ROM of cervical, thoracic and lumbar spines was measured again by the researcher immediately after intervention (as described in sections 3.8.1.2 and 3.8.1.3).</td></tr>
<tr><td colspan="2">Thereafter, the participant’s were asked to perform another three drag flicks with the same instructions.</td></tr>
<tr><td colspan="2">The participants flick speed was measured again by an independent observer (as described in section 3.8.1.1).</td></tr>
<tr><td colspan="2">The final assessment included the participants perception of change of drag flicking speed. Each participant was asked by the researcher ‘Did you feel any change in your flicking speed after the chiropractic adjustment?’ If the answer was a Yes, a second question was asked ‘if it increased or decreased?’ (as described in 3.8.2.1).</td></tr>
</table>

3.10 Controlling variables

An attempt was made to minimise any variables through:

- A FIH approved hockey ball was used which will has standard size and weight.
- Each participant was asked to bring their own preferred stick so to minimize the effect of using an incorrect sized stick.
- The Queensmead Hockey Stadium and Riverside Sports Club turf is situated outdoor. There were potential effects of humidity and wind on the flicking speed.
- Testing took place on various days due to varying availability of participants, thus weather and humidity could have an impact on the performance of the participants.

3.11 Data analysis

IBM SPSS version 21 was used for data analysis. A *p* value <0.05 was considered as statistically significant. Intra-group changes over time were assessed using repeated measures ANOVA without intra-group effects, and inter-group changes over time were tested using repeated measures ANOVA with a between groups effect of treatment. A time x treatment interaction signified the comparative effect of the intervention versus control and a *p* value <0.05 for the interaction indicated statistical significance. Profile plots were establish the direction and trend of the effects (McCaul, 2014).

3.12 Ethical considerations

Participation was based on participants' own free will to participate in the study and no coercion was used by the researcher. The details of the research were explained to each participant and each participant were required to sign Informed Consent Form (Appendix D) before the research process could be started. Their confidentiality was ensured by the use of a coding system to hide their identity. It was highlighted to the participants that may have feel slight discomfort after the manipulation, but that should subsided within 24hours. However, they were advised that if the discomfort persisted for more than 24hours they were to contact the researcher for further advice. As such, if any adverse reactions to any treatment were to occur, the researchers supervisor would be informed and the appropriate documentation would be submitted to the Institution Research Ethics Committee (IREC). There were no adverse reactions in this study. The was no reimbursement for participants although participants in the sham intervention group were notified at the end of the research process and offered a free treatment voucher (to be used within 6 weeks) at the Durban University of Technology Chiropractic Day Clinic.

3.13 Conclusion

The methodology in the above Chapter was used to generate the results presented in Chapter Four.

CHAPTER FOUR

RESULTS

4.1 Introduction

This chapter includes the presentation of the data obtained as per the methodology outlined in Chapter 3. The data includes the representation of the demographic data (age, height and weight) and the results after statistical analysis from the subjective (participants perception of change of speed post intervention) and objective (cervical, thoracic and lumbar range of motion pre and post intervention, drag flicking speed pre and post intervention) results (McCaul, 2014). All calculations were based on N=40.

Abbreviations:

- N - Sample size.
- Std. - Standard.
- CI - Confidence interval.
- Ave - Average.
- RLF - Right lateral flexion.
- LLF - Left lateral flexion.
- LR PA - Left rotation posterior to anterior.
- RR PA Right rotation posterior to anterior.

4.2 Aims and objectives

The aim of this study was:

To determine the effect of SMT of the cervical, thoracic and lumbar spine compared to placebo intervention in terms of subjective (perception in change of speed) and objective measurements (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) on drag flicking performance of premier league hockey players. The objectives of this study were:

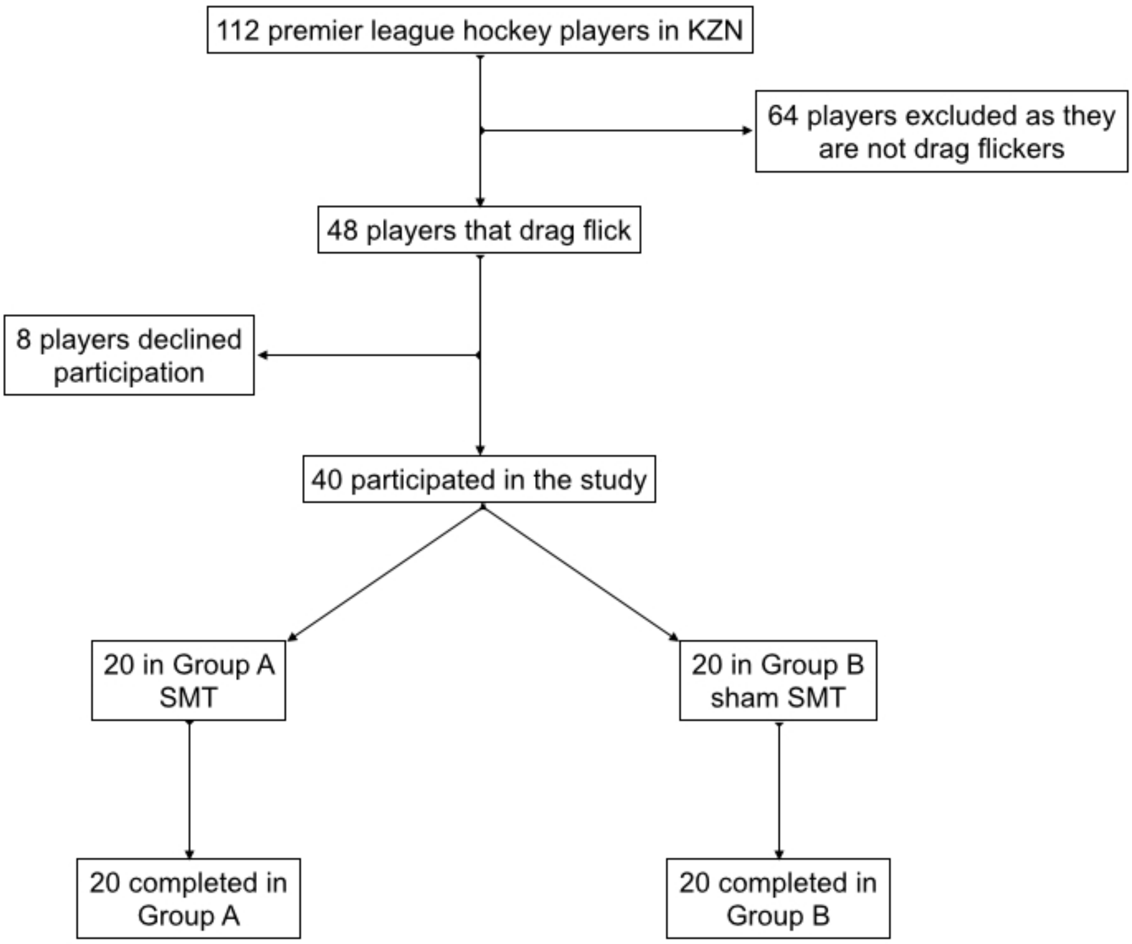
- To determine the effect of SMT of the cervical, thoracic and lumbar spine in terms of subjective (perception in change of speed) and objective (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) measurements on drag flicking performance of premier league field hockey players.
- To determine the effect of placebo intervention of the cervical, thoracic and lumbar spine in terms of subjective (perception in change of speed) and objective (range of motion of cervical, thoracic and lumbar spine, and speed of the drag flick) measurements on drag flicking performance of premier league field hockey players.
- To compare results pre and post intervention between the SMT and the placebo intervention groups.

The following results and statistical analysis are presented in this chapter:

- Demographic data that was collected by the researcher.
- Drag flicking speed (Km/h), measured using Speed Trac X Sports radar gun (Pair 1).
- Cervical ROM (degrees), measured using a CROM goniometer (Pair 2-7).
- Thoracic ROM (degrees), measured using a Saunders Digital Inclinometer (Pair 8-11).
- Lumbar ROM (degrees), measured using a BROM II goniometer (Pair 12-17).
- Participant's perception of change of drag flick speed post intervention.

4.3 Flow diagram of participants

The following flow diagram shows a chronological sequence of events of this study:



4.4 Results

4.4.1 Baseline comparisons

4.4.1.1 Demographic variables

Table 4.1 - Demographic variables

	Group	N	Mean	Std. Deviation	95%CI of the difference	*p*-value
Age	Group A	20	22.50	3.49	-1.428 to 2.428	0.603
	Group B	20	22.00	2.45		
Height	Group A	20	176.00	5.12	-7.853 to 0.7531	0.105
	Group B	20	179.55	8.01		
Weight	Group A	20	74.95	8.50	-8.414 to 5.244	0.637
	Group B	20	76.55	12.42		

Participant demographics are represented in Table 4.1 and there were no significant difference between intervention and control groups (A and B). The purposive selection of the two groups (based on dysfunctions in spinal movments that the chiropractor diagnosed), resulted in two groups with similar baseline demographics, implying that the outcomes of the study could reflect the measures of the effect of the intervention.

4.4.1.2 Comparison of repeated measures at baseline between the groups

Table 4.2 – Comparison of repeated measures at baseline between the groups

	Group	N	Mean	Std. Deviation	*p*-value
Pre Ave Speed in Km/h	Group A	20	86.50	8.10	0.580
	Group B	20	80.91	9.88	
Pre Cervical Flexion ROM	Group A	20	68.75	14.04	0.804
	Group B	20	69.80	12.50	
Pre Cervical Extension ROM	Group A	20	71.30	9.25	0.097
	Group B	20	76.10	8.57	
Pre Cervical RLF ROM	Group A	20	42.40	8.50	0.254
	Group B	20	39.20	8.98	
Pre Cervical LLF ROM	Group A	20	42.30	6.97	0.221
	Group B	20	38.80	10.47	
Pre Cervical LR PA ROM	Group A	20	71.80	5.76	1.000
	Group B	20	71.80	7.84	
Pre Cervical RR PA ROM	Group A	20	72.50	6.12	0.819
	Group B	20	73.10	9.92	
Pre Thoracic Flexion ROM	Group A	20	28.60	8.47	0.283
	Group B	20	26.05	6.17	
Pre Thoracic Extension ROM	Group A	20	16.65	6.72	0.620
	Group B	20	15.75	4.41	
Pre Thoracic RLF ROM	Group A	20	22.60	5.82	0.335
	Group B	20	21.10	3.61	
Pre Thoracic LLF ROM	Group A	20	21.85	6.76	0.244
	Group B	20	19.65	4.84	
Pre Lumbar Flexion ROM	Group A	20	34.10	16.23	0.216
	Group B	20	27.90	14.93	
Pre Lumbar Extension ROM	Group A	20	19.60	8.72	0.315
	Group B	20	16.70	9.30	
Pre Lumbar RLF ROM	Group A	20	19.30	9.87	0.105
	Group B	20	15.20	4.92	
Pre Lumbar LLF ROM	Group A	20	19.40	11.26	0.111
	Group B	20	15.00	3.76	
Pre Lumbar LR PA ROM	Group A	20	34.00	13.01	0.056
	Group B	20	26.90	9.53	
Pre Lumbar RR PA ROM	Group A	20	30.20	11.35	0.368
	Group B	20	27.30	8.62	

The information stated in Table 4.2 indicates that there were no significant differences between the two groups (A and B) at baseline, implying randomisation was effective and that outcomes of the study reflect the measures of the effect of the intervention.

4.4.2 Intra-group analysis for Group A

Table 4.3 - Paired samples statistics for Group A

Group			Mean	N	Std. Deviation	Std. Error Mean
Group A	Pair 1	Pre Ave Speed in Km/h	86.50	20	8.07	1.80
		Post Ave Speed in Km/h	89.88	20	8.71	1.95
	Pair 2	Pre Cervical Flexion ROM	68.75	20	14.04	3.14
		Post Cervical Flexion ROM	73.80	20	9.56	2.14
	Pair 3	Pre Cervical Extension ROM	71.30	20	9.25	2.07
		Post Cervical Extension ROM	79.50	20	8.31	1.86
	Pair 4	Pre Cervical RLF ROM	42.40	20	8.50	1.90
		Post Cervical RLF ROM	47.00	20	8.72	1.95
	Pair 5	Pre Cervical LLF ROM	42.30	20	6.97	1.56
		Post Cervical LLF ROM	46.90	20	7.61	1.70
	Pair 6	Pre Cervical LR PA ROM	71.80	20	5.76	1.29
		Post Cervical LR PA ROM	76.20	20	7.14	1.60
	Pair 7	Pre Cervical RR PA ROM	72.50	20	6.12	1.37
		Post Cervical RR PA ROM	77.60	20	6.48	1.45
	Pair 8	Pre Thoracic Flexion ROM	28.60	20	8.47	1.89
		Post Thoracic Flexion ROM	31.75	20	8.35	1.87
	Pair 9	Pre Thoracic Extension ROM	16.65	20	6.72	1.50
		Post Thoracic Extension ROM	23.30	20	14.77	3.30
	Pair 10	Pre Thoracic RLF ROM	22.60	20	5.87	1.30
		Post Thoracic RLF ROM	27.60	20	7.35	1.64
	Pair 11	Pre Thoracic LLF ROM	21.85	20	6.76	1.51
		Post Thoracic LLF ROM	26.60	20	7.03	1.57
	Pair 12	Pre Lumbar Flexion ROM	34.10	20	16.23	3.63
		Post Lumbar Flexion ROM	36.50	20	16.98	3.80
	Pair 13	Pre Lumbar Extension ROM	19.60	20	8.72	1.95
		Post Lumbar Extension ROM	26.65	20	13.06	2.92
	Pair 14	Pre Lumbar RLF ROM	19.30	20	9.87	2.21
		Post Lumbar RLF ROM	24.30	20	9.23	2.06
	Pair 15	Pre Lumbar LLF ROM	19.40	20	11.26	2.52
		Post Lumbar LLF ROM	24.30	20	9.23	2.06
	Pair 16	Pre Lumbar LR PA ROM	34.00	20	13.03	2.91
		Post Lumbar LR PA ROM	36.80	20	15.15	3.39
	Pair 17	Pre Lumbar RR PA ROM	30.20	20	11.35	2.53
		Post Lumbar RR PA ROM	36.20	20	13.69	3.06

Table 4.4 - Paired samples test for Group A

Group			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Group A	Pair 1	Pre Ave Speed (Km/h) - Post Ave Speed (Km/h)	-3.38	4.97	1.11	-5.71	-1.06	-3.05	19	**0.0070**
	Pair 2	Pre Cervical Flexion ROM - Post Cervical Flexion ROM	-5.05	10.57	2.36	-10.00	-0.10	-2.14	19	**0.0460**
	Pair 3	Pre Cervical Extension ROM- Post Cervical Extension ROM	-8.20	8.05	1.80	-11.97	-4.43	-4.56	19	**<0.0001**
	Pair 4	Pre Cervical RLF ROM - Post Cervical RLF ROM	-4.60	7.20	1.61	-7.97	-1.23	-2.86	19	**0.0100**
	Pair 5	Pre Cervical LLF ROM - Post Cervical LLF ROM	-4.60	5.47	1.22	-7.16	-2.04	-3.76	19	**0.0010**
	Pair 6	Pre Cervical LR PA ROM - Post Cervical LR PA ROM	-4.40	7.04	1.57	-7.69	-1.11	-2.80	19	**0.0120**
	Pair 7	Pre Cervical RR PA ROM - Post Cervical RR PA ROM	-5.10	4.18	0.93	-7.06	-3.14	-5.46	19	**<0.0001**
	Pair 8	Pre Thoracic Flexion ROM - Post Thoracic Flexion ROM	-3.15	5.93	1.33	-5.93	-0.37	-2.38	19	**0.0280**
	Pair 9	Pre Thoracic Extension ROM- Post Thoracic Extension ROM	-6.65	15.67	3.50	-13.98	0.68	-1.90	19	0.0730
	Pair 10	Pre Thoracic RLF ROM - Post Thoracic RLF ROM	-5.00	6.81	1.52	-8.19	-1.81	-3.29	19	**0.0040**
	Pair 11	Pre Thoracic LLF ROM - Post Thoracic LLF ROM	-4.75	5.98	1.34	-7.55	-1.95	-3.55	19	**0.0020**
	Pair 12	Pre Lumbar Flexion ROM - Post Lumbar Flexion ROM	-2.40	5.24	1.17	-4.85	0.05	-2.05	19	0.0540
	Pair 13	Pre Lumbar Extension ROM - Post Lumbar Extension ROM	-7.05	9.45	2.11	-11.47	-2.63	-3.33	19	**0.0030**
	Pair 14	Pre Lumbar RLF ROM - Post Lumbar RLF ROM	-5.00	4.57	1.02	-7.14	-2.86	-4.90	19	**<0.0001**
	Pair 15	Pre Lumbar LLF ROM - Post Lumbar LLF ROM	-4.90	5.09	1.14	-7.28	-2.52	-4.31	19	**<0.0001**
	Pair 16	Pre Lumbar LR PA ROM - Post Lumbar LR PA ROM	-2.80	11.79	2.64	-8.32	2.72	-1.06	19	0.3020
	Pair 17	Pre Lumbar RR PA ROM - Post Lumbar RR PA ROM	-6.00	11.13	2.49	-11.21	-0.79	-2.41	19	**0.0260**

Note: The intra-group analysis of Group A is shown in In Table 4.3 and Table 4.4. The *p*-values in bold in Table 4.4 are statistically significant at the 0.05 level. Significance indicates there is a true difference between the pre and post measurements within this particular group.

4.4.3 Intra-group analysis for Group B

Table 4.5 - Paired samples statistics for Group B

Group			Mean	N	Std. Deviation	Std. Error Mean
Group B	Pair 1	Pre Ave Speed in Km/h	80.91	20	9.88	2.2100
		Post Ave Speed in Km/h	81.32	20	9.74	2.1786
	Pair 2	Pre Cervical Flexion ROM	69.80	20	12.50	2.7944
		Post Cervical Flexion ROM	71.90	20	10.08	2.2547
	Pair 3	Pre Cervical Extension ROM	76.10	20	8.57	1.9165
		Post Cervical Extension ROM	77.50	20	8.70	1.9460
	Pair 4	Pre Cervical RLF ROM	39.20	20	8.98	2.0074
		Post Cervical RLF ROM	39.50	20	8.56	1.9133
	Pair 5	Pre Cervical LLF ROM	38.80	20	10.47	2.3414
		Post Cervical LLF ROM	38.20	20	10.26	2.2937
	Pair 6	Pre Cervical LR PA ROM	71.80	20	7.84	1.7526
		Post Cervical LR PA ROM	73.90	20	6.57	1.4688
	Pair 7	Pre Cervical RR PA ROM	73.10	20	9.91	2.2170
		Post Cervical RR PA ROM	73.50	20	8.99	2.0098
	Pair 8	Pre Thoracic Flexion ROM	26.05	20	6.17	1.3793
		Post Thoracic Flexion ROM	27.50	20	7.05	1.5770
	Pair 9	Pre Thoracic Extension ROM	15.75	20	4.41	0.9864
		Post Thoracic Extension ROM	14.60	20	4.44	0.9931
	Pair 10	Pre Thoracic RLF ROM	21.10	20	3.61	0.8075
		Post Thoracic RLF ROM	21.15	20	4.78	1.0694
	Pair 11	Pre Thoracic LLF ROM	19.65	20	4.84	1.0816
		Post Thoracic LLF ROM	20.10	20	4.85	1.0856
	Pair 12	Pre Lumbar Flexion ROM	27.90	20	14.93	3.3387
		Post Lumbar Flexion ROM	29.00	20	13.68	3.0591
	Pair 13	Pre Lumbar Extension ROM	16.70	20	9.30	2.0788
		Post Lumbar Extension ROM	16.65	20	9.00	2.0135
	Pair 14	Pre Lumbar RLF ROM	15.20	20	4.92	1.0993
		Post Lumbar RLF ROM	15.00	20	4.61	1.0311
	Pair 15	Pre Lumbar LLF ROM	15.00	20	3.76	0.8398
		Post Lumbar LLF ROM	15.60	20	4.66	1.0423
	Pair 16	Pre Lumbar LR PA ROM	26.90	20	9.53	2.1299
		Post Lumbar LR PA ROM	25.95	20	10.16	2.2717
	Pair 17	Pre Lumbar RR PA ROM	27.30	20	8.62	1.9264
		Post Lumbar RR PA ROM	26.10	20	9.35	2.0900

Table 4.6 - Paired samples test for Group B

Group			Paired Differences					t	df	Sig. (2-tailed)
			Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
						Lower	Upper			
Group B	Pair 1	Pre Ave Speed (Km/h) - Post Ave Speed (Km/h)	-0.40	4.70	1.05	-2.60	1.80	-0.38	19	0.708
	Pair 2	Pre Cervical Flexion ROM - Post Cervical Flexion ROM	-2.10	8.14	1.82	-5.91	1.71	-1.15	19	0.263
	Pair 3	Pre Cervical Extension ROM- Post Cervical Extension ROM	-1.40	7.57	1.69	-4.94	2.14	-0.83	19	0.418
	Pair 4	Pre Cervical RLF ROM - Post Cervical RLF ROM	-0.30	7.43	1.66	-3.78	3.18	-0.18	19	0.859
	Pair 5	Pre Cervical LLF ROM - Post Cervical LLF ROM	0.60	5.43	1.21	-1.94	3.14	0.49	19	0.627
	Pair 6	Pre Cervical LR PA ROM - Post Cervical LR PA ROM	-2.10	7.55	1.69	-5.63	1.43	-1.24	19	0.229
	Pair 7	Pre Cervical RR PA ROM - Post Cervical RR PA ROM	-0.40	5.49	1.23	-2.97	2.17	-0.33	19	0.748
	Pair 8	Pre Thoracic Flexion ROM - Post Thoracic Flexion ROM	-1.45	5.61	1.26	-4.08	1.18	-1.16	19	0.262
	Pair 9	Pre Thoracic Extension ROM- Post Thoracic Extension ROM	1.15	3.76	0.84	-0.61	2.91	1.37	19	0.187
	Pair 10	Pre Thoracic RLF ROM - Post Thoracic RLF ROM	-0.05	5.16	1.15	-2.46	2.36	-0.04	19	0.966
	Pair 11	Pre Thoracic LLF ROM - Post Thoracic LLF ROM	-0.45	5.38	1.20	-2.97	2.07	-0.37	19	0.712
	Pair 12	Pre Lumbar Flexion ROM - Post Lumbar Flexion ROM	-1.10	4.79	1.07	-3.34	1.14	-1.03	19	0.317
	Pair 13	Pre Lumbar Extension ROM - Post Lumbar Extension ROM	0.05	4.08	0.91	-1.86	1.96	0.06	19	0.957
	Pair 14	Pre Lumbar RLF ROM - Post Lumbar RLF ROM	0.20	4.25	0.95	-1.79	2.19	0.21	19	0.836
	Pair 15	Pre Lumbar LLF ROM - Post Lumbar LLF ROM	-0.60	4.16	0.93	-2.55	1.35	-0.65	19	0.527
	Pair 16	Pre Lumbar LR PA ROM - Post Lumbar LR PA ROM	0.95	6.82	1.52	-2.24	4.14	0.62	19	0.541
	Pair 17	Pre Lumbar RR PA ROM - Post Lumbar RR PA ROM	1.20	6.91	1.55	-2.03	4.43	0.78	19	0.447

The intra-group analysis of Group B is shown in Table 4.5. and Table 4.6. In contrast to Group A, it is important to note that Group B had no significant differences between measurements.

Therefore a cursory comparison of the intra-group analyses of the two arms of this study suggest that there is a difference between these groups. These differences however need to be interpreted with caution as intragroup analysis does not take into account the comparison of the two groups and thus no comment or inference should be made regarding the effectiveness of the intervention or control. The following section therefore presents the inter-group analysis, which is more accurately able to determine the differences between the two groups.

4.4.4 Inter-group analysis

4.4.4.1 Average speed

Table 4.7 - Average Speed[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.86	6.11	1.00	38.00	**0.018**
Time * Group	Wilks' Lambda	0.91	3.80[b]	1.00	38.00	0.059

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

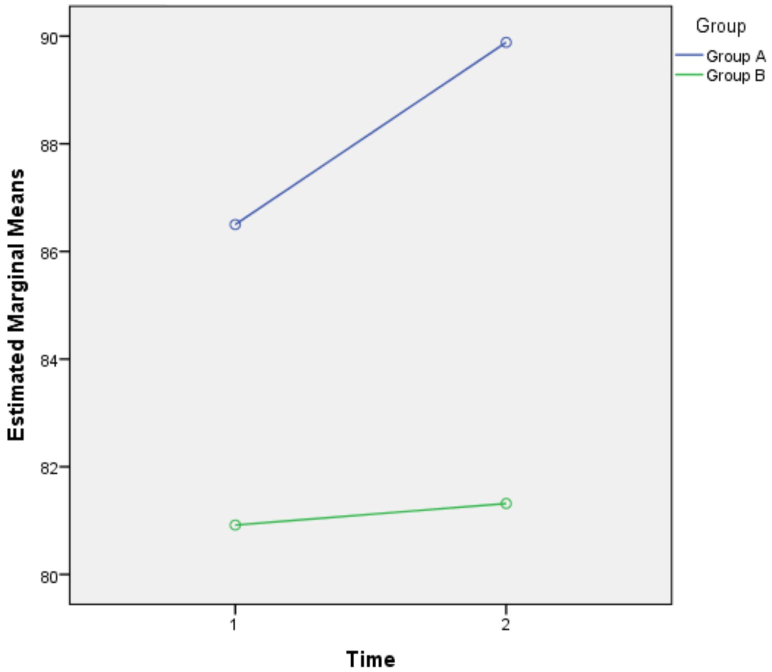


Figure 4.1 – Profile plot of average speed (Km/h)

Based on the outcomes in Table 4.7 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.018. However when accounting for change over time in real measured terms (kms/h), there was no significant difference between the groups.

4.4.4.2 Cervical flexion ROM

Table 4.8 - Cervical flexion ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.87	5.74[b]	1.00	38.00	**0.022**
Time * Group	Wilks' Lambda	0.98	0.978[b]	1.00	38.00	0.329

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

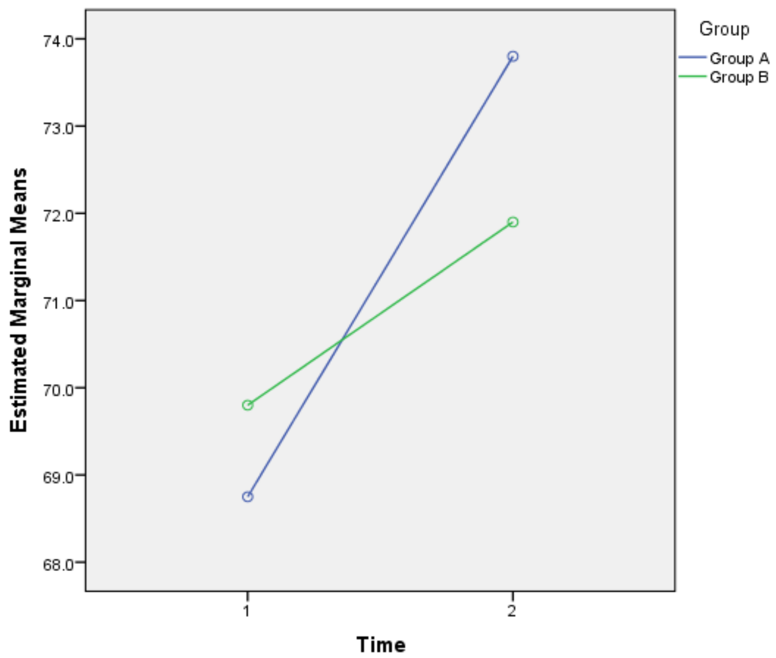


Figure 4.2 – Profile plot of cervical flexion ROM (Degrees)

Based on the outcomes in Table 4.8 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with p=0.022. However when accounting for change over time in real measured terms (kms/h), there was no significant difference between the groups.

4.4.4.3 Cervical extension ROM

Table 4.9 - Cervical extension ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.72	15.10[b]	1.00	38.00	**0.000**
Time * Group	Wilks' Lambda	0.83	7.57[b]	1.00	38.00	**0.009**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

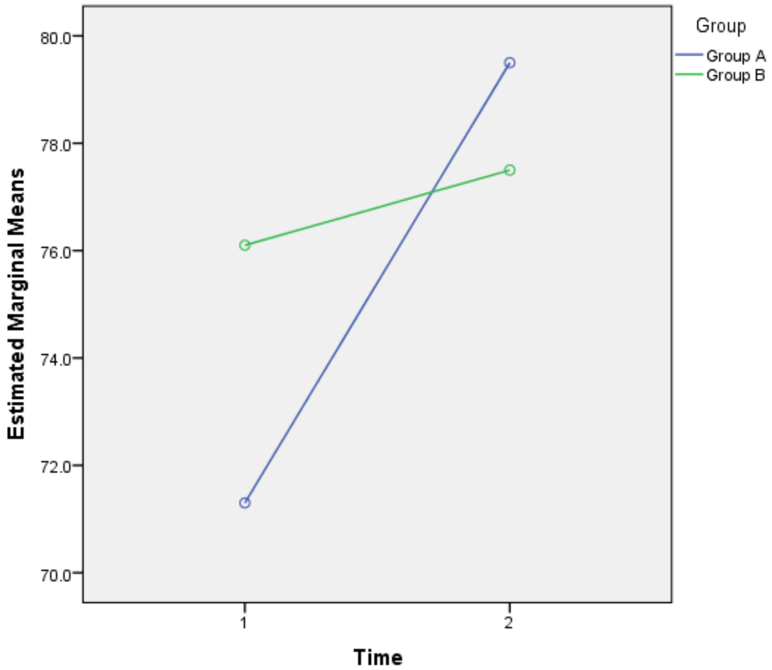


Figure 4.3 – Profile plot of cervical extension ROM (Degrees)

Based on the outcomes in Table 4.9 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with p=0.000. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (p=0.009). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.4 Cervical RLF ROM

Table 4.10 - Cervical RLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.89	4.48[b]	1.00	38.00	**0.041**
Time * Group	Wilks' Lambda	0.92	3.45[b]	1.00	38.00	0.071

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

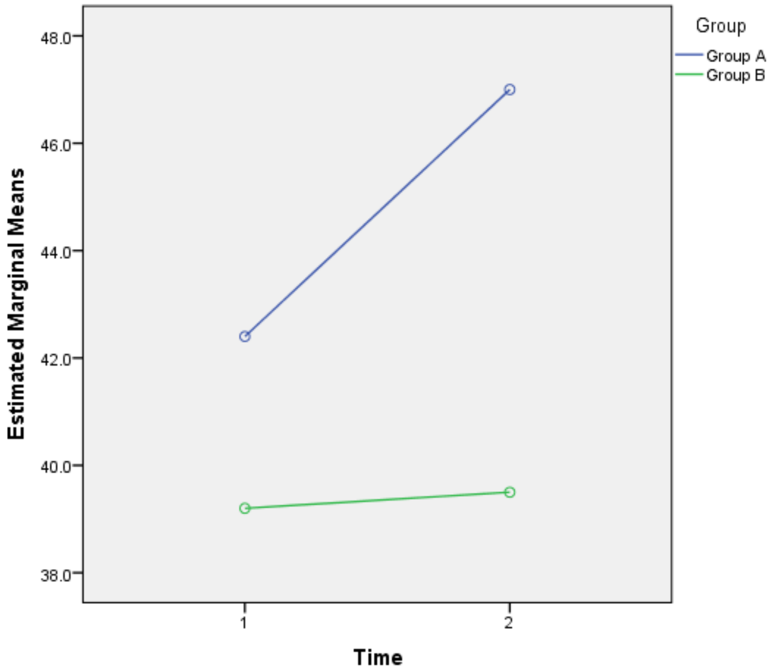


Figure 4.4 – Profile plot of cervical RLF ROM (Degrees)

Based on the outcomes in Table 4.10 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.041. However when accounting for change over time in real measured terms (degrees), there was no significant difference between the groups.

4.4.4.5 Cervical LLF ROM

Table 4.11 - Cervical LLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.88	5.38[b]	1.00	38.00	**0.026**
Time * Group	Wilks' Lambda	0.81	9.10[b]	1.00	38.00	**0.005**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

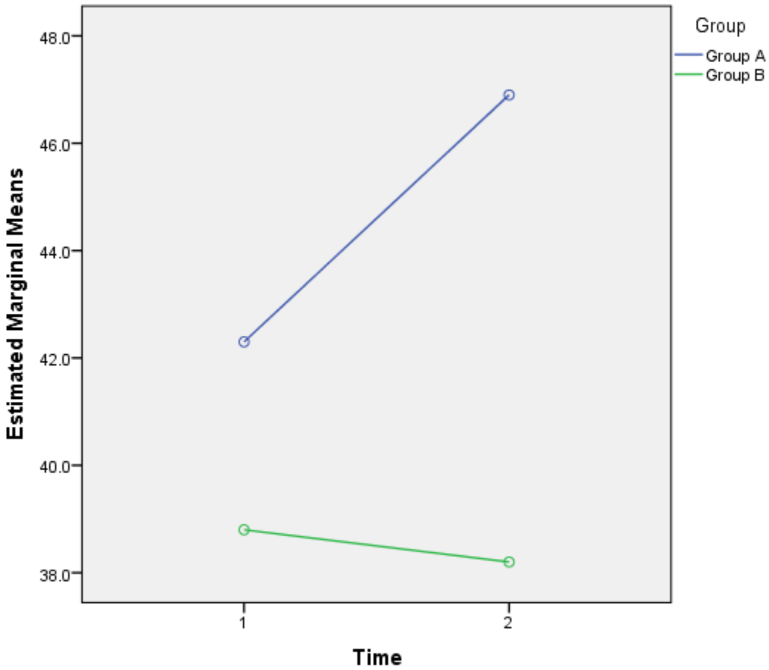


Figure 4.5 - Profile plot of cervical LLF ROM (Degrees)

Based on the outcomes in Table 4.11 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.026. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (*p*=0.005). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.6 Cervical LR PA ROM

Table 4.12 - Cervical LR PA ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.83	7.93[b]	1.00	38.00	**0.008**
Time * Group	Wilks' Lambda	0.98	0.99[b]	1.00	38.00	0.325

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

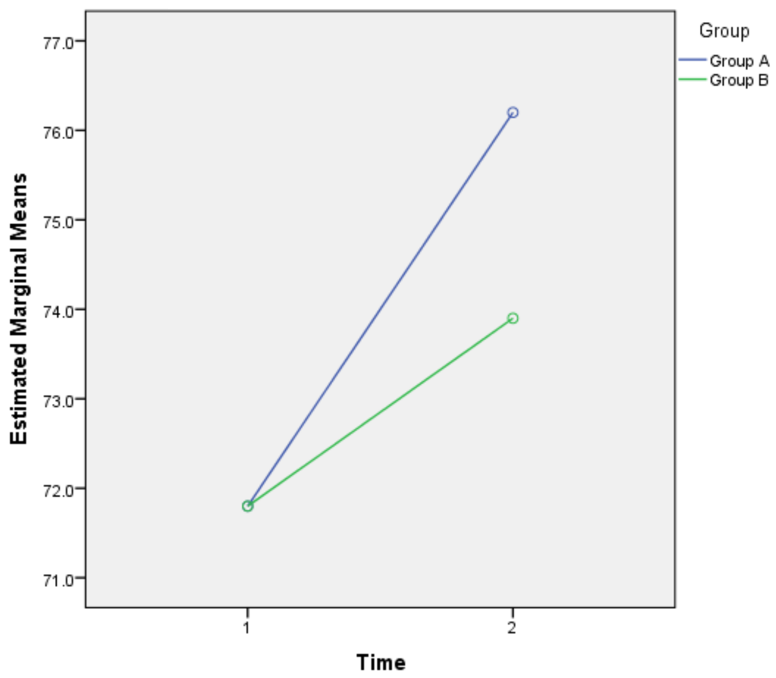


Figure 4.6 – Profile plot of cervical LR PA ROM (Degrees)

Based on the outcomes in Table 4.12 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with p=0.008. However when accounting for change over time in real measured terms (degrees), there was no significant difference between the groups.

4.4.4.7 Cervical RR PA ROM

Table 4.13 - Cervical RR PA ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.75	12.71[b]	1.00	38.00	**0.001**
Time * Group	Wilks' Lambda	0.80	9.28[b]	1.00	38.00	**0.004**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

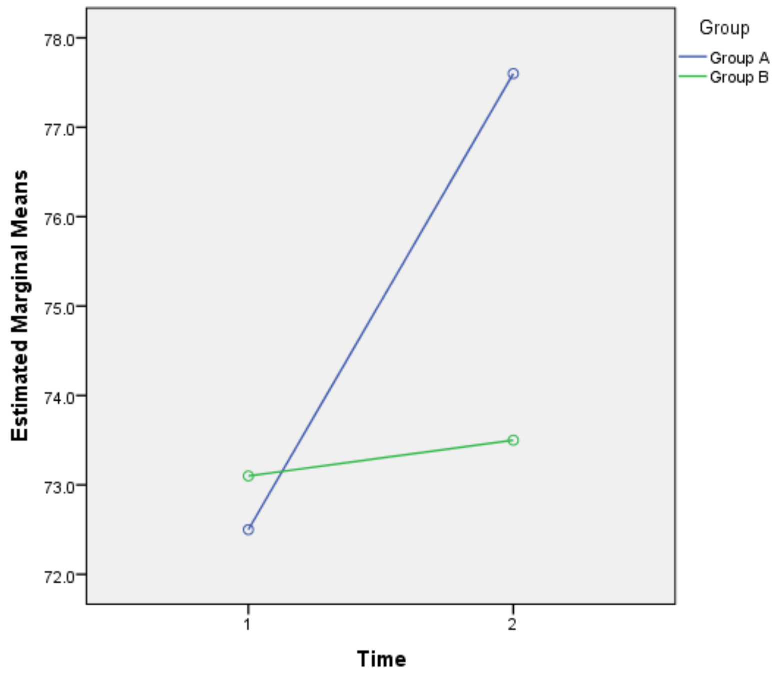


Figure 4.7 - Profile plot of cervical RR PA ROM (Degrees)

Based on the outcomes in Table 4.13 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.001. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (*p*=0.004). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.8 Thoracic flexion ROM

Table 4.14 – Thoracic flexion ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.86	6.34[b]	1.00	38.00	**0.016**
Time * Group	Wilks' Lambda	0.98	0.87[b]	1.00	38.00	0.358

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

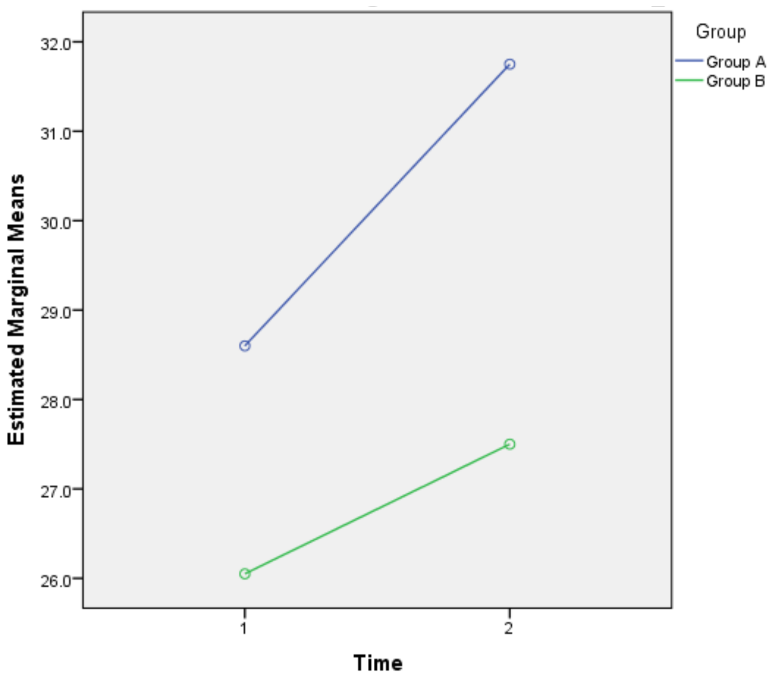


Figure 4.8 – Profile plot of thoracic flexion ROM (Degrees)

Based on the outcomes in Table 4.14 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.016. However when accounting for change over time in real measured terms (degrees), there was no significant difference between the groups.

4.4.4.9 Thoracic extension ROM

Table 4.15 - Thoracic extension ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.94	2.33[b]	1.00	38.00	0.135
Time * Group	Wilks' Lambda	0.89	4.69[b]	1.00	38.00	**0.037**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

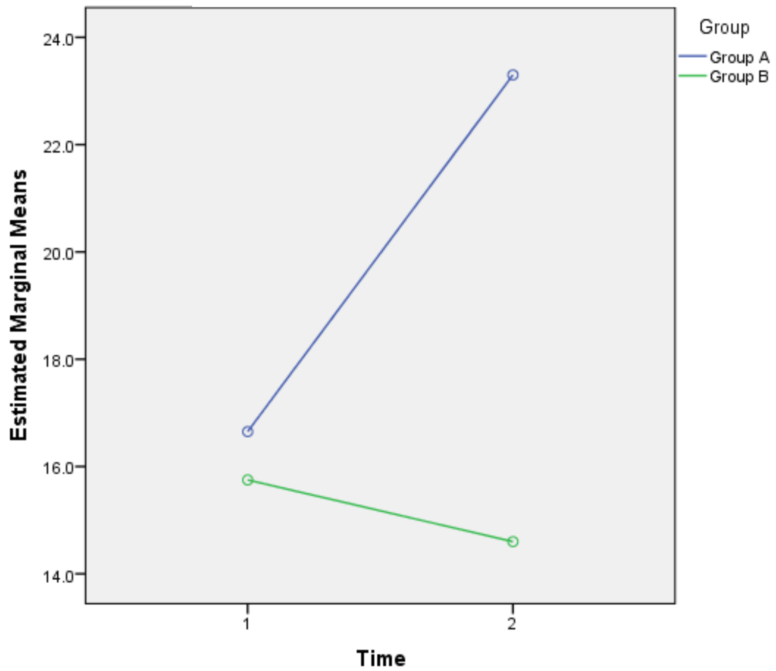


Figure 4.9 - Profile plot of thoracic extension ROM (Degrees)

Based on the outcomes in Table 4.15 of the Wilk's Lambda statistical analysis, it was found that over time there was no statistical significance in terms of the degree of change between the groups (*p*=0.135). However, when accounting for change over time in real measured terms (degrees), there was a statistically significant difference between the groups (*p*=0.037). Therefore, it is unlikely that the result of this analysis was purely as a result of time. This strengthens this outcome measure as being the most direct measure of the intervention used in this study. It is however possible that sample size may affect the outcomes of this measure if larger sample populations were to be used, as the significance is not at the 95% or 99% confidence interval level.

4.4.4.10 Thoracic RLF ROM

Table 4.16 - Thoracic RLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.84	6.99[b]	1.00	38.00	**0.012**
Time * Group	Wilks' Lambda	0.85	6.72[b]	1.00	38.00	**0.013**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

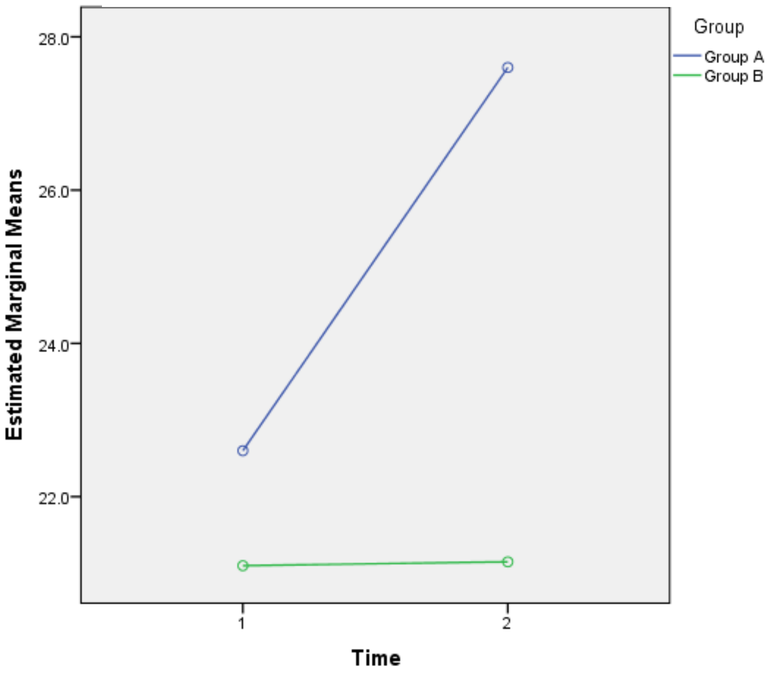


Figure 4.10 – Profile plot of thoracic RLF ROM (Degrees)

Based on the outcomes in Table 4.16 of the Wilk's Lambda statistical analysis, it was found that over time there is a statistical significance in terms of the degree of change between the groups with *p*=0.012. In addition, when accounting for change over time in real measured terms (degrees), it is noted in the differences between the groups remained statistically significant (*p*=0.013). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.11 Thoracic LLF ROM

Table 4.17 - Thoracic LLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.82	8.36[b]	1.00	38.00	**0.006**
Time * Group	Wilks' Lambda	0.87	5.72[b]	1.00	38.00	**0.022**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

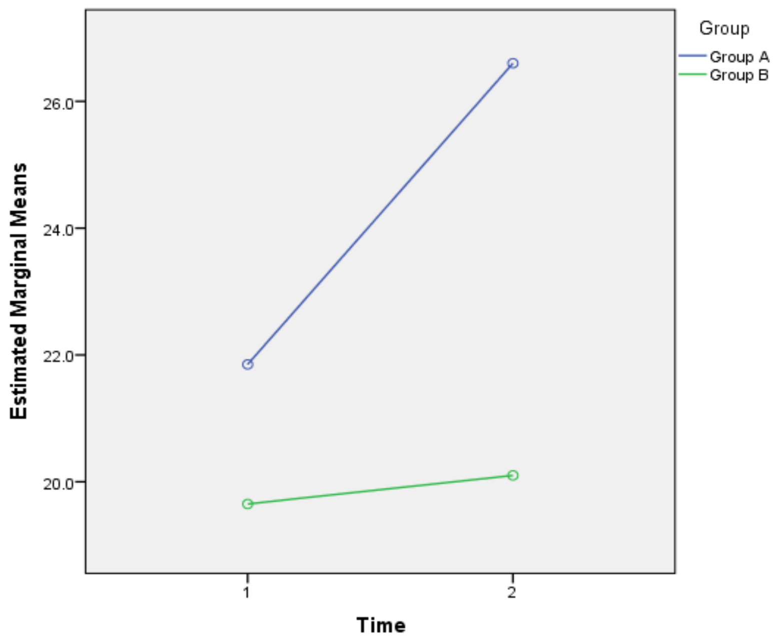


Figure 4.11 – Profile plot of thoracic LLF

Based on the outcomes in Table 4.17 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.006. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (*p*=0.022). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.12 Lumbar flexion ROM

Table 4.18 - Lumbar flexion ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.89	4.87[b]	1.00	38.00	**0.034**
Time * Group	Wilks' Lambda	0.98	0.67[b]	1.00	38.00	0.418

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

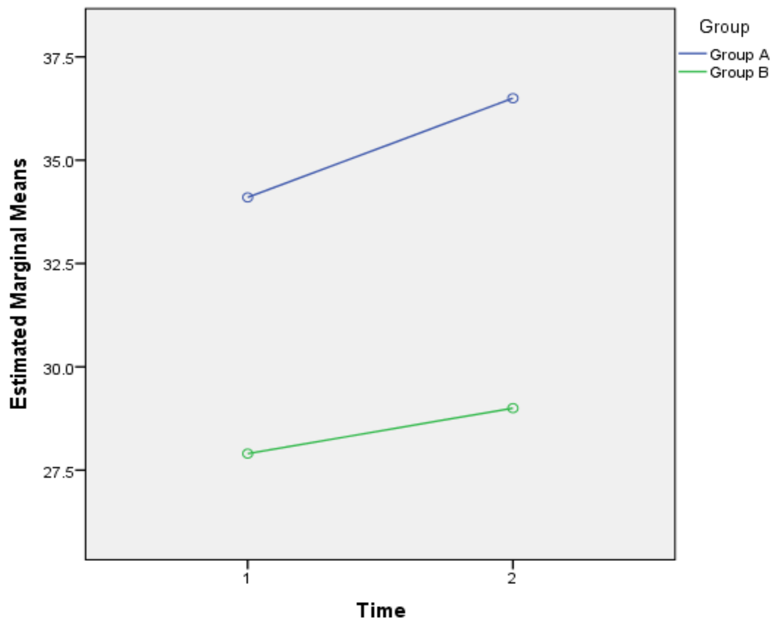


Figure 4.12 – Profile plot of lumbar flexion

Based on the outcomes in Table 4.18 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.034. However when accounting for change over time in real measured terms (degrees), there was no significant difference between the groups.

4.4.4.13. Lumbar extension ROM

Table 4.19 - Lumbar extension ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.80	9.26[b]	1.00	38.00	**0.004**
Time * Group	Wilks' Lambda	0.80	9.52[b]	1.00	38.00	**0.004**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

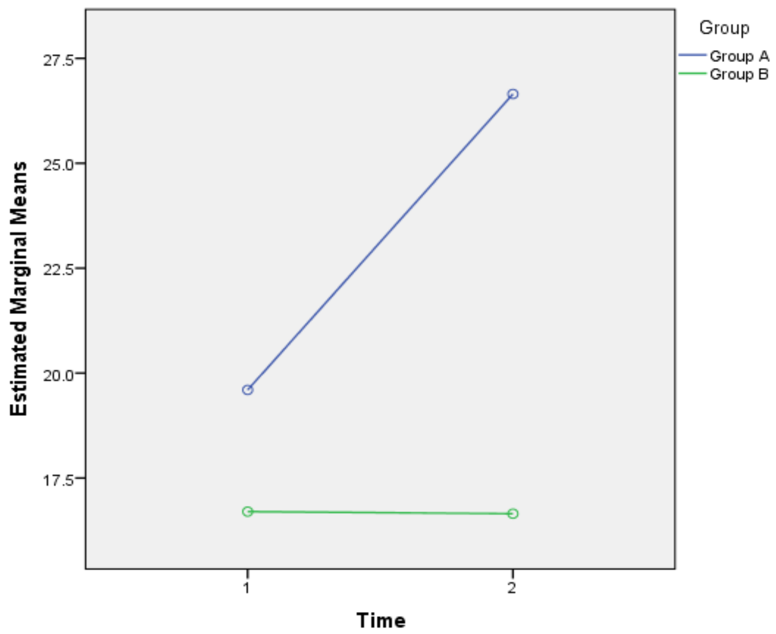


Figure 4.13 – Profile plot of lumbar extension

Based on the outcomes in Table 4.19 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.004. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (*p*=0.004). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.14 Lumbar RLF ROM

Table 4.20 - Lumbar RLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.76	11.84[b]	1.00	38.00	**0.001**
Time * Group	Wilks' Lambda	0.73	13.90[b]	1.00	38.00	**0.001**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

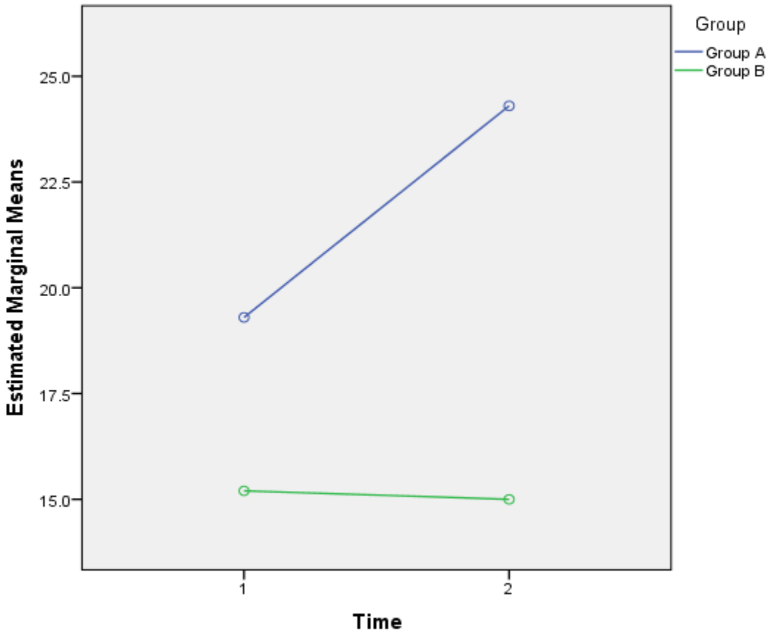


Figure 4.14 – Profile plot of lumbar RLF

Based on the outcomes in Table 4.20 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with p=0.001. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (p=0.001). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.15 Lumbar LLF ROM

Table 4.21 - Lumbar LLF ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.73	14.01[b]	1.00	38.00	**0.001**
Time * Group	Wilks' Lambda	0.82	8.56[b]	1.00	38.00	**0.006**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

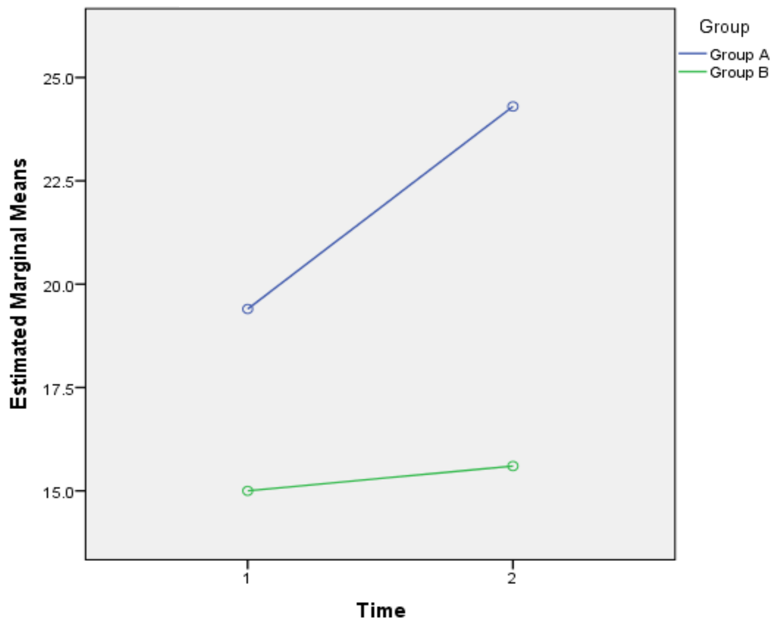


Figure 4.15 – Profile plot of lumbar LLF

Based on the outcomes in Table 4.21 of the Wilk's Lambda statistical analysis, it was found that over time there was a statistical significance in terms of the degree of change between the groups with *p*=0.001. In addition, when accounting for change over time in real measured terms (degrees), the differences between the groups remained statistically significant (*p*=0.006). It is unlikely that the sample size would change the significances reached in this analysis and therefore this outcome is likely to be reproduced in future studies with similar methodologies.

4.4.4.16 Lumbar LR PA ROM

Table 4.22 - Lumbar LR PA ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.99	0.37[b]	1.00	38.00	0.547
Time * Group	Wilks' Lambda	0.96	1.52[b]	1.00	38.00	0.226

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

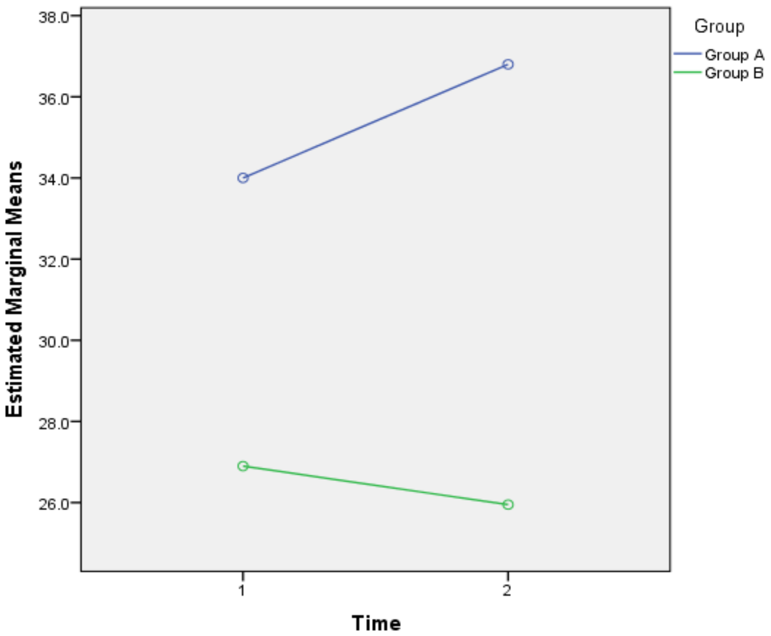


Figure 4.16 – Profile plot of lumbar LR PA

There is no statistical significance in Table 4.22.

4.4.4.17 Lumbar RR PA ROM

Table 4.23 - Lumbar RR PA ROM[a]

Effect		Value	F	Hypothesis df	Error df	Sig.
Time	Wilks' Lambda	0.93	2.69[b]	1.00	38.00	0.109
Time * Group	Wilks' Lambda	0.86	6.04[b]	1.00	38.00	**0.019**

(a. Design: Intercept + Group within Participants Design: Time) (b. Exact statistic)

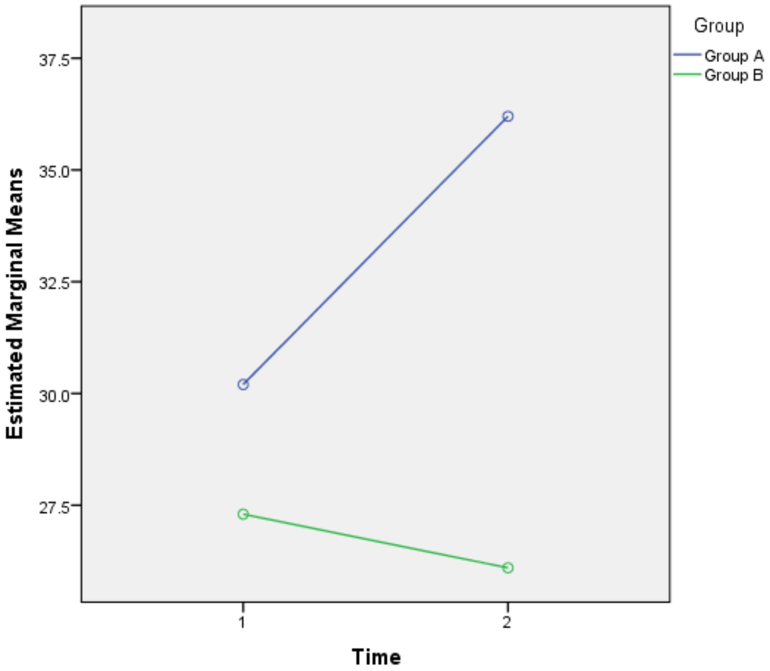


Figure 4.17 – Profile plot of lumbar RR PA ROM

Based on the outcomes in Table 4.15 of the Wilk's Lambda statistical analysis, it was found that over time there was no statistical significance in terms of the degree of change between the groups (*p*=0.135). However, when accounting for change over time in real measured terms (degrees), there was a statistically significant difference between the groups (*p*=0.037). Therefore, it is unlikely that the result of this analysis was purely as a result of time. This strengthens this outcome measure as being the most direct measure of the intervention used in this study. It is however possible that sample size may affect the outcomes of this measure if larger sample populations were to be used, as the significance is not at the 95% or 99% confidence interval level.

4.4.5 Perception outcome

Table 4.24 - Hypothesis Test Summary

Null Hypothesis	Test	Sig.	Decision
The distribution of OrderP is the same across categories of Group	Independent Samples Mann-Whitney U Test	0.040	Reject the Null hypothesis

Exact significance is displayed for this test

For Table 4.24 an order was established to the outcome categorical variables (1=decrease, 2=no change, 3=increase). A non-parametric test (Mann Whitney U) was done to indicate if there was any significant difference between the categories.

Table 4.25 - Medians of Groups

Group	Median
Group A	3
Group B	2
Total	3

Table 4.25 indicates (through medians) where most of the values lie.

Based on the outcomes of Tables 4.24 and 4.25, the Null was rejected and thus there was a difference.

4.5 Conclusion

Table 4.26 – Colour coded inter and intra group analysis of Group A and B

Intra-group Analysis of Group A	*p* value	Intra-group Analysis of Group B	*p* value	Inter-group Analysis	*p* value
Pre Cervical Extension ROM- Post Cervical Extension ROM	**<0.0001**	Pre Thoracic Extension ROM- Post Thoracic Extension ROM	0.187	Lumbar RLF ROM	**0.001**
Pre Cervical RR PA ROM - Post Cervical RR PA ROM	**<0.0001**	Pre Cervical LR PA ROM - Post Cervical LR PA ROM	0.229	Cervical RR PA ROM	**0.004**
Pre Lumbar RLF ROM - Post Lumbar RLF ROM	**<0.0001**	Pre Thoracic Flexion ROM - Post Thoracic Flexion ROM	0.262	Lumbar Extension ROM	**0.004**
Pre Lumbar LLF ROM - Post Lumbar LLF ROM	**<0.0001**	Pre Cervical Flexion ROM - Post Cervical Flexion ROM	0.263	Cervical LLF ROM	**0.005**
Pre Cervical LLF ROM - Post Cervical LLF ROM	**0.001**	Pre Lumbar Flexion ROM - Post Lumbar Flexion ROM	0.317	Lumbar LLF ROM	**0.006**
Pre Thoracic LLF ROM - Post Thoracic LLF ROM	**0.002**	Pre Cervical Extension ROM- Post Cervical Extension ROM	0.418	Cervical Extension ROM	**0.009**
Pre Lumbar Extension ROM - Post Lumbar Extension ROM	**0.003**	Pre Lumbar RR PA ROM - Post Lumbar RR PA ROM	0.447	Thoracic RLF ROM	**0.013**
Pre Thoracic RLF ROM - Post Thoracic RLF ROM	**0.004**	Pre Lumbar LLF ROM - Post Lumbar LLF ROM	0.527	Thoracic LLF ROM	**0.022**
Pre Ave Speed (Km/h) - Post Ave Speed (Km/h)	**0.007**	Pre Lumbar LR PA ROM - Post Lumbar LR PA ROM	0.541	Thoracic Extension ROM	**0.037**
Pre Cervical RLF ROM - Post Cervical RLF ROM	**0.010**	Pre Cervical LLF ROM - Post Cervical LLF ROM	0.627		
Pre Cervical LR PA ROM - Post Cervical LR PA ROM	**0.012**	Pre Ave Speed (Km/h) - Post Ave Speed (Km/h)	0.708		
Pre Lumbar RR PA ROM - Post Lumbar RR PA ROM	**0.026**	Pre Thoracic LLF ROM - Post Thoracic LLF ROM	0.712		
Pre Thoracic Flexion ROM - Post Thoracic Flexion ROM	**0.028**	Pre Cervical RR PA ROM - Post Cervical RR PA ROM	0.748		
Pre Cervical Flexion ROM - Post Cervical Flexion ROM	**0.046**	Pre Lumbar RLF ROM - Post Lumbar RLF ROM	0.836		
Pre Lumbar Flexion ROM - Post Lumbar Flexion ROM	0.054	Pre Cervical RLF ROM - Post Cervical RLF ROM	0.859		
Pre Thoracic Extension ROM- Post Thoracic Extension ROM	0.073	Pre Lumbar Extension ROM - Post Lumbar Extension ROM	0.957		
Pre Lumbar LR PA ROM - Post Lumbar LR PA ROM	0.302	Pre Thoracic RLF ROM - Post Thoracic RLF ROM	0.966		

Table 4.26 shows the *p* values of the: the intra-group analysis of Group A; the intra-group analysis of Group B; and the statistically significant values of the inter-group analysis of Group A and B. All statistically significant values have been highlighted in bold. Each measurement is colour coded to highlight the differences of the intergroup analysis against the intragroup analysis.

Based on Chapter Four results, the statistically and clinically significant results will be discussed in Chapter Five.

Table 4.26 shows the *p* values of the: the intra-group analysis of Group A; the intra-group analysis of Group B; and the statistically significant values of the inter-group analysis of Group A and B. All statistically significant values have been highlighted in bold. Each measurement is colour coded to highlight the differences of the intergroup analysis against the intragroup analysis.

Based on Chapter Four results, the statistically and clinically significant results will be discussed in Chapter Five.

CHAPTER FIVE

DISCUSSION

5.1 Introduction

This chapter will discuss the results of Chapter Four in terms of the review of the literature.

5.2 Discussion of flow of participants

KZN Premier League hockey has a population size of 112 players of which 48 of those can perform the drag flick skill and were therefore eligible for the study. 40 of the 48 players participated in the study, as eight players declined for various reasons (e.g. time, availability and not interested).

The participants were divided into Group A (SMT) or Group B (Sham SMT) using purposive allocation (Mouton, 1996). The reason for the use of purposive allocation was to attempt to get full spinal and/or regional manipulation into each group for homogeneity. Every participant had dysfunctions in cervical, thoracic and lumbar spine and thus were divided in equal numbers to Group A or Group B.

A total of 20 participants in Group A and 20 participants Group B completed the full research process with each participant having dysfunctional segments in the cervical, thoracic and lumbar regions of the spine. 20 participants per group was the minimum number for statistical analysis (McCaul, 2014). There were no exclusions or dropouts in this study. No participants reported any side effects to treatment.

5.3 Discussion on baseline comparisons

5.3.1 Demographic variables

There were no statistically significant differences between the two groups with regards to age, height and weight. In Group B there was however a higher mean height and weight measurements while in Group A there was a higher mean age measurement as shown in

Table 4.1. The allocation of participants to the groups did not introduce bias and was therefore effective due to similar mean values in demographic data of the participants.

According to Lopez *et al.* (2010) the participant's age, height and weight are factors that could affect drag flicking speed and thus it is relevant to this study that there was no statistically significant differences between the groups with regards to the demographic data. This implies that the outcomes (ROM, drag flick speed and perception of change of speed) obtained in each of the groups is directly related to the intervention and not differences in the demographic factors.

Nevertheless the age, height and weight mean measurements of this study as stated in Table 4.1 were slightly higher than the mean measurements used in the study by Lopez *et al.* (2010). This may be attributed to the fact that their study comprised of a single male drag flicker with 29 years experience of international calibre and 6 elite male drag flickers with a mean of 7.3 years experience. The international drag flicker was 36 years old 170cm tall and weighed 66,5kg in comparison the mean measurements of the 6 elite male drag flickers: 19.8 years old, 70.4kg, 175.5cm (Lopez *et al.,* 2010).

The demographics of the participant's in the study by Lopez *et al.* (2010), McLaughlin (1997), Yusoff *et al.* (2008) are similar to the demographics in this study in terms of age, height and weight. The results of this study are thus equally relevant to the participants in the above mentioned study. Based on the similarity of the participants of the above studies to this study, it could be suggested that the expected outcomes of the data discussed below would be similar.

5.3.2 Comparison of repeated measures at baseline between the groups

Table 4.2 shows the comparison of repeated measurements at baseline between Group A and Group B. There were no statistically significant differences implying that allocation was effective and that the outcomes of the study reflected the measures (average speed and cervical, thoracic and lumbar ROM) of the effect of the intervention.

5.3.2.1 Average speed

The baseline average speed of the drag flick stated in Table 4.2 is consistent with the average speed described by Yusoff *et al.* (2008) and Lopez *et al.* (2010), which is 71-100km/h (five international players) and 93km/h (one international player) respectively. This is in contrast to McLaughlin (1994) and Lopez *et al,* (2010) who reported an average speed of 68-79km/h (fifteen state / provincial players) and 79km/h (six elite players) respectively. The former two studies utilising International players (Yusoff *et al.,* 2008; Lopez *et al.,* 2010) reflect higher baseline average speeds than those stated in Table 4.2. However, the latter studies using provincial / elite players (McLaughlin 1994; Lopez *et al,* 2010) compare arguably with this study, which has a baseline average speed of 86.50km/h for Group A and 80.91km/h for Group B. This indicates that the players that participated in this study are more comparable to provincial players, which is consistent with the players that were recruited for this study. Therefore the results of this study would be applicable to players of a similar calibre and it may not be possible to generalize the outcomes to international players.

The top speed recorded in this study was 117km/h, which is consistent with findings from Yusoff *et al*. (2008), who recorded 120km/h.

5.3.2.2 Range of motion

The baseline means (+/- SD) of the ROM of the cervical, thoracic and lumbar spine is shown in Table 4.2.

> The cervical spine ROM baseline means (+/- SD) are within normal values for asymptomatic individuals described in Table 2.1 except for the following movements, which were all below the normal values: cervical LR PA ROM (Group A and B), cervical RR PA ROM (Group A only).
>
> The thoracic spine ROM baseline means (+/- SD) are within normal values for asymptomatic individuals described in Table 2.2 except for thoracic extension ROM (Group A and B), which are below the normal values.

The lumbar spine ROM baseline means (+/- SD) are within normal values for asymptomatic individuals as described in Table 2.3 except for the following movements, which were all above the normal values: lumbar LR PA ROM (Group A only), lumbar RR PA ROM (Group A and B).

Factors that could explain the differences in these baseline findings are:

- The examiner's accuracy in locating of the bony landmarks when utilizing devices such as the CROM, BROM II and the inclinometer as variability in placing theses devices has been known to affect the outcome of the results (Mayer *et al*, 1995).
- Lack of familiarity with the use of measuring devices such as the CROM, BROM II and the Inclinometer as non-routine use (e.g. seldom use of the measuring device) of these measuring instruments in clinical practice has been known to affect the outcome of the results (Mayer *et al*, 1995).
- Human error may have occurred in data collection due to minor movements of the spine and the incorrect positioning of measuring instruments. This may have occurred slightly in all readings, and in both groups, as the CROM, BROM II and inclinometer is operator dependent (Mayer *et al*, 1995).

The above factors were minimized in this study as the researcher practiced with the equipment prior to the start of the study and data collection. Multiple examiners were not used in this study and therefore the inter-examiner reliability did not affect the outcomes of this study in any way (Haas, 1991), however this did not preclude intra-examiner variability (Haas, 1991). One manner in which this could have been improved in this study would have been to utilize a non-permanent marker that is not affected by the participant sweating or the movement of clothes over the regions that required marking. Such a marker would have retained the anatomical locations of the measurement points for the post / second set of readings. An example of this would be the use of Henna dye.

5.4 Discussion on intra-group analysis of Group A

Group A received SMT to the cervical, thoracic and lumbar spine only where dysfunctions were found by the experienced qualified chiropractor by the use of motion palpation (Schafer and Faye, 1990).

5.4.1 Average speed

The mean average speed of Group A as shown in Table 4.3 and 4.4 increased pre SMT from 86.50km/h to 89.88km/h post SMT. The average speed of Group A was considered statistically significant with a *p* value of 0.007. In the absence of being able to compare results to similar studies in hockey for drag flicking, a comparison can only be made on the basis of increased performance. Sood (2008), Deutschmann (2015) and Costa and Chibana *et al.* (2009) studies on SMT found that their participants bowling in cricket; kicking speed in football; and golf swing performance increased. As such, these researchers stated that SMT is a valid intervention to increase performance in sport (Sood, 2008; Costa and Chibana *et al.*, 2009; Deutschmann, 2015). However in an earlier study on golf performance Le Roux's (2008) results indicated that the participants had limited improvement in performance.

5.4.2 Range of motion

The mean measurements of Group A with regards to values pre and post intervention as shown in Tables 4.3 and 4.4 for ROM of the cervical, thoracic and lumbar spine all increased in value. The following were found to be statistically significant (*p* values are shown in brackets) with regards to the values pre and post intervention:

- Cervical extension (<0.0001)
- Cervical RR PA (<0.0001)
- Lumbar LLF (<0.0001)
- Lumbar RLF (<0.0001)
- Cervical LLF (=0.001)
- Thoracic LLF (=0.002)
- Lumbar extension (=0.003)
- Thoracic RLF (=0.004)
- Cervical RLF (=0.010)
- Cervical LR PA (=0.012)
- Lumbar RR PA (=0.026)
- Thoracic Flexion (=0.028)
- Cervical Flexion (=0.046)

The results in Tables 4.3 and 4.4 are keeping with the studies / reports on studies by Rogers *et al.* (2003), Leach (2004), Haldeman (2005) and Bergmann and Peterson (2011), who stated that manipulation of the spine increased joint mobility and thus increase ROM of the spine. Additionally, previous studies compiled by Sood (2008) and Deutschmann (2015) showed an increase in ROM to the spine immediately post SMT on asymptomatic participants.
Possible explanations for the increase in ROM include the effects of altered orientation and / or positioning of various anatomic structures (Leach, 2004), increased motion segment ROM (Rogers *et al.*, 2003), ligament unbuckling and releasing of entrapped meniscoids (Haldeman, 2005; Bergmann and Peterson, 2011), breaking of adhesions (Leach, 2004) and / or re-establishment of motion segment function (Rogers *et al.*, 2003). These changes, the resultant increase in neurological input and the increased flexibility and mobility of the manipulated joints (Herzog, 2000; Gatterman, 2003) (as in Section 2.6.2) are therefore consistent with the results obtained for Group A.

As no participants reported any adverse reaction to spinal manipulation in this study, the outcomes of this study concur with Dagenais and Haldeman (2012), who indicate that SMT is a safe procedure provided that it is performed by a qualified chiropractor that has completed the necessary diagnostic and clinic examinations prior to the intervention.

5.5 Discussion on intra-group analysis of Group B

The sham manipulation was done by means of an activator gun, which was held a small distance away from the skin. At the same time a similar size and shape headpiece to the activator gun was placed on the skin of the participant. However, although the researcher fired the activator gun (to cause the participant to believe the gun was fired onto their skin), it was not directed onto the skin of the participant (Yates *et al*., 1988; Hawk *et al*., 1999) (as in Section 3.5.2).

5.5.1 Average speed

The mean average speed of the participants in Group B, as shown in Tables 4.5 and 4.6 increased pre sham manipulation from 80.91 km/h to 81.32km/h post sham manipulation. However, their average speed was not considered as statistically significant with a *p* value of 0.708. Both, Sood (2008) and Deutschmann (2015) utilised a sham laser as a control (placebo). The sham laser was placed on the participant's body while lying prone (Sood, 2008; Deutschmann, 2015), in comparison to this study where participants where placed in similar positions as in Group A, resulting in muscle stretch. This will be discussed in Section 5.6.1. There were no statistically significant values shown by Sood (2008) and Deutschmann (2011) in their placebo groups.

5.5.2 Range of motion

There were no significant changes in ROM with sham manipulation to the cervical, thoracic and lumbar spine. The findings of this study also supported studies undertaken by Conway *et al*. (1993), Sood (2008) and Deutschmann (2015) who reported that SMT is more effective than a placebo.

5.5.3 Placebo

it is possible that with a placebo (control) group as part of this study, differences in the outcomes between the groups were not necessarily related to the intervention / sham that was compared but may also have been influenced by the participant's perception of treatment they received (Mouton, 1996; Maigne and Vautravers, 2003).

In this context, it should be noted:

- the researcher advised the participants that their involvement would assess the degree to which manipulation affected their drag flicking speed.
- the researcher also advised the participants that they would either be placed in an intervention or placebo group. There was no explanation as to which manipulative procedure was linked to the placebo group (Group B).
- the sham manipulation / placebo was administered in a manner that was similar to that of SMT. This required that the participant was placed in a similar position to the participant receiving manual SMT in Group A.

Therefore, all participants in the sham manipulation / placebo where unaware that they were not receiving an active intervention (the inverse being true of the manual manipulation group) which allowed the researcher to 'measure' the effect of SMT separately to the participants' expectations and perceptions (Draper, 2002).

Therefore the results of Group B were not related to their belief in the efficacy of the intervention (Draper, 2002). Thus, it could be said that SMT has an effect of increasing the average speed of a drag flick and ROM of the spine.

5.6 Discussion of the inter-group analysis

5.6.1 Average speed

When comparing the outcomes over time between the groups, it is apparent that the Group A achieved a statistically significant improvement in the average speed readings (Group A; p=0.007). This result was expected, as clinical investigations have supported the outcome from the use of SMT (discussed in Section 2.5.2). These included the:

- effects in change of the orientation and/or positioning of various anatomical structures resulting in both functional changes in structures and improved neurological co-ordination (Leach, 2004),
- increased in ROM of motion segments (Rogers *et al.*, 2003),
- increase of neurological input and improvement in functional co-ordination of nervous system (Haldeman, 2005),
- breaking of adhesions (Leach, 2004) and,

Therefore the return of normal full motion within the vertebral motion segment (Rogers *et al.*, 2003).

These neurological changes and the increased flexibility and mobility of the manipulated joints (Herzog, 2000; Gatterman, 2003) are therefore thought to be the mechanism which resulted in increased speed of the rotation of the pelvis, trunk and arms, allowing for the improved results that the participant's achieved. Thus, it is possible for the participant's in Group A to state that such increases may, in physiological function improve a player's performance in their drag flick motion ability and the resultant speed of the ball (Sood, 2008; Le Roux, 2008; Costa and Chibana *et al.*, 2009; Miners, 2010; Deutschmann, 2015).

This is consistent with the outcomes achieved in Group B (Group B: 0.708), where these effects were not present and statistically significant improvement was not recorded.

In contrast, when comparing the changes over time between the groups, it becomes apparent that there was no significant difference that was achieved.

This outcome may be the result of several factors:

- The first may be related to participant positioning in the placebo group (Group B). The participant was put into a similar position as if receiving SMT as in the participants in Group A and thus a participant in Group B would receive a similar muscle stretch to those who received SMT in Group A (Kendall *et al.*, 2005; Mense and Gerwin, 2010). The physiological effect of muscle stretch indicates that the stretch imparted to the participant, may have fired receptors in the muscle spindles (Mense and Gerwin, 2010). This would result in action potentials in muscle fibres, which connect the muscle spindles to the central nervous system (Kendall *et al.*, 2005; Mense and Gerwin, 2010), increasing the neurological input and increase flexibility of the stretch muscle (Kendall *et al.*, 2005; Mense and Gerwin, 2010). Therefore effectively reducing the difference between the groups and thus mitigating against achieving a significant difference in changes over time.
- The second factor that may have influenced the outcomes of average speed difference between the groups could be based on participant interaction. This could include the type of motion dysfunctions found and which were manipulated. The current study was only able to ensure that each vertebral region (cervical, thoracic and lumbar) were addressed systematically for each patient and in each group. However, without epidemiological evidence indicating the type and direction of dysfunctions in these regions, there was limited ability to ascertain whether each of the groups received similar manipulative interventions. It is therefore suggested that future studies look at stratifying groups according to both regions and type or dysfunction (therefore manipulative procedure) in order to determine the effect of these on the outcomes presented.
- The third factor may be in terms of the baseline differences. The only ROM parameter that approximated significance was lumbar LR PA ROM. In this comparison, Group A had a larger ROM on average as compared to Group B. It is therefore theoretically possible that the neurological stimulation afforded by manipulation was reduced as the ROM present more closely approximated to

normal motion (Bergmann and Peterson, 2011). In contrast, the stretch in Group B, could have resulted in increased stimulation as a result of the decreased average ROM in this Group (Kendall *et al.*, 2005; Mense and Gerwin, 2010). This latter increased associated with the decrease stimulation in Group A, would again have resulted in a decreased likelihood of achieving a significant difference between the groups. This assumption however would need to be further explored with a detailed assessment of the ROM outcomes in this study. This follows in the next section (Section 5.6.2)

5.6.2 Range of motion

<u>Table 5.1 – Inter-group analysis ranked in statistical significance</u>

Intra-group analysis	***p* value**
Lumbar RLF ROM	0.001
Cervical RR PA ROM	0.004
Lumbar Extension ROM	0.004
Cervical LLF ROM	0.005
Lumbar LLF ROM	0.006
Cervical Extension ROM	0.009
Thoracic RLF ROM	0.013
Thoracic LLF ROM	0.022
Thoracic Extension ROM	0.037

Table 5.1 shows the statistically significant ROM between Group A and Group B.

When comparing the changes over time between the groups:

- The cervical spine showed a statistically significant increase in ROM for extension, RR PA and LLF. However, a statistical significance was not found in ROM for flexion, LR PA and RLF.

- The thoracic spine showed a statistically significant increase in ROM for extension, RLF and LLF. However, a statistical significance was not found in ROM for flexion.

- The lumbar spine showed a statistically significant increase in ROM for extension, RLF and LFF. However, statistical significance was not found in ROM for flexion, LR PA and RR PA.

- Extension in the cervical, thoracic and lumbar spine was shown to be statistically significant for an increase in ROM. This is not unexpected because the natural position of the drag flicker is to flex or hunched over the ball (Yusoff *et al.*, 2008).
- RLF and LLF in the thoracic and lumbar spine were shown to be statistically significant for an increase in ROM. This is in contrast to the cervical spine were only LLF was shown to be statistically significant for an increase in ROM. This may be explained by the iliopsoas and quadratus lumborum muscles in the lumbar spine which are both affected by continued forward flexion position contractures as in for example, drag flick players. But these muscles are also responsible for limiting the lateral flexion in the players (Yusoff *et al.*, 2008; Bergmann and Peterson, 2011). This is also true of the thoracic spine (Yusoff *et al.*, 2008; Bergmann and Peterson, 2011).

- In contrast from a practical perspective, the cervical spine would have slightly different changes in that the drag flicker is required to keep an eye on the hockey stick and ball, which are usually to the right side and either alongside or slightly behind the player. This means that the player will have to contract their right scalene, right upper trapezius and levator scapulae muscles, which may become contractured or spastic (Kendall *et al.*, 2005; Mense and Gerwin, 2010; Bergmann and Peterson, 2011). This would mean that the player would have decreased ability to left laterally flex (restricted by the scalene and upper trapezius muscles) and rotate to the left (restricted by the levator scapulae and upper trapezius muscles) (Kendall *et al.*, 2005; Mense and Gerwin, 2010; Bergmann and Peterson, 2011).

- This is important to note as the usual coupled movement of the left lateral flexion and LR PA are associated, however with the dysfunctional movement required of a drag flicker, these movements are limited by the consequences of repetitive muscular contractions / contractures.

It is therefore evident from the above bulleted statements that the differences between Group A and Group B is as a result of the effect of the improved joint function as well as the effect of this intervention in the muscles that surround that joint and to enable ROM improvements. This was made possible, in that the difference between the groups in terms of average speed was not statistically significant in that the effects of the manipulation and the “sham” group stretch, indicating that both these groups benefitted from the intervention.

For example: a rotation SMT as in lumbar side posture for RR or LR would result in a high amount of muscular stretch irrespective of whether a true or “sham” manipulation was applied: thereby reducing the effective difference in outcomes for both groups.

5.7 Perception of change in drag flicking speed

According to the information stated in Table 4.24 a Mann-Whitney U Test was performed and it was found that the participants perception in change of speed post intervention was considered statistically significant with a p value of =0.040.

From the information supplied in Table 4.25, it was found that the majority of the participants perceived an increase in drag flicking speed following SMT intervention (Group A) in contrast to sham intervention / placebo (Group B) where the majority of the participants perceived no increase in their ball speed. As such, the null hypothesis stated in Section 1.3 is rejected

This high correlation between participants’ perception and objective results is a positive sign, and could be due to one of the following:

- Post SMT intervention, the majority of participants commented saying that they felt much “looser” and less stiff and that drag flicking felt easier. According to various researchers, this could be a direct result from the effects of manipulation (Herzog, 2000; Gatterman, 2003; Bergmann and Peterson, 2011). The stretching of the muscles in the position that SMT was performed in could also attribute to participants feeling “looser”.

- Change in perception, may be a result of the physical contact and interaction, the sound of the cavitation and the associated sound of the SMT adjustment to give the impression that the vertebrae is being correctly repositioned. (Maigne and Vautravers, 2003)

5.8 Conclusion

The aim of this study was:

- To determine the effect of SMT of the cervical, thoracic and lumbar spine compared to placebo intervention in terms of subjective (perception in change of speed) and objective measurements (ROM of cervical, thoracic and lumbar spine, and speed of the drag flick) on drag flicking performance of premier league hockey players.

With regards to the aim and objectives of the study:

- Group A showed a statistically significant increase in ROM:
  1) All cervical spine movements.
  2) Thoracic extension, flexion, RLF movements.
  3) Lumbar extension, RR PA, RLF, LLF.
- Group B showed no statistically significant increase for all ROM.
- The intra-group analysis showed a statistically significant increase in ROM in the following:
  1) Cervical extension, RR PA, LLF movements.
  2) Thoracic extension, RLF, LLF movements.
  3) Lumbar extension, RLF, LLF movements.
- Average flicking speed showed a statistically significant increase within Group A post SMT intervention.
- Average flicking speed showed no statistically significant increase within Group B post sham SMT intervention.
- Average flicking speed showed no statistically significant increase between the groups post intervention.
- There was a significant association between change in drag flicking speed pre-post- intervention and the participants perception in change of drag flicking speed.

In term of objectives and associated hypothesises that were stated at in section 1.3:

- There would be no statistically significant increase in drag flicking speed post intervention for any of the two groups, Group A was accepted while group B was rejected.
- There would be no statistically significant increase in ROM post intervention for any of the two groups, Group A was accepted while Group B was rejected.
- There would be no statistically significant difference between change in drag flicking speeds immediately post intervention and the participants' perception of change in drag flicking speed, was rejected.
- There would be no statistically significant difference between the groups in terms of drag flicking speed, range of motion and participants' perception of change, was rejected for ROM as in Table 5.1 and participants' perception of change in drag flicking speed, while accepted for all other measures.

CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

The immediate effect of SMT on drag flicking performance of hockey players was inconclusive. The outcomes of this study suggests that SMT results in an increase in the average speed of drag flicking, however further larger studies are required to confirm this.

Chiropractic manipulation may affect the performance of drag flickers.

6.2 Recommendations

- The sample size of this study was limited to forty participants. The small sample groups results were interpreted via the use of a statistical package, which yielded statistically significant results, but trends observed within the study may allow for recommendations of a larger sample size for future studies as this would reduce the risk of having a Type Two error.
- A similar study to be done in females in order to determine any possible gender differences in spine ROM and drag flicking speed post intervention
- Record manipulative procedures used as well as levels manipulated to ascertain any correlation in outcomes
- Stratify groups according to both regions and type of dysfunction and therefore manipulative procedure in order to determine the effect of the outcomes presented
- Use of a non-permanent marker (that is not affected by the participant sweating or the movement of clothes over the regions that required marking) to retain the anatomical locations of the measurement points for the post / second set of readings. An example of this would be the use of Henna dye
- Use of a sham intervention that didn't result in participants receiving any stretch to the surrounding muscles. An example of this would be to use a sham laser with the participant placed in a prone position (Sood, 2008; Deutschmann 2015).

- Inclusion criteria could be more specific targeting international / professional drag flickers. Reason being there drag flicking technique is more refined, which results in greater consistency in drag flicking speed.
- From general observation, a study to determine the effect of core stability muscular strength or forearm strength on drag flicking speed.
- It is recommended that further research on the effect of manipulation of the joints of the lower and upper biomechanical chain, involved in the drag flicking action and speed of the participants be performed. This recommendation would add to this study in that it would show, to which joint, the manipulation is of greatest effect as a tool to increasing drag flicking speed.

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Appendix A

Attention all Hockey Drag Flick Specialists

Are you a healthy male, between 18 and 35 years of age, and interested in having your drag flicking speed measured?

Research* is being conducted at Queensmead Hockey Stadium which may affect your drag flicking speed

If you are interested in participating in this study, please contact Mike Wiggett 0714855201

*This research is being conducted under the auspices of the Durban University of Technology

Appendix B

From: Lennie Botha <lennieb@pinnacle.co.za>
Subject: RE: My Research - Mike Wiggett
Date: 24 April 2013 12:18:10 PM SAST
To: Michael Wiggett <michael.wiggett@gmail.com>
Cc: "Lennie.botha@gmail.com" <Lennie.botha@gmail.com>

No Problem,

Regards
Lennie

-----Original Message-----
From: Michael Wiggett [mailto:michael.wiggett@gmail.com]
Sent: 24 April 2013 11:28
To: Lennie Botha
Cc: Lennie.botha@gmail.com
Subject: My Research - Mike Wiggett

Hi Lennie,

Hope you are well.

I am now in the process of completing my Masters and as i am sure you are aware we need to complete a thesis.

My topic involves drag flicking and adjustments with a possible increase in speed.

What I will need is the possibility to use the Queensmead astro to do this research, i am not sure when but probably towards the end of the year. Also maybe a room where the the adjustments can examinations take place.

If this is possible please could you send me a letter approving the use of the turf so I can put it in with all the other documentation that I need to submit.

Thanks

Regards,

Michael Wiggett
071 485 5201

Appendix C

RIVERSIDE SPORTS

A community branding of the Glenwood Old Boys Club

March 2014

To Whom This May Concern

This letter is to serve confirmation that, Michael Wiggett, member of Riverside Hockey Club, is authorized to use the Riverside Sports Facilities when needed for his research.

Yours sincerely

Candice Eales
Riverside Sports Executive Secretary

Appendix D

LETTER OF INFORMATION

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

Title of the Research Study:
The immediate effect of spinal manipulative therapy on drag flicking performance of hockey players.

Principal Investigator/s/researcher: Michael Wiggett
Co-Investigator/s/supervisor/s: Dr. H. Kretzmann (MDipChiro CCFC SA)

Brief Introduction and Purpose of the Study:

In sport, athletes are required to perform to the best of their ability in order to maintain their position within a team and beat the opposing side. Recently there has been an increase in athletes making the use of chiropractic treatment, with emphasis on spinal manipulative therapy and its aim to increase sports performance.

Hockey players, like any other professional athlete, are required to perform at peak physical function through out the game and during specific specialised skills. One such skill is the drag flick. This research aims to investigate if spinal manipulation will have an effect on drag flicking performance by measuring range of motion or amount of movement of the spine and speed of the ball.

The consultation: The first step in the consultation is for you to read this letter and ask any questions about the research in order for you to give your full informed consent for participation in this study. There after, a full case history, physical examination and orthopaedic examination of the spine will be done at DUT Chiropractic Clinic.

If all inclusion criteria are met and there is no reason for exclusion, you will then be booked to perform the trial at a given date and time at Queensmead Hockey Stadium (QMHS). The consultation is expected to last one and a half hours.

At the QMHS the following will take place; A quick assessment for any injury, 10 minute warm up exercise to stretch your muscles. Range of motion (or amount of movement) of your back will be measured using a digital inclinometer and a goniometer (simple non-invasive devices). You will be assessed by a qualified chiropractor and allocated to either Group A or Group B depending on the findings. This is a placebo controlled study and thus you may be placed in the placebo group. You will then be asked to flick as fast as you can 3 times and the speeds will be measured by a sports radar device. Depending on which group you were allocated to, the appropriate intervention will be applied. Range of motion of your back will be measured as before and you will be asked to flick as fast as you can 3 more times, and again the flicking speed will be measured. The consultation is expected to last half an hour.

Risks or Discomforts to the Participant:
All consultations are supervised by a registered, qualified chiropractor. Spinal manipulation and activator gun manipulative therapy may cause transient (short interval) stiffness or discomfort after the treatment this should resolve within 24-48 hours. Should the symptoms persist please report this to me.

Reason/s why the Participant May Be Withdrawn from the Study:
Should you not attend the follow up session you will be withdrawn from the study. Should you choose to not attend there will be no adverse consequences to you.

Remuneration and Costs of the Study:
There will be no remuneration or cost to participants who take part in the study

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

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

Persons to Contact in the Event of Any Problems or Queries:
Please contact the researcher: Michael Wiggett (tel no. 0714855201), my supervisor: Dr Kretzmann (tel no. 031 2055520) or the Institutional Research Ethics administrator on 031 373 2900. Complaints can be reported to the DVC: TIP, Prof F. Otieno on 031 373 2382 or dvctip@dut.ac.za.

Yours sincerely,

____
Researcher: Michael Wiggett

____
Supervisor: Dr H. Kretzmann

Appendix E

Chiropractor

Manipulation; Dry Needling; Massage; Rehab

Dr. BRUCE GRANT
M.Tech.Chiropractic D.U.T.
Practice No: 0238708

Tel: (031) 563 1313/4 or (031) 563 1359 Fax: 0865 167 370 Cell: 084 707 7789
E-mail: brucefgrant@gmail.com 110 Kensington Drive (Adelaide Tambo), Durban North 4051

To Whom It May Concern 26.11.2013

I, Dr Bruce Grant, am willing to assist Mr Michael Wiggett with his research in terms of data collection.

Regards,

Dr. Bruce Grant
M-Tech Chiropractic DUT

110 Kensington Drive/Adelaide Tambo Drive
Durban North
(Tel 1) +2731 563 1313/4
(Tel 2) +2731 563 1359
(Fax) +27865167370
(Cell) +27847077789

mailto:brucefgrant@gmail.com

Appendix F

Name:______________________________ Date:_________

File Number:________________________

Group A (SMT) ☐

Group B (Activator gun) ☐

Cervical Range of Motion (CROM)		Adjustment performed: ☐
Range of motion	**Before intervention**	**After intervention**
Flexion		
Extension		
Left Lateral Flexion		
Right Lateral Flexion		
Left Rotation		
Right Rotation		

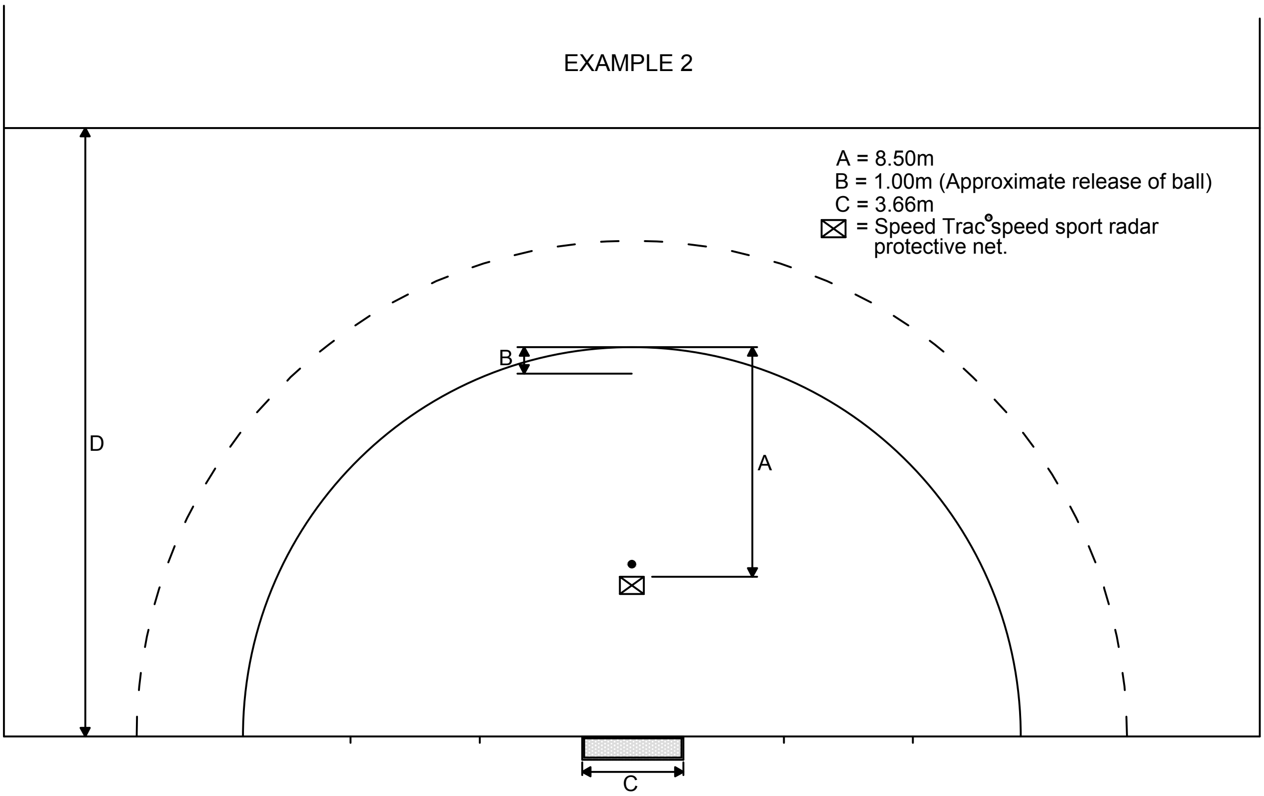
Thoracic Range of Motion (Saunders digital inclinometer)		Adjustment performed: ☐
Range of motion	**Before intervention**	**After intervention**
Flexion		
Extension		
Left Lateral Flexion		
Right Lateral Flexion		

Lumbar Range of Motion (BROM)		Adjustment performed: ☐
Range of motion	**Before intervention**	**After intervention**
Flexion		
Extension		
Left Lateral Flexion		
Right Lateral Flexion		
Left Rotation		
Right Rotation		

Perception of Drag Flicking Speed Post Manipulation (mark with an 'X')		
Increase	**Decrease**	**No Change**

Speed (Km/h)			
Pre-intervention		Post-intervention	
1		1	
2		2	
3		3	

Appendix G


EXAMPLE 2
A = 8.50m
B = 1.00m (Approximate release of ball)
C = 3.66m
= Speed Trac® speed sport radar
protective net.
B
D
A
C

Appendix H

Procedure for Measuring Back Motion
with the BROM II

The BROM II (Back Range Of Motion) instrument is a product of:

Performance Attainment Associates
3600 LaBore Road, Suite 6
St. Paul, MN 55110-4144

Flexion/Extension Measurements

The Flexion/Extension Unit is a modified inclinometer that eliminates the need to measure sacral flexion. The pointer is part of the base that is placed on the sacrum so all readings are relative to the sacrum. The arm moves the scale with the upper measuring point so that the reading is the range of motion relative to the sacrum. Since only one hand is required for holding the BROM II the second hand is available to assist the patient in achieving maximum flexion. The reading (in centimeters) on the sliding arm scale can be used in future evaluations so the same spine segment will be measured. This assures that the measurements can be easily reproduced by a second examiner.

1) For lumbar measurements palpate and mark S1 and T12.

2) Place the BROM Flexion/Extension Unit on the sacrum with the pivot point on S1. Have the patient stretch the velcro straps across the lower abdomen. Check that both contact points on the unit are held firmly against the sacrum. The downward pull of the straps is essential to maintain the contact points against the sacrum during flexion and extension.

3) Demonstrate and have the patient perform flexion and extension movements. Emphasize the importance of smooth steady movements that go to end range. Check that both contact points remain on the sacrum and the pivot point remains on S1 during patient flexion and extension.

4) Have the patient stand erect. Feet should be shoulder width apart. Place the moveable arm on the upper measuring point T12 and record the arm reading. This reading is the distance in centimeters between S1 and T12 and can be used to position the arm during future measurements to assure that the same segment of spine is measured. The typical reading for an adult is 15 centimeters.

5) With the arm tip on T12 record the initial reading from the outer scale. Remove the arm tip from T12 and place a finger securely on T12. Have the patient slowly bend forward trying to lay the palms of the hands on the floor. Replace the arm tip on T12 and record the full flexion reading. Subtract the initial flexion reading from the full flexion reading to obtain true flexion (Typical Value is 30 degrees). By placing a finger on the spine the examiner can follow the spine instead of a mark on the skin which would move relative to the spine during bending. Also by placing the finger on the spine the examiner can monitor if the patient is going to full flexion or extension.

6) Repeat step 5. If this true flexion reading is within 3 degrees of the first reading record the higher reading. If it is not within 3 degrees repeat step 5.

7) Extension Measurements. Check that the patient is standing erect. Have the patient put their arms across the chest with hands on their shoulders. Place the arm tip on T12 and record the initial reading from the outer scale. Remove the arm tip from T12 and have the patient extend backward (provide the necessary support to prevent the patient from falling backward). Place the arm tip on T12 and record the full extension reading. Subtract the full extension reading from the initial reading to obtain true extension (Typical Value is 12 degrees).

8) Repeat step 7. If this true extension reading is within 2 degrees of the first reading record the higher reading. If it is not within 2 degrees repeat step 7.

9) Pelvic Tilt Measurement. Remove the arm. Have the patient stand erect. Move the dial until the vial bubble is between the two lines. Record the pelvic tilt reading from the inner scale.

Thoracic Flexion can be measured by placing the pivot point on T12 and placing the tip of the long arm on T1.

Rotation Measurements

The magnetic angle meter measures to the magnetic reference placed on the spine thus eliminating unwanted spine movement below that point. An added advantage of this method is that measurements are made with the trunk in the vertical position. The meter unit is designed so when the examiner grasps the rib cage the unit becomes a part of the patient, thus eliminating tracking errors.

1) Utilize the markings made for S1 and T12 made during the flexion/extension measurements.

2) Place the belt between S1 and T12 with the velcro side out. Place the magnetic reference over the sacrum (approximately 4 cm below S1) and attach the velcro straps.

3) Have the patient sit erect on a non rotating stool facing west so the arrow on the magnetic reference points north. Feet should be flat on the floor. This sitting position will stabilize the pelvic area. The patient's arms should be crossed over the chest with the hands placed on the shoulders.

4) Demonstrate and have the patient do rotation movements. Emphasize the importance of smooth steady movements that go to end range.

5) Place the Rotation/Lateral Flexion Unit so the unit's feet are in line with T12. Hold the center of the unit firmly against the patient's back and zero the magnetic meter. Place the thumbs over the back of the unit's feet and grasp the rib cage with the fingers. Check that the meter is still zero.

6) Have the patient slowly turn the shoulders to the right making sure they go to full range. Record the reading (Typical Value is 10 degrees).

7) Have the patient slowly turn the shoulders to the left making sure they go to full range. Record the reading.

8) Repeat steps 5 & 6. If readings are within 2 degrees of the respective readings in steps 5 & 6 record the higher reading. If not repeat steps 5 & 6.

Thoracic/lumbar rotation can be measured by leaving the magnetic reference on the sacrum and placing the Rotation/Lateral Flexion Unit at T1. To measure only thoracic rotation the belt should be moved up so the magnetic reference can be placed on T12 and the meter unit should be placed at T1.

Lateral Flexion Measurements

The meter unit is designed so when the examiner grasps the rib cage the unit becomes a part of the patient, thus eliminating tracking errors. The protocol eliminates unwanted hip rotation and flexion.

1) Demonstrate and have the patient do lateral flexion movements. Emphasize the importance of smooth steady movements that go to end range.

2) Have the patient stand erect with nose nearly touching the wall. This position will keep the patient from bending forward during lateral flexion measurements.

3) Place the Rotation/Lateral Flexion Unit so the unit's feet are in line with T12. Place the thumbs over the back of the unit's feet and grasp the rib cage with the fingers. Adjust the unit's position on the back until the inclinometer reads zero.

4) For right lateral flexion have the patient slide their right hand down the back of their leg with the body weight shifted to the left foot and keeping the legs straight. Record the reading (Typical Value is 25 degrees).

5) For left lateral flexion have the patient slide the left hand down the back of the leg with the body weight shifted to the right foot and keeping the legs straight. Record the reading (Typical Value is 25 degrees).

6) Repeat steps 4 & 5. If readings are within 2 degrees of the respective readings in steps 4 & 5 record the higher reading. If not repeat steps 4 & 5.

Thoracic/Lumbar Lateral Flexion can be measured by placing the Rotation/Lateral Flexion Unit at T1.

Appendix I

CROM Procedure Manual

Procedure for Measuring Neck Motion with the CROM

CROM (Cervical Range of Motion Instrument) is a product of:

Performance Attainment Associates
3600 Labore Road, Suite 6
St. Paul, MN 55110-4144

Pain and loss of motion in the cervical region are common problems that increase with age. Over 40 million adult Americans suffer from some form of osteoarthritis or degenerative joint disease, and 50 to 85 percent of these people will experience debilitating back or neck pain of a temporary or chronic nature.

Accurate measurement of cervical motion during the course of a therapeutic regime can provide objective data on the benefits of the selected treatment. However, currently available measurement devices are time consuming, cumbersome, poorly standardized and poorly accepted by practitioners. In response to this lack of a acceptable means of measurement, existing devices were evaluated and the following design criteria established:

- easily applied
- measures all planes of motion
- comfortable
- time efficient
- easily adjusted
- quickly read
- standardized landmarks and positioning
- standardized protocol
- reproducibility
- simple design
- reasonable cost

Based on these criteria, the CROM instrument, accessories and protocol were developed. The CROM accurately and quickly measures the range of sagittal, coronal and horizontal movements that can be performed by the head and neck.

To perform and document accurate cervical measurements you will need the following items:

- CROM Instrument, including the rotation arm and the forward head arm
- magnetic yoke
- vertebra locator
- tape measure
- recording sheets
- procedure manual

Cervical Flexion and Extension

Instruct the subject to sit erect in a straight-back chair with the sacrum against the back of the chair, the thoracic spine away from the back of the chair, arms hanging at sides and feet flat on the floor. Next, instruct the subject to position the CROM instrument as if putting on a pair of glasses. Fasten the velcro straps snuggly in line with the bows. You will not need the magnetic yoke, rotation arm, forward head arm or vertebra locator for these measurements.

To assure full flexion in this multi-joint area, first instruct the subject to "nod your head to make a double chin" (suboccipital flexion). Then encourage the subject to flex further until full cervical flexion is obtained (see figure 6). To take the reading on the sagittal plane meter, read through the meter's beveled edge; from this angle the pointer will be magnified to the dial edge. Record this measurement in the appropriate space on the recording sheet.

Figure 6: Cervical flexion

To measure cervical extension, first instruct the subject to "nod your head back" (suboccipital extension). Then have the subject extend further until full extension is achieved (see figure 7). Record this measurement also.

Figure 7: Cervical extension

Lateral Flexion

Instruct the subject to sit erect in a straight-back chair with the sacrum against the back of the chair, the thoracic spine away from the back of the chair, arms hanging at sides and feet flat on the floor. Note: to eliminate rotation during lateral flexion the subject should focus on a point on a wall straight ahead. The sagittal plane meter will read zero if the subject is looking straight ahead. The lateral flexion meter will also read zero if the head is not laterally flexed. If the lateral flexion meter does not read zero, record the reading as lateral flexion at rest. You will not need the magnetic yoke, rotation arm, forward head arm nor vertebra locator for these measurements.

Instruct the subject to flex the head laterally to the left, keeping the shoulders level and without rotating the head (see figure 8). Monitor for shoulder elevation by lightly placing your hand on the right shoulder, and correct manually any head motion outside the coronal plane. Note and record the measurement from the lateral flexion meter.

Figure 8: Left lateral flexion

Now instruct the subject to flex the head laterally to the right, again keeping the shoulders level without rotating the head (see figure 9). As before, monitor for left shoulder elevation and correct head motion.

Figure 9: Right lateral flexion

Rotation

You will need to use the CROM instrument plus the magnetic yoke and rotation arm for these measurements. To obtain an accurate rotation measurement, first determine which direction is north.*

Next, place the magetic yoke on the subject's shoulders with the arrow pointing north (see figure 10). Instruct the subject to sit erect in a straight-back chair with the sacrum against the back of the chair, the thoracic spine away from the back of the chair, arms hanging at sides and feet flat on the floor. The lateral flexion and sagittal plane meters must read zero for the rotation meter to be level; if necessary, assist the subject into the correct position. As the subject faces straight ahead, grasp the rotation meter between your thumb and index finger and turn the meter until one of the pointers is at zero.

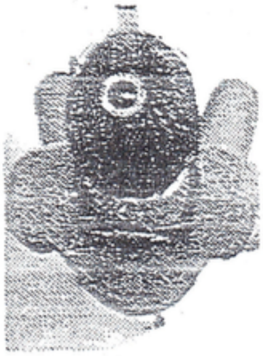


Figure 10: Magnetic yoke pointing north

Instruct the subject to focus on a horizontal line on the wall so the head is not tipped during rotation. Have the subject turn the head as far to the left as possible (see figure 11), and to ensure that no shoulder rotation occurs, lightly stabilize the right shoulder with your hand. (Note: if the head and shoulders are rotated together the pointer will not move because the magnetic yoke positioned on the shoulders eliminates shoulder substitution.) Record this measurement in the appropriate place on the recording sheet.

Figure 11: Left rotation

While you lightly stabilize the left shoulder, instruct the subject to turn the head as far as possible to the right (see figure 12). Record this measurement also.

*You can find magnetic (map) north by noting the direction of the red needle on the rotation meter when it is at least four feet from the magnetic yoke.

Appendix J

CHIROPRACTIC PROGRAMME

CHIROPRACTIC DAY CLINIC
CASE HISTORY

Patient: ________________ Date: ________

File #: ________ Age: ________

Sex: ______ Occupation: ________________

Student: ________________ Signature ____________

FOR CLINICIANS USE ONLY:

Initial visit

Clinician: Signature:

Case History:

Examination:

Previous: Current:

X-Ray Studies:

Previous: Current:

Clinical Path. lab:

Previous: Current:

CASE STATUS:

PTT: Signature: Date:

CONDITIONAL:

Reason for Conditional:

Signature: Date:

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

Case Summary signed off: Date:

<u>Student's Case History:</u>

1. Source of History:

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

3. Present Illness:

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

4. Other Complaints:

5. Past Medical History:

General Health Status

Childhood Illnesses

Adult Illnesses

Psychiatric Illnesses

Accidents/Injuries

Surgery

Hospitalizations

6. Current health status and life-style:

Allergies

Immunizations

Screening Tests incl. x-rays

Environmental Hazards (Home, School, Work)

Exercise and Leisure

Sleep Patterns

Diet

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

Tobacco
Alcohol
Social Drugs

7. Immediate Family Medical History:

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

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

8. Psychosocial history:

Home Situation and daily life
Important experiences
Religious Beliefs

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

General

Skin

Head

Eyes

Ears

Nose/Sinuses

Mouth/Throat

Neck

Breasts

Respiratory

Cardiac

Gastro-intestinal

Urinary

Genital

Vascular

Musculoskeletal

Neurologic

Haematological

Endocrine

Psychiatric

Appendix K

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:**		

Appendix L

DUT DURBAN UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CHIROPRACTIC AND SOMATOLOGY

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION – CERVICAL SPINE

Patient: .... File No: ....

Date: .... Student: ....

Clinician: .... Sign: ....

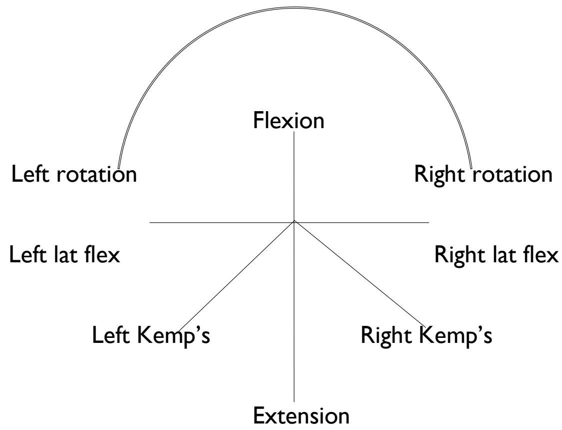
OBSERVATION:

Posture
Swellings
Scars, discolouration
Hair line
Body and soft tissue contours

Shoulder position
Left:
Right:
Shoulder dominance (hand):
Facial expression:

RANGE OF MOTION:

Extension (70°):
L/R Rotation (70°):
L/R Lat flex (45°):
Flexion (45°):



PALPATION:

Lymph nodes
Thyroid Gland
Trachea

MYOFASCIAL ASSESSMENT

Tenderness		Right	Left
Trigger Points:	SCM		
	Scalenii		
	Post Cervicals		
	Trapezius		
	Lev scapular		

ORTHOPAEDIC EXAMINATION:

	Right	Left		Right	Left
Adson's test			Halstead's test		
Brachial plexus test			Hyper-abduction test		
Cervical compression			Kemp's test		
Cervical distraction			Lateral compression		
Costoclavicular test			Lhermitte's sign		
Dizziness rotation test			Shoulder abduction test		
Doorbell sign			Shoulder compression test		
Eden's test					

NEUROLOGICAL EXAMINATION:

Dermatones	**Left**	**Right**	**Myotomes**	**Left**	**Right**	**Reflexes**	**Left**	**Right**
C2			C1			C5		
C3			C2			C6		
C4			C3			C7		
C5			C4					
C6			C5					
C7			C6					
C8			C7					
T1			C8					
			T1					

Cerebellar tests:	Left	Right
Dysdiadochokinesis		

VASCULAR:	**Left**	**Right**		**Left**	**Right**
Blood pressure			Subclavian arts.		
Carotid arts.			Wallenberg's test		

MOTION PALPATION & JOINT PLAY:

Left: Motion Palpation:
Joint Play:

Right: Motion Palpation:
Joint Play:

BASIC EXAM: SHOULDER:

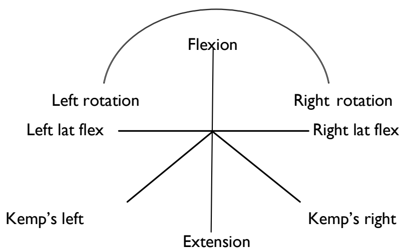
Case History:

ROM: Active:
Passive:
RIM:
Orthopaedic:
Neuro:
Vascular:

BASIC EXAM: THORACIC SPINE:

Case History:

ROM:



Motion Palpation:	
Orthopaedic:	
Neuro:	
Vascular:	
Observ/Palpation:	
Joint Play:	

Appendix M

THORACIC SPINE REGIONAL EXAMINATION

Patient:_______________________________________File:___________ Date:__________________________

Student:_______________________________________Signature:_______________________________________

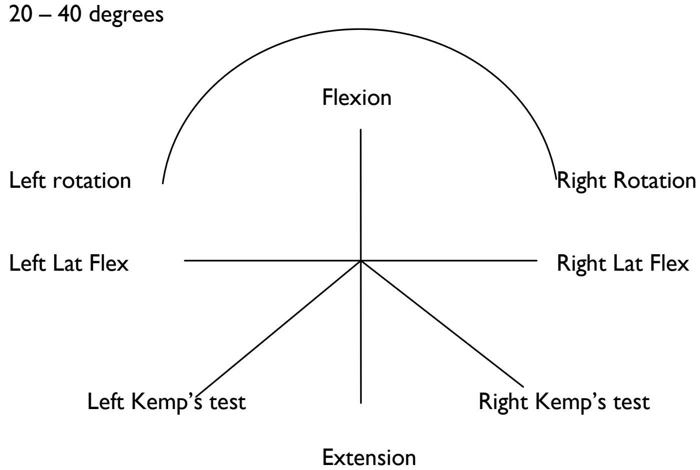
Clinician: _____________________________________Signature:_______________________________________

STANDING:

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

RANGE OF MOTION:

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



RESISTED ISOMETRIC MOVEMENTS: (in neutral)

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

SEATED:

Palpate Auxillary Lymph Nodes
Palpate Ant/Post Chest Wall
Costo vertebral Expansion (3 – 7cm diff. at 4th intercostal space)
Slump Test (Dural Stretch Test): LOCAL PAIN (T/S) DISTAL PAIN (L/S) DISTAL PAIN (LEG)

SUPINE:

Rib Motion (Costo Chondral joints)
Soto Hall Test (#, Sprains)
SLR
Palpate abdomen

PRONE:

Passive Scapular Approximation
Facet Joint Challenge
Vertebral Pressure (P-A central unilateral, transverse)
Active myofascial trigger points:

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

COMMENTS:____

NEUROLOGICAL EXAMINATION:

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

Basic LOWER LIMB neuro:

Myotomes	T11	T12	L1	L2	L3	L4	L5	S1	S2	S3
Dermatomes	T11	T12	L1	L2	L3	L4	L5	S1	S2	S3
Reflexes	Patella – Left					Achilles – Left				
	Patella - Right					Achilles – Right				

MOTION PALPATION:

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

BASIC EXAM	History	ROM	Neuro/Ortho
LUMBAR			
CERVICAL			

Appendix N

CHIROPRACTIC PROGRAMME

REGIONAL EXAMINATION
LUMBAR SPINE AND PELVIS

Patient: ________________________________ File#: ______________ Date: _________

Student: ________________________________ Clinician:______________________________

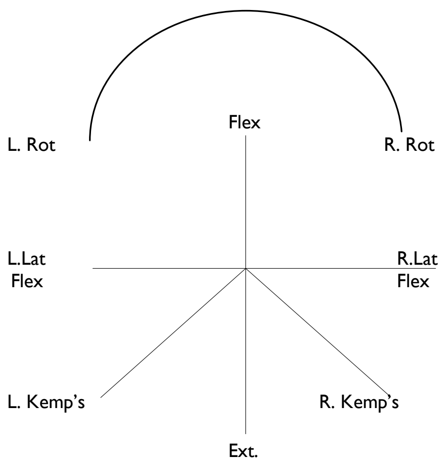
STANDING:

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

SLUMP 7 TEST	L										
	R										

LATERAL RECUMBENT:

	L	R
Ober's		
Femoral n. stretch		
SI Compression		

PRONE:

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

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

NON ORGANIC SIGNS:

Pin point pain
Trunk rotation
Flip Test
Ankle dorsiflexion test

Axial compression
Burn's Bench test
Hoover's test
Repeat Pin point test

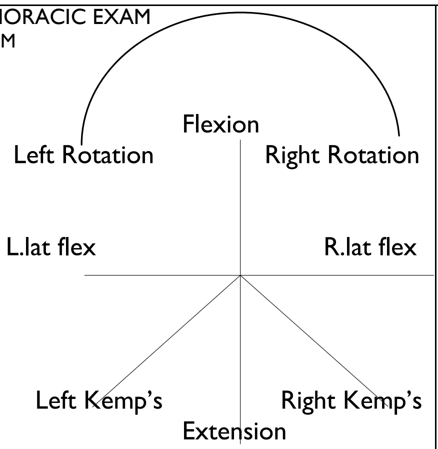
NEUROLOGICAL EXAMINATION

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

MYOTOMES

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

BASIC THORACIC EXAM
Passive ROM



History :

Orthopedic assessment:

BASIC HIP EXAM

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

B) Supine (hip flexed):
- Trochanteric bursa

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

Appendix O

Warm up routine for field hockey

Below is the stretching/warm up guide for field hockey players according to www.sport-spine.com. It incluc dynamic and static stretching.

The warm up program shown below will take about 10 minutes to complete.

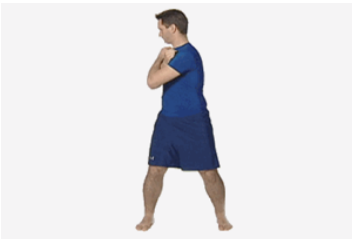
• Warm up jog around the field (2min)

• Arm Swings (10-15 times)

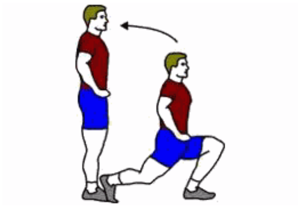
• Leg Swings Forward and Back (10-15 times)

• Leg Swings Sideways (10-15 times)

• Back Rotation Stretch: (10-15 times)



• Lunges (10-15 times)



• Leg Curls (10-15 times)

Static Stretches (described according to the methods by Travell and Simons (1993a and 1993b)

A seated self-stretch for the hamstrings (2x 30 seconds). Performed by slowly and gently sliding the fingers down the shins, keeping the knees straight. Post isometric relaxation combined with deep breathing enhanced relaxation in the hamstrings.

A prone self-stretch for the quadriceps (30 seconds each side). The subject lies on the opposite side to the side being stretched, and uses their hand to hold the ankle and slowly bring the heel against the buttock to flex the knee fully while maintaining and then increasing extension of the thigh at the hip by also pulling the knee and thigh posteriorly.

A seated stretch for the adductor muscles (2x 30 seconds). The legs are bent at the knees and the soles of the feet brought together. The subject then pushes down on the knees with their elbows to cause an increased stretch on the adductor muscles.

A supine self-stretch for the quadratus lumborum (30 seconds each side). The starting position for this stretch is supine, with the hips and knees bent. The hands are placed behind the head to elevate the rib cage. The controlling left leg is crossed over the right thigh (the side to be stretched). After the right thigh is adducted as far as possible without resistance, during slow deep inhalation, the left leg is used to resist a gentle isometric abductive effort of the right thigh. The subject then slowly exhaled and relaxed the right side. The same procedure is then performed to stretch the left side.

A standing stretch for the gastrocnemius and soleus muscles (30 seconds each side). The subject leans forward into a stride stance and places his outstretched hands against the wall. One leg at a time the heel of the back leg is slowly pushed towards the floor.

Appendix P

DUT DURBAN UNIVERSITY OF TECHNOLOGY

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

P O Box 1334, Durban, South Africa, 4001

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

www.dut.ac.za

5 March 2014

IREC Reference Number: **REC 5/14**

Mr M Wiggett
Flat 35 Riebeck
208 Cowey Road
Morningside
Durban
4001

Dear Mr Wiggett

The immediate effect of spinal manipulative therapy on drag flicking performance of hockey players

I am pleased to inform you that Full Approval has been granted to your proposal REC 5/14.

The Proposal has been allocated the following Ethical Clearance number IREC 016/14. Please use this number in all communication with this office.

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

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

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

Yours Sincerely

[redacted]

Prof J K Adam
Chairperson: IREC