THE EFFECT OF DEEP NECK FLEXOR MUSCLE ENDURANCE AND STABILITY ON THE SPRINTING TECHNIQUE OF YOUNG SPRINTERS AT THE UNIVERSITY OF THE WESTERN CAPE ATHLETICS CLUB

Student:
Andrea Anders
2632386

A thesis submitted in fulfilment for the Master’s degree in Physiotherapy at the Department of Physiotherapy,
The University of the Western Cape

November 2012

Supervisor:
Prof. J. M. Frantz
KEY WORDS

Deep neck flexors
Sprinting
Sprinting technique
Step length
Step Frequency
Contact time
Postural stability
Velocity

ABBREVIATIONS

DNI   Disability Neck Index
CCFT  Craniocervical Flexion Test
SPSS  Statistical Package for the Social Sciences
ABSTRACT

Sprinting can be described as the ability to cover a short distance in the fastest possible time. It requires enormous stability, strength and speed to achieve this goal. Any improvements in technique or speed can be the difference between winning and losing and ultimately gold or silver. Many coaches focus their training on improving the mechanics of the lower limb in order to achieve their goal. They often neglect to consider the effect the upper limb, head, neck and trunk has on the sprinters technique. This study aimed to determine the effect the muscles that assist in stabilising the head and neck namely the deep neck flexors, has on sprinting technique. A systematic review was conducted to determine the factors that influence the acquisition of the correct and most efficient sprint technique. Thereafter assessments were done to determine the prevalence of neck discomfort and how it impacts the athlete’s life by use of the Disability Neck Index. In addition, the endurance of the participant’s deep neck flexors using the Craniocervical Flexion Test and an analysis of their sprinting technique through video analysis were conducted. Variables for each assessment were coded and analysed with Chi-squared tests to determine statistically significant relationships. Results show that there was to prevalence of neck pain among participants and although the participants have poor deep neck flexor endurance and an inadequate sprinting technique, no statistically significant relationships could be found between these two variables. Thus poor endurance in the deep neck flexors has no effect on sprinting technique. The results of the study was limited due to a small sample size and lack of equipment, thus further research is required in order to completely reject the possibility that the deep neck flexors effects a sprinters ability to acquire an efficient sprinting technique.
DECLARATION

I declare that “The effect of deep neck flexor muscle endurance and stability on the sprinting technique of young sprinters at The University of the Western Cape Athletics Club” is my own work, that it has not been submitted to any other university for any examination and that all the sources used in the study has been referenced and acknowledge in a complete reference list.

Andrea Anders

November 2012
DEDICATION

I dedicate my thesis to my parents, Ruth and Robert Anders, who have supported and motivated me to do the best that I can in all areas of my life and therefore I would like to thank them.
I would like to thank my supervisor, Professor José Frantz, for the advice, continuous guidance and pushing me to finish.

To Mr Barry Andrews, thank you sincerely for all the assistance in setting up and analysing my data; without your guidance I would not be able to complete my thesis.

I would also like to thank Dr Smith for the statistical guidance and assisting me in making sense of all the random numbers.

I would like to thank Hayley Jacobs for encouraging me to keep working and going through this process with me.

Lastly, I want to thank my parents, my siblings and Bradley for all their support and love throughout my studies.
CONTENTS PAGE

TITLE i
KEY WORDS ii
ABBREVIATIONS ii
ABSTRACT iii
DECLARATION iv
DEDICATION v
ACKNOWLEDGEMENTS vi
TABLE OF CONTENTS vii
LIST OF APPENDICES x
LIST OF FIGURES xi
LIST OF TABLES xi

CHAPTER 1: INTRODUCTION
1.1 INTRODUCTION 1
1.2 BACKGROUND 1
1.3 PROBLEM STATEMENT 6
1.4 RESEARCH QUESTION 7
1.5 AIM 7
1.6 OBJECTIVES 7
1.7 SIGNIFICANCE OF THE STUDY 8
1.8 DEFINITION OF TERMS 8
1.9 CHAPTER OUTLINES 10
CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION 12

2.2 THE DEEP NECK FLEXORS AND POSTURAL CONTROL 12

2.3 SPRINTING TECHNIQUE 14

2.3.1 THE ROLE OF THE HEAD AND NECK IN SPRINTING 16

2.3.2 THE ROLE OF THE ARMS IN SPRINTING 17

2.3.3 THE ROLE OF THE FOOT AND ANKLE IN SPRINTING 18

2.3.4 THE ROLE OF THE TRUNK AND THE PELVIS IN SPRINTING 18

2.4 STEP LENGTH 19

2.5 STEP FREQUENCY 20

2.6 ASSESSING THE DEEP NECK FLEXORS 20

2.7 EVALUATING SPRINTING TECHNIQUE 21

2.8 CONCLUSION OF LITERATURE 21

2.9 SYSTEMATIC REVIEW

2.9.1 INTRODUCTION 22

2.9.2 AIM OF REVIEW 23

2.9.3 METHODS OF REVIEW

2.9.3.1. SEARCH STRATEGY 23

2.9.3.2. INCLUSION EXCLUSION CRITERIA 24

2.9.3.3. METHODOLOGICAL APPRAISAL 24

2.9.3.4. DATA SELECTION 25

2.9.3.5. DATA EXTRACTION 26

2.9.4 RESULTS 31

2.9.4.1. VELOCITY 31

2.9.4.2. STEP LENGTH AND STEP FREQUENCY 32

2.9.4.3. GROUND REACTION FORCES, CONTACT AND AERIAL TIMES 32

2.9.4.4. STABILITY 33

2.9.5 DISCUSSION 34

2.9.5.1 CONTACT TIMES 34

2.9.5.2 GROUND REACTION FORCES 35

2.9.5.3 STEP LENGTH AND FREQUENCY 36

2.9.5.4 POSTURAL STABILITY 37

2.9.6 CONCLUSION 37
CHAPTER 3: METHODS

3.1 INTRODUCTION 38
3.2 RESEARCH SETTING 38
3.3 STUDY POPULATION AND SAMPLE 38
3.4 STUDY DESIGN 39
3.5 DATA COLLECTION AND INSTRUMENT 39
3.5.1 STAGE 1 - SYSTEMATIC REVIEW 40
3.5.2 STAGE 2 - DISABILITY NECK INDEX 40
   - CRANIOCERVICAL FLEXION TEST 42
   - SPRINTING TECHNIQUE 45
3.6 PROCEDURE:
   3.6.1 STAGE 1 48
   3.6.2 STAGE 2 48
3.7 STATISTICAL ANALYSIS 49
3.8 ETHICAL CONSIDERATIONS 50
3.9 LIMITATIONS TO THE STUDY 51

CHAPTER 4: RESULTS

4.1 INTRODUCTION 52
4.2 DEMOGRAPHICS 52
4.3 DISABILITY NECK INDEX 53
4.4 CRANIOCERVICAL FLEXION TEST 53
4.5 SPRINTING TECHNIQUE 54
4.6 INDIVIDUAL STATISTICS 58
   4.6.1 GENDER AND VARIOUS ASSESSMENTS 60
   4.6.2 DNI AND VARIOUS ASSESSMENTS 61
   4.6.3 CCFT AND SPRINTING TECHNIQUE 61
4.7 CONCLUSION 62

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION 63
5.2 FACTORS THAT INFLUENCE SPRINTING TECHNIQUE 63
5.3 NECK DISCOMFORT AMONG SPRINTERS 64
5.4 DEEP NECK FLEXOR ENDURANCE AND STABILITY 65
5.5 SPRINTING TECHNIQUE 66
5.6 THE RELATIONSHIP BETWEEN DEEP NECK FLEXOR FUNCTIONING AND SPRINTING 68
5.7 CONCLUSION 69

CHAPTER 6: CONCLUSION
6.1 INTRODUCTION 70
6.2 SUMMARY 70
6.3 CONCLUSIONS 71
6.4 LIMITATIONS 72
6.5 RECOMMENDATIONS 73

REFERENCES 74
EDITORS LETTER 114
TURNITIN REPORT 115

LIST OF APPENDICES
Appendix 1: Stanford University Critical Appraisal tool 84
Appendix 2: CASP tool 97
Appendix 3: Disability Neck Index 101
Appendix 4: Craniocervical Flexion Test Score sheet 103
Appendix 5: Information Sheet 104
Appendix 6: Consent form 106
Appendix 7: Letter to the Coach 107
Appendix 8: Ethical Approval 108
Appendix 9: Systematic review protocol 109

LIST OF FIGURES
Figure 1: Demonstration of the placement of the stickers to identify the joint during the sprint 46
LIST OF TABLES

Table 2.1: Types of studies included in the systematic review. 25
Table 2.2: Articles included in the review 27
Table 3.1: Scoring for Disability Neck Index 42
Table 3.2: Code assigned to percentage range for CCFT 45
Table 3.3: Amount of head movement during the maximum velocity phase 48
Table 4.1: Demographics of the participants 52
Table 4.2: Results of DNI for each participant 53
Table 4.3: The percentage of participants that achieved each level of the CCFT 54
Table 4.4: The average stride length per step during maximum velocity phase 55
Table 4.5: The average speed per step 56
Table 4.6: The angle of the head at first contact 57
Table 4.7: Code assigned to change in head position 58
Table 4.8: The DNI, CCFT and sprinting technique for each participant 60
CHAPTER 1
INTRODUCTION

1.1 INTRODUCTION
The following chapter focuses on introducing the topic of the research study. The chapter gives detailed background information regarding the importance the research question has in the physiotherapy field. Descriptions of the study’s aims and objectives are included. The significance of this study is for physiotherapists to educate athletes and coaches with regard to injury prevention by improving the technique of the individual based on the goal of the event. Therapists have the necessary skills needed to identify and correct impairments that may exist. The chapter is concluded with a definition of terms used in the study along with an outline of all the chapters that follows.

1.2 BACKGROUND
Athletics, also known as track and field, is a sport that consists of various events such as running, jumping and throwing. It started in ancient Greece as a part of religious festivals. The modern form of the sport was made popular in England in the 19th century when the universities competed against one another in the various events (Columbia University Press, 2007). The most popular event of the track and field is the 100 meter sprint. It originally started as a 100 yard dash before the metric system came into effect when it then changed to the 100 meter (m) sprint. With sprinting, before the modern day start, athletes started from a standing position until one particular athlete, Charles Sherrill, began in a crouched position by digging holes in the grass track. In 1937 The International Amateur Athletics Federation (IAAF)
officially authorized the use of starting blocks, it is now a requirement of all professional short distance (100 – 400 m) athletes to use standardized starting block during an event (IAAF, 2002). Sprinting can be described as an activity where the goal is to cover a short distance in the fastest possible time. Milliseconds can separate an athlete from achieving greatness, it is the difference between winning and losing, gold or silver and can determine whether you hold the world record or not. It can therefore be said any advantage an athlete can gain in improving their performance can impact enormously on their success (Cissik, n. d.).

Sprinting is divided into three (3) phases, the acceleration phase which begins in the blocks and can also be called the driving phase, the maximal velocity phase where the athlete is at their top speed with the body erect and lastly the deceleration phase which occurs at the end of the race as the athlete crosses the line (Faccioni, n.d.). The acceleration phase begins with the athlete in the starting blocks, which are set to the athletes preference and is adapted from a basic start posture. The sprinter must feel comfortable in the blocks; otherwise it could negatively influence the race. This basic starting posture is as follows: the front leg, the hip is at slightly less than full flexion with the knee in about 100° flexion and the ankle plantar flexed; the rear leg, the hip is in slightly more than 90° with the knee resting on the ground and ankle in slight dorsiflexion; both feet are resting against the starting blocks; the shoulders are in 90° flexion; elbows in full extension; the hands are resting directly behind the starting line; the neck should be in neutral and relaxed with the face down looking at the ground. At the set position before the starting gun is shot both knees extend to 90° and the shoulders extend slightly to bring the athletes weight forward, the shoulders should now be slightly in front of the hands. As the athlete leaves the
blocks the rear knee extends fully with the hip extending to 45° of flexion, as the rear leg begins the swing cycle the hip and knee flexes while the front leg moves into full hip and knee extension; the arm on the same side as the front leg moves into flexion past the athlete’s head with the elbow relaxed at approximately 90°. The arm on the side of the back leg moves into shoulder extension, again with the elbow relaxed at approximately 90°. The head and neck remain neutral, no extension, flexion, rotation or side flexion occurs. During the first 20 meters the athlete drives the body forward, for the period the athlete remains low but gradually begins to decrease the amount of body lean as they reach their top speed, the head must remain relaxed with the neck in neutral at all times. A deviation in the position of the head can hamper the athletes’ ability to drive with their arms (Sporting Excellence Ltd, n.d.). It is therefore important to understand the components of the position.

During the maximal velocity phase of the sprint, the athlete is at their top speed which is normally between the 30 to 90 marks. The forefoot provides the point for initial contact; this phase requires the most amount of dynamic balance during the sprint. Only the forefoot makes contact with the ground therefore there is a reduction in the base of support during the stance phase of the sprint, when compared to walking and jogging. This means that there are great neuromuscular and musculoskeletal balance demands with sprinting. The head remains facing forward throughout the sprint to ensure optimal dynamic balance while running (Novacheck, 1998).
As top speed is reached, the athlete extends to approximately $5^\circ$ forward lean of the trunk, in relation to the ground. The leading leg comes forward with the hip moving into $90^\circ$ flexion with the knee reaches a maximum of $127^\circ$ flexion and the ankle is in full dorsiflexion. The shoulder on the same side as the leading leg is in full extension with the elbow at $90^\circ$, the head and neck remain in an anatomically neutral position throughout the race. The foot is then brought down rapidly by extending the hip and knee. As the ball of the foot (forefoot) makes contact with the ground the ankle plantar flexes. At foot strike the hip is in about $10^\circ$ flexion with the knee in extension this is the stance phase, during this phase the shoulder is in neutral with the elbow at $90^\circ$. The hip then continues to extend as the body is brought forward. At push off the hip and knee is fully extended, as the foot leaves the ground, the hip and knee begins to flex. With the hip in extension the shoulder moves into $90^\circ$ of flexion (Adrian, 2011).

The correct technique is essential for all athletes to master, this is important because it allows the sprinter to break their own speed barrier and thus improve their performance by running more efficiently. By adopting the correct technique an athlete can also minimize the risk of injury. With incorrect technique a sprinter can slow down their maximum speed by allowing brake forces to occur and tensing the face and neck muscles when fatigue sets in. It is thus important for an athlete to relax the upper body, namely the head, neck and shoulders, to limit the amount of energy consumption and thus providing the lower body with more energy thereby delaying fatigue and allowing the athlete to maintain their maximum speed for a longer period (Adrian, 2011).
The position of the head and neck affects the athlete’s sprinting ability by affecting their running economy. Researchers claim that forward lean or a crouched over position decreases the athlete’s running economy therefore athletes that run with their head in extension increase their energy consumption and decreases their ability to generate optimal speed (Eston & Reilly, 1996). The position of the head also influences the athlete’s sprinting ability with regards to their breathing. An abnormal head position negatively influences the athlete performance by increasing the work of breathing (Miller, 2011). When the neck is put in extension, by raising the chin, the body compensates by creating an increase in the lordosis of the lumbar spine. This places the pelvis in an anterior pelvic tilt limiting hip flexion therefore resulting in a decrease in the stride length of the athlete (Williams, n. d.).

In order for the head and neck to remain neutral or in a stationary position during sprinting, it is essential that the muscles that act on the head and neck remain relaxed. Tension in the muscles that control the movement of the jaw, called the hyoid muscles, causes tension to occur in the muscles on the posterior surface on the head and neck. These muscles extend the head and neck, increased tension in these muscles causing a shortening in the muscle length thus producing a forward head posture. In order to compensate for this position and stabilize the head in this posture, the sternocleidomastoid and upper trapezius activates and contracts so that balance can be restored. The forward head posture and excessive activity in the sternocleidomastoid and upper trapezius muscles means that the muscles that stabilize the head and flexes the upper part of the neck are put under strain as they need to work extremely hard to counteract the position the head is in, these muscles are known as the deep neck flexors (Ayub, Glasheen-Wray & Kraus; 1984).
If the deep neck flexors are not strong enough to counteract the position the head is in, it creates tension in other muscles groups such as the muscles that act on the shoulder girdle in order to maintain balance and stability. The deep neck flexors (DNF) are an important muscle group in the maintenance of a stable head and neck and dynamic balance (Armstrong, McNair & Taylor, 2008). Many training programmes, coaches and guides focus on lower limb training and exclude anything on the upper limb and neck. Based on the above mentioned literature we can hypothesize that an inhibition, weakness or poor stability of the deep neck flexor muscles can compromise optimal sprinting technique and therefore optimal performance could not be possible.

Cissik (n. d.) states that the driving action of the upper limb complex provides the athlete with the balance or stability needed to propel the body forward. The upper limb plays a very important role in propelling the body forward in the driving phase of sprinting. Hinrichs, Cavanagh and Williams (1987) found that the arms driving action is limited by excessive trunk rotation, the trunk rotates along with the head in order to counteract pelvic motion, thus reducing the amount of velocity generated in the lower limbs. It can therefore be concluded that minimal movement at the head and trunk can increase acceleration therefore improving an athlete’s performance.

1.3 PROBLEM STATEMENT

Impairments in endurance and/or stability within the deep neck flexors are not always evident due to compensation by other muscles. These possible impairments of the deep neck flexors (DNF) can be concealed by improving the strength and function of surrounding muscles such as the Sternocleidomastoid (Strimpakos,
A lack of research exists regarding the role of the head and neck during running and the effect that poor deep neck flexor functioning might have on sprinting. It is therefore important to look at all components of sprinting as well as to do a full assessment of the cervical spine to identify the possible contribution it could make to the sprinting technique.

1.4 RESEARCH QUESTION
Does endurance of the deep neck flexors influence sprint technique in short distance sprinters at club level in Cape Town?

1.5 AIM
To determine the effect deep neck flexor muscle endurance and stability has on the sprinting technique of young sprinters at the University of the Western Cape Athletics Club in Cape Town.

1.6 OBJECTIVES
1. To conduct a systematic review to determine the correct sprinting technique components and to identify the factors which influence it.
2. To determine the prevalence of neck discomfort among sprinters at the University of the Western Cape.
3. To determine the deep neck flexor muscle endurance of the sprinters at the University of the Western Cape.
4. To determine the sprint technique of selected sprinters
5. To determine the relationship between the deep neck flexors and sprinting technique.
1.7 SIGNIFICANCE OF THE STUDY
Many athletes are instructed by coaches on what the optimal sprinting technique is in order to improve performance. Many coaches focus on the lower limbs of the athlete and only touch on the activities of the upper limb. Control and stability of the head and neck are important for all gross motor function. Weakness in the deep neck flexors can result in a decrease in head control and balance. Problems with deep neck flexors can result in a Cervical Joint Position Error (JPE) an important concept when assessing ones proprioception. Due to the deep neck flexor’s role in postural control, it plays a major role in control of eye movement and static standing balance (Treleaven, Jull & LowChoy, 2006).

Physiotherapists play an important role in injury treatment and prevention in athletes. Physiotherapists can contribute in identifying problem areas in technique and therefore reduce the risk of injury. The correct sprint technique could minimize the occurrence of injury by minimizing the overuse of musculoskeletal components. If improving the stability and endurance of the deep neck flexors improves sprinting technique it can therefore improve performance as well as reduce the risk of injury.

1.8 DEFINITION OF TERMS

SPRINT PHASES

Drive phase: The phase of the sprint race when the athlete moves from the starting blocks to the first step (Joseph, 2005).

Acceleration phase: The phase of the sprint where the athlete generates momentum to reach their top speed, this starts from the first step out of the blocks until the
athlete is erect. This is the first 30-60m of the race, depending on the caliber of athlete (IAAF, 2009).

**Maximal velocity phase:** This is when the athlete is erect and at top speed, it is normally from the 30/60m to approximately the 90m mark (IAAF, 2009).

**Final stage:** Also known as the deceleration phase where the athlete crosses the finish line. This normal occurs in the last 10 m of the race (IAAF, 2009).

**Deep neck flexors:** Consists of the Longus Colli and Longus Capitis (Jull, O'Leary, & Falla, 2008) which originates from the transverse processes of C3-6 and inserts into the occipital bone. They both flex the head and neck (Seeley, Stephens & Tate, 2006).

**Flexion:** The act of bending the joint by bringing two bones together thereby decreasing the angle of the joint (Seeley, et al., 2006).

**Proprioception:** The ability of the body to sense the position, location and orientation of the limbs in space (Seeley, et al., 2006).

**Dynamic balance:** The capability of an individual to retain equilibrium while in motion (Mull, Bayless & Jamieson, 2005).

**Postural control:** The ability to maintain the correct posture while performing skilled tasks (Trew & Everette, 2005).
1.9. CHAPTER OUTLINE

CHAPTER 1: INTRODUCTION

This chapter provides background information about the purpose of the study. It highlights the main problem and describes the aims, objectives, significance of the study and concludes in important definitions and outlines the chapters that follow.

CHAPTER 2: LITERATURE

This chapter describes the literature used to validate the research question and aim of the study. The topics discussed include the role of the deep neck flexors, a detailed description of the sprinting technique and various methods of assessing the deep neck flexors and sprinting technique. The chapter is concluded with the main points found in the literature and highlights the significance it has on Physiotherapy.

CHAPTER 3: METHODS

This chapter describes the methods used to conduct the study. It includes the research setting, the sample population, the instruments used as well as the ethical considerations while conducting the research study.

CHAPTER 4: RESULTS

This chapter describes the findings of the study. The results of the study are presented by use of tables and statistical relationships between the Disability Neck Index, Craniocervical flexion test and sprinting technique. Statistical significant associations are indicated by the use of chi-square tests described in terms of p-value.
Chapter 5: Discussion

The discussion chapter explains all results in terms of the objectives identified in chapter one (1). It covers all variations in findings and relationships found between data. The chapter attempts to explain possible reasons for the results and how it corresponds to literature.

CHAPTER 6: CONCLUSION

This chapter summarizes all the important points found in the research study. It also covers the possible implications the study has on the population. Limitations of the study and recommendations for further research are made in this chapter.
CHAPTER 2
LITERATURE REVIEW

2.1 INTRODUCTION
The following chapter describes the literature used to rationalize the research study. The chapter includes topics such as the role the deep cervical flexors play in postural control, postural control and sprinting as well as a full description of the correct sprinting technique.

2.2 THE DEEP NECK FLEXORS AND POSTURAL CONTROL
The deep neck flexors contain receptors that are involved in postural control; pain or decreased control in this muscle group can cause impairment in the athlete’s sense of proprioception (Jorgensen, Skotte, Holterman, Sjogaard, Petersen & Sogaard, 2011). Postural control is achieved through interactions and input of the visual, vestibular and somatosensory systems (Trew & Everett, 2005). Information about the head’s position in space is relayed using the vestibular system via the ear. The visual system provides the individual with joint position sense by using the eyes to see the movement while the somatosensory system makes use of proprioception in order for the joint to judge its position in space (Trew & Everett, 2005).

Without input from the three systems described above postural control is not possible, this results in instability (Pendergrass, 2003). The neck contains large amounts of receptors within its musculature which relay postural control information to the central cortex, with the majority of these located within the deep cervical musculature. Thus it can be shown that damage or inhibition of these muscles
results in a decrease in postural control with regards to proprioception and oculomotor movements (Treleaven, Jull & Sterling; 2003) (Jull, Falla, Treleaven, Hodges & Vincenzino, 2006). The cervical facet joints contain nerve endings known as mechanoreceptors which respond to stimuli such as tension in the muscles or pressure being placed on the joints; injury to the joint negatively influences the body’s proprioception (Armstrong, McNair & Taylor, 2008). Falla, Jull and Hodges (2004) found that the deep neck flexors are primarily involved in maintaining the cervical curve during rapid upper limb movement, during injury there is a decrease in activity in the deep neck flexors and this leads to a poor sense of proprioception.

Proprioception is of utmost importance to all sprinters in order to maintain their balance and therefore optimize their technique. Without good proprioception of the neck and other joints in the body, the athlete must make use of excessive visual input to remain within the boundaries of their lanes. This is a conscious effort and takes the athlete’s concentration away from their goal. In terms of feedback throughout the race the central nervous system continually provides the athlete with input about the environment so that postural adjustment can be made where necessary - this is known as postural control. Without this control the athlete is unable to optimally perform their sprint race (Browne, 2010). It is important to maintain flexibility, strength and stability within the neck musculature to prevent the neck from becoming injured and stiff. According to Coachr880.com, as stated by Nelson and Kokkonen (2007), mentions that stiffness in the neck muscles results from maintaining static neck positions for prolonged periods. Therefore, stronger and more flexible muscles are able to maintain static positions longer, thereby reducing injury.
2.3 SPRINTING TECHNIQUE

It is important for a sprinter to have good balance and proprioception in order to optimize their technique and improve their performance. To facilitate optimal performance there are various biomechanical aspects to sprinting that need to be achieved. The neck, jaw and upper limbs need to be relaxed (i.e. no unnecessary muscle tension) with the head in neutral, the trunk/torso needs to lean forward relative to the ground approximately 5°, the knees need lift as high as possible in order to achieve the correct sprint stride based on the athlete’s height. It is important to note that the athlete’s foot placement must be slightly ahead of the center of gravity to prevent braking forces from occurring. Thus all of the above mentioned aspects are ultimately important to reduce the risk and occurrence of injuries by improving technique and performance (Cissk, n.d.).

An athlete begins a sprint in a bent over position with the arms in slight abduction, approximately 90° flexion of the shoulder with the hands resting behind the start line. Both feet are resting against the starting blocks; the back leg’s knee is in contact with the track. At ‘set’ the back leg lifts, bringing the athlete’s chest forward over the hands and shifting the center of gravity forward in preparation for propulsion. The acceleration phase starts when the arms are raised as the legs push against the blocks to propel the athlete forward across the start line; the back leg is brought forward as the athlete takes the first step. The legs and arms drive the body forward while maintaining a low body position (Doscher, 2009).
After the acceleration phase the sprinter reaches an upright stance where the head and neck remain in neutral with the eyes focusing on the finish line. The shoulders move through brisk flexion-extension, elbows relaxed at 90°, trunk flexed forward, hips and knees move from flexion in the swing phase to extension at toe-off in the stance phase. During sprinting, initial contact is made with the forefoot, the stance phase of sprinting ends once the forefoot moves into the swing phase with toe-off. This means that when sprinting is compared to walking, a greater degree of dynamic balance is required during stance phase. The need for dynamic balance increases due to a decrease in the base of support, a decrease in the amount of time spent in the stance phase and due to elevation of the center of gravity during this phase (Novacheck, 1998; Trew & Everett, 2005).

Trew and Everett (2005), states that with an increase in height of the center of gravity, a person becomes less stable. They also show that as an individual’s walking skill improves, their cadence improves. Cadence is the amount of steps taken within a minute. This also shows that with an increase in cadence there is a decrease in the amount of time spent in the stance phase. Novacheck (1998) states that studies have shown that sprinting stance phase is approximately between 22-39% of the gait cycle, compared to walking which is 70-50%. Optimal sprint technique requires forward flexion of the trunk at the level of the lower lumbar or hip region which lowers the center of gravity, therefore improving the sprinter’s stability. During sprinting it is imperative to minimize movement of the head and neck in order to achieve postural control; this is achieved through movement of the lumbar spine and the pelvis. The pelvis counteracts adduction during stance and abduction during swing phase of the hip joint. It remains in the neutral position to counteract the
difference in rotation between the upper limb and the lower limb. The lumbar spine, thereafter, counteracts the movements of the pelvis which limits movements of the upper body (Novacheck, 1998).

2.3.1 THE ROLE OF THE HEAD AND NECK IN SPRINTING

During the set position of the start athletes are required to maintain a straight spinal column. The head must be in line with the spine, with the neck in a relaxed position. This means the athlete must avoid looking up at the start line when in the starting blocks, as well as avoid maintaining a tucked in chin position (i.e. relaxed neck muscles no active contraction of the deep neck flexors). As the athlete drives out of the blocks during acceleration they are required to maintain a head down and relaxed position. When the athletes’ posture becomes more erect during the maximum velocity phase the head and neck are still line with the spine with eyes fixed on the finish line. During this phase the athlete needs to keep the head erect, with the chin level and the jaw should be relaxed. Various researchers have found a distinct relationship between the functioning of the jaw and the position of the head. Muscles involved in the functioning of the jaw include the hyoid muscle group, the masseter and the temporal muscles. An increase in extension of the upper cervical spine associated with weakness in the deep cervical flexors, results in a greater amount of muscle tension and increased activity in the hyoid muscles (Ayub, et al, 1984; Nicolakis, Erdogmus, Kopf, Piehslinger, Fialka-Moser., 2000).

Nicolakis, et al (2000) has shown that abnormal positions of the upper cervical spine can create an increase in tension in the muscles that close the jaw, namely the masseter and the temporal muscles. This relaxed position of the head and neck
assists in preventing injuries and allowing a more efficient race. With an unstable head and neck the head bobs around resulting in increased muscle activity in the sternocleidomastoid to minimize this instability and thus a greater deal of energy expenditure (The American Sport Education Programme, 2008).

The American Sport Education Programme (2008) describes how important it is to prevent the head and neck from working too much during the race as well as being tense as the athlete runs. They state that tight neck, face and upper limb musculature can result in a restriction of the hip and lower leg movement, thus slowing the athlete down during the maximal velocity phase.

2.3.2 THE ROLE OF THE ARMS IN SPRINTING

Many authors, researchers and coaches state that the arms are used to drive the lower limbs forward during the race. They are known to provide the body with a counteracting force to the leg drive in order to regain balance and create the momentum needed to drive the body forward (Dugan & Bhat., 2005; Harrison, 2010).

The arms are expected to remain relaxed while the shoulder joint moves through flexion and extension. This action becomes most important in the final stages of the race, as the athlete is about to cross the line. At this stage, when fatigue of the lower limbs sets in, the upper limbs provide the athlete with the drive needed to allow the legs to increase the stride length; the upper body is meant to remain relaxed to prevent tension from restricting the runner (Dintiman, Ward & Tellez., 2003).
2.3.3 THE ROLE OF THE FOOT AND ANKLE IN SPRINTING

During the stance phase of sprinting, at foot strike, the forefoot provides the point for initial contact which places the ankle in slight plantar flexion at that moment. The ankle moves into dorsiflexion immediately after initial contact. The ankle continues to dorsiflex throughout the swing phase. The action of the foot and ankle are affected by alignment of joints in the back and leg. If mal-alignment exists in other areas of the body it affects the balance of the individual and thus the foot must compensate for this. Thus, it is important to ensure optimal alignment and function of all the joints in the body to prevent the foot and ankle being over worked during the sprint when providing the athlete with sufficient proprioception and balance (Dugan, et al., 2005).

2.3.4 THE ROLE TRUNK AND PELVIS IN SPRINTING

In order for an athlete to increase the stride length when moving from the acceleration phase of the start to the maximum velocity phase, the trunk is required to extend (Chai, 2003). Thus the trunk must be erect relative to the rest of the body while leaning forward relative to the ground. This lean is required in order to displace the center of gravity during the race as well as to create a stretch reflex within the hamstring so that the athlete can conserve their energy. Some authors claim that the lean comes from the hip joint of the athlete (The American Sports Education Programme, 2008). The stride length for all short distance sprinters is supposed to be one third of their overall height. Once the length is increased beyond one third the athlete tends to step in front of the center of gravity therefore resulting in a reduction of speed due to the occurrence of braking forces. Braking forces can also be a result of instability which is caused by incorrect posture. By
minimizing braking forces and optimizing the stride length one can increase the maximum velocity thus decreasing the time it takes to cover the 100m and improve the athlete’s performance provided that they have the correct stride frequency. This is the amount of steps taken during the sprint (Young, n. d.).

2.4 STEP LENGTH

According to the IAAF (2009) one of the few indications to the efficiency of one’s sprinting performance is step or stride length. The step length lasts from the moment of initial contact from the leading leg, through the flight phase of the step and ends at initial contact of the opposite leg. On average an efficient 100m athlete has a stride length equating to approximately 1.14 times their height during the maximal velocity phase of the sprint. In South Africa the average male height is estimated to be 1.68 m and the average female height 1.59 m (South African Department of Health, 2003). Thus the average step length for a female sprinter is approximately 1.81m and the average male sprinters step length 1.92m. With a step length longer than 1.14 of a sprinters height, the athlete hampers their performance by applying what is known as brake forces to their velocity, due to an increase in contact time with the ground and a decrease in the athletes momentum. When the step length is too short the sprinter is unable to generate sufficient speed to complete the race in their shortest possible time (Tellez, n. d.; Young, n. d.). Step length is influenced by the amount of force the athlete exerts on the ground the stronger the athlete the greater amount of force and the more efficient the step length. Poor alignment and posture hampers the lower limbs ability to apply sufficient force to the ground in order to produce the correct step length (Dintiman, et al, 2003).
2.5 STEP FREQUENCY

Another determinant of sprint performance is the step frequency, the amount of step the athlete takes. A good male sprinter would take, on average, between 43 to 46 steps and a good female sprinter would take between 47 and 52 steps during the 100 m race. On average, a male sprinter will take four (4) steps between the 60 – 70 m marks. A female sprinter will take about five (5) steps. Step frequency is influenced by the athlete’s ability to complete a step cycle in the fastest amount of time. The sprinter’s average velocity during the race is a product of the optimal step length and step frequency (Dintiman, et al, 2003).

2.6 ASSESSING THE DEEP NECK FLEXORS

According to Strimpakos (2010), there are two clinically reliable tests that can be done to assess the endurance of the deep neck flexors. The first is the Craniocervical Flexion Test, which makes use of a biofeedback machine to assess the patient’s ability to contract and hold upper cervical flexion at various pressure readings. The second is the Conventional Cervical Flexion Test. This test is done with the patient in supine; the patient is required to perform upper cervical flexion, a chin tuck, and simultaneously raise the head off the bed. The difference between the two assessments is that the Craniocervical Flexion Test assesses the endurance of the deep neck flexors in isolation, whereas the Conventional Cervical Flexion test assesses the deep and superficial neck flexors together. It is important for any assessor to note the difference in the two assessments since the superficial neck flexors, the sternocleidomastoid and anterior scalenes, could conceal deficiency in the deep neck flexors (Strimpakos, 2010).
2.7 EVALUATING SPRINT TECHNIQUE

Evaluating kinematic aspects of an athlete’s sprinting technique is done using video analysis of the athlete (Satkunskiene & Rauktys, 2006). An athlete sprinting ability can also be assessed by assessing various components needed to acquire the correct sprinting technique. Researchers such as Kruger and Pienaar (2011), evaluated their participants step length, explosive muscle power, reaction time and velocity in order to evaluate their sprinting capability. Kilani (n. d.) evaluated sprinters technique by placing camera’s at various point along the track, 10 m away from the outside lane, in order to capture acceleration phase, maximum velocity phase and deceleration phase of the sprint.

2.8 CONCLUSION OF LITERATURE

The chapter highlights the possible role the deep neck flexors plan in the development and attainment of optimal sprinting technique. We found that the deep neck flexors impact an individual’s postural control mechanisms. Weakness in these muscles negatively affects the mechanisms resulting in increased activity in the anterior neck flexors. Tight, stiff neck muscles limits the sprinters ability to correctly utilize the upper limbs, causing a decrease in stability and limiting the attainment of sufficient stride length and permitting fatigue from setting in prematurely. This fatigue limits the athlete’s stride frequency, thus preventing the athlete from achieving optimal technique and ultimately hampering his/her performance. These aspects are important for Physiotherapist to note due to their role in injury prevention. Physiotherapists must be able to identify the correct sprinting technique and which factors influence the acquisition thereof because they have the necessary skill to address any shortcomings and thus, improve the technique and performance.
2.9.1 INTRODUCTION

Sprinting is a track event that requires an athlete to cover a required distance in the shortest amount of time possible. Research has highlighted that athletes have their own individual running or sprinting style, but has noted that there are key aspects that sprinters need to master in order to improve their performance by decreasing their time (Dintiman, et al, 2003). Thus all athletes are shown the basic technique at a young age in order for them to incorporate this technique into their sprinting style. This basic running style is important to master in order to not only improve performance, but to minimise the risk of injury when running (Dintiman, et al, 2003). For an athlete to improve their overall performance and reduce the risk of injury they must be aware of the three phases that exist during the sprint race and therefore master all three aspects so that they can achieve their optimal performance.

The race begins with a block start leading into the acceleration phase; it is required that all athletes start with starting blocks, therefore the athlete must become familiar with the blocks, the rules and the biomechanics of a sprint start. This is very important because the athlete must feel comfortable in the blocks and must be able to use them effectively. If an athlete is not comfortable within the blocks it hampers their ability to sprint at their best during the rest of the race (The American Sport Education Programme, 2008). The acceleration phase is where the athlete needs to
drive out of the blocks, gradually becoming erect and transitioning into the Maximum Velocity phase - this is where the athlete is at full speed.

Understanding correct sprinting technique and the factors that influences the athletes’ ability to achieve this is vital for both athletes and coaches. Correct technique allows all body systems that determine the individual’s ability to sprint function optimally in order for the individual to perform at the ideal level. The correct sprinting techniques also minimizes the overuse of joints and muscles when placed in the incorrect positions thus limiting injury and directly benefitting the athletes performance. Thus, in order for an athlete to perform at their best, a clear understanding of the correct posture and biomechanics involved with sprinting is essential for the athlete as well as the coach, so that he/she can guide the athlete (Williams, 2007).

2.9.2 AIM OF THE REVIEW

The aim of the systematic review was to determine what biomechanical factors influence the performance and sprinting technique of short distance sprinters.

2.9.3 METHODOLOGY

2.9.3.1 SEARCH STRATEGY

A comprehensive search was conducted in June – July 2011 using all appropriate databases accessible at The University of the Western Cape. The databases that were used in the review included EBSOCHOST, Science Direct, CINHAL plus, Med Scape, Pub Med. Various search strategies were used for each data base depending on their indexing terms and functions. The key words and terms used in
the search included biomechanics of sprinting, sprinting technique, running technique, sprinting and maximal velocity phase running.

2.9.3.2 INCLUSION EXCLUSION CRITERIA

All studies were examined using the title as well as the abstract in order to determine its suitability. Those included in the review were required to be written in or available in the English language. The population used in these studies was required to be short distance athletes, i.e. sprinters. The interventions involved in the studies focused on improving sprinting technique and/or performance. The focus of the outcomes in each study needed to be the biomechanical aspects that influence and determine inefficient sprinting technique. It was essential that the studies focus on the biomechanical aspects of sprinting technique. Articles that did not fit the above mentioned criteria were excluded from the review.

2.9.3.3 METHODOLOGICAL APPRAISAL

The methodological quality of the articles was assessed by two independent reviewers with an agreed upon criteria. The critical appraisal tool that was used in the systematic review to assess the methodological quality is a tool from Stanford University’s paediatric department (Stanford School of Medicine, 2011) [APPENDIX 1]. Data extracted from the articles used in the systematic review which were cohort and randomized control trials were done using the CASP tool (Public Health Resource Unit, 2006). Articles with an agreed upon score of less that 50% from both reviewers was excluded from the review. The methods of all the articles was analyzed and appraised in terms of study population, inclusion and exclusion criteria,
the outcome measures, interventions used, results and the authors’ conclusions along with the generalizability of the study.

2.9.3.4 DATA SELECTION

Articles were considered for inclusion firstly based on the title. Thereafter, key points and abstract of the articles was analyzed and relevant articles were included. A total of 33 articles were identified during the initial analysis and 21 articles were included based on the relevance and inclusion criteria. The 21 articles used for critical appraisal included the outcomes mentioned in the methods section and focused on sprinters in their studies. Of the articles included for critical appraisal, seven (7) were excluded due to the poor methodological quality found, finally 14 articles included in the analysis. Articles included were nine (9) descriptive studies, three (3) randomized control trials, three (3) controlled trials, two (2) cohort studies and finally four (4) case controlled studies. Articles with a score of less than 50% were excluded from analysis, this included three (3) descriptive studies, two (2) controlled trials and two (2) of the case controlled studies.

Table 2.1: Types of studies included in the systematic review.

<table>
<thead>
<tr>
<th>Type of studies</th>
<th>No. of articles</th>
<th>Good methodological quality</th>
<th>Poor methodological quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Descriptive</td>
<td>9</td>
<td>6</td>
<td>3</td>
</tr>
<tr>
<td>Randomized control trial</td>
<td>3</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Controlled trials</td>
<td>3</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Cohort studies</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Case controlled studies</td>
<td>4</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>21</strong></td>
<td><strong>14</strong></td>
<td><strong>7</strong></td>
</tr>
</tbody>
</table>
2.9.3.5 DATA EXTRACTION

Data was extracted from all included articles by two independent researchers. Information from the extraction was extracted into a purpose-built MS Excel sheet and the data extracted for each study included information on the author, year of publication, title of the article, purpose of the study, inclusion and exclusion criteria, the research setting, outcomes looked at by the researcher (e.g. stride length), the results and the study’s generalizability. Table 2.2 highlights the relevant information extracted from the included articles.
Table 2.2: Articles included in the review

<table>
<thead>
<tr>
<th>Article</th>
<th>Purpose of the study</th>
<th>Population</th>
<th>Setting</th>
<th>Intervention/ experiment</th>
<th>Outcomes</th>
<th>Article Results</th>
<th>Generalizability</th>
<th>Critical Appraisal Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weyand, P. G., Sternlight, D. B., Bellizzi, M. J. &amp; Wright, S. (2000). Faster top running speeds are achieved with greater ground forces not more rapid leg movements. <em>Journal of Applied Physiology</em></td>
<td>To assess whether greater ground reaction forces rather than rapid leg movements produces faster top speeds</td>
<td>Target population: sprinters Subjects used in the study: physically active men and women. Non sprinters</td>
<td>Experiments were conducted on a treadmill</td>
<td>Trials were performed and compared. Subjects run on horizontal, 9° incline and 6° decline surfaces</td>
<td>Velocity, force applied to the running surface, contact time, aerial time, step length and step frequency</td>
<td>Data was analyzed using ANOVA post hoc means. They found that force applied to the surface was the most important determinant in developing faster top speeds</td>
<td>Researchers believe that results are generalizable because results are not affected by characteristics of the running surface.</td>
<td>52%</td>
</tr>
<tr>
<td>Paradisis, G. P &amp; Cooke, C. B. (2000). Kinematic and postural characteristics of sprint running on sloping surfaces. <em>Journal of Sports Science</em></td>
<td>The aim of the research was to identify the kinematic and postural characteristics of running on three conditions: an incline, decline and level surface</td>
<td>Target population: sprinters Subjects included in the research: 8 male physical education students</td>
<td>Horizontal (control) trials were done on a synthetic track. Incline and decline trials were conducted on a platform. All tests were done using natural light and ambient temp</td>
<td>Subjects performed randomized trials based on the conditions on a horizontal surface, a 3° incline 20m surface and 3° decline 20m surface</td>
<td>Contact time, aerial time, step length and step frequency, running speed</td>
<td>ANOVA two-way analysis was used to analyze statistics. Results showed speed was faster for decline. Posture at touchdown: step length in downhill running was longer, decreased lean in uphill, center of mass was located further behind the contact point.</td>
<td>Sample not a representative sample for sprinters. Not generalizable for sprinters</td>
<td>50%</td>
</tr>
<tr>
<td>Young, M. (n.d.). Maximal velocity sprint mechanics. <em>United States Military Academy &amp; Human Performance Consulting</em></td>
<td>The purpose of the article is to describe essential aspect of sprinting that allows an athlete to optimize their performance</td>
<td>The target population is short distance / 100 m sprinters</td>
<td>Not applicable</td>
<td>None</td>
<td>Step length step frequency, ground reaction forces and stability</td>
<td>Athletes must optimize postural stability, reduce braking forces and increase propulsion in order to achieve their maximum top speed</td>
<td>Yes</td>
<td>100%</td>
</tr>
<tr>
<td>Study</td>
<td>Target Population</td>
<td>Study Details</td>
<td>Results</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Martinopoulou, K., Argeitaki, P., Paradisis, G., Katsikas, C. &amp; Smirniotou, A. (2011). The effects of resisted training using parachute on sprint performance. Journal of Biology of Exercise</td>
<td>To identify the effects resistance training has on sprint performance when compared to non-resistance training</td>
<td>Testing took place on an indoor track to minimize external factors affecting the results. The control and the experimental group were randomly divided and given the same training programme. The experimental group were required to perform all exercise while attached to a parachute to add resistance while training</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee, S.S.M., &amp; Piazza, S.J. (2009). Built for speed: musculo-skeletal structure and sprinting ability. <em>Journal of experimental Biology</em></td>
<td>The aim of the study is to compare the plantar flexors and the arthrokinematics of the ankle and foot between sprinters and non-sprinters. Target population: sprinters Study sample: 12 sprinters and 12 non-sprinters (height matched)</td>
<td>Not clear</td>
<td>Ultrasound images of all participants Achilles tendons were taken along with measurement of the foot and ankle’s bony landmarks. A computer model was done to identify how the above mentioned affects sprinting</td>
<td>Ground force reaction (push-off force), plantar flexor moment arm of Achilles, arthrometric measurements</td>
<td>Two-tailed t-tests done for differences between sprinters and non-sprinters. Plantar flexor moment arms were 25% smaller for sprinters therefore resulting in the production of greater ground reaction forces (stronger push-off). Sprinters have longer toes which enhances acceleration and ground reaction forces</td>
<td>Yes</td>
<td>58%</td>
<td></td>
</tr>
<tr>
<td>Dugan, S.A. &amp; Bhat, K.P. (2005). Biomechanics and Analysis of running gait. <em>Physical Medicine and Rehabilitation Clinics of North America</em></td>
<td>Describe the anatomy of the foot, the differences between walking and running, as well as the effect velocity has on gait. Not clear if the target is population is sprinter.</td>
<td>Not applicable</td>
<td>None done</td>
<td>Kinetic and kinematic parameters of gait</td>
<td>Pronation allows the foot to be flexible to absorb impact at foot strike; supination allows the foot to be rigid for propelling the body. With increase in velocity means an increase in swing phase and decrease in stance phase.</td>
<td>Not applicable</td>
<td>50%</td>
<td></td>
</tr>
<tr>
<td>Bezodis, N.E., Salo, A.I.T. Trewartha, G. (n.d.). Kinematic aspects of block phase technique in sprinting. <em>International Symposium on Biomechanics in Sports</em></td>
<td>The aim of the study was to identify the lower limb kinematics during the block phase. Target population: sprinters Study sample: 16 male sprinters with a PB* of 9.98s 13 sprinters data were collected on an indoor track, for 3 sprinters data was collected on an outdoor track Participants formed 3 30m sprints from a crouched start</td>
<td>Velocity, aerial time, step length and distance, joint angles in the blocks.</td>
<td>A stronger rear leg push off results in better performance</td>
<td>Yes</td>
<td>75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Johnson, M.D. &amp; Buckley, J.G. (2001). Muscle power patterns in the mid-acceleration phase of sprinting. Journal of Sport Sciences</strong></td>
<td>To describe the action of the hip and knee during the mid-acceleration phase of sprinting...</td>
<td>Target population: sprinters</td>
<td>Indoor athletics track.</td>
<td>3 trials of 35m sprints on a track fitted with a plate form than recorded the amount of force applied.</td>
<td>Ground reaction forces, velocity and joint moments.</td>
<td>Sprinters increase their velocity during stance phase.</td>
<td>No sample is too small</td>
<td>50%</td>
</tr>
<tr>
<td><strong>Coh, M., Tomazin, K. &amp; Stuhec, S. (2006). The biomechanical model of the sprint start and block acceleration. Journal of Physical Education and Sport</strong></td>
<td>To analyse kinematic parameters contributing to acceleration of a world class sprinter.</td>
<td>Target: sprinters</td>
<td>The sports hall of the Track and Field Center of Slovenia</td>
<td>The athlete performed 5 20 m starts from crouched position using starting blocks.</td>
<td>Aerial time, step length, step frequency, velocity</td>
<td>An excessive step length results in a negative ground reaction force causing braking forces to occur. Step length and frequency increases as contact time decreases and aerial time increases.</td>
<td>Cannot be generalized, one athlete used</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Hughes, D. (n.d.). The art running: A biomechanical look at efficiency</strong></td>
<td>Looks at basic biomechanics of running in relation to running economy.</td>
<td>Target: long distance runners</td>
<td>Not applicable</td>
<td>Running phases</td>
<td>Arms are important at the end of the race to maintain lift and drive. An increase in stride frequency and length increases velocity. A runner loses velocity during swing therefore force applied to propel the body is important</td>
<td>Not applicable</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td><strong>Harrison, A.J. (2010). Biomechanical factors in sprint training – where science meets coaching. International Symposium of Biomechanics in Sports</strong></td>
<td>Examines how training should be structured and developed to achieve optimal sprinting technique</td>
<td>Target population: sprinters</td>
<td>Not applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>Not Applicable</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>
2.9.4 RESULTS

The following section is aimed at representing the results found in the systematic review. A description of the various components that were identified as factors that influences sprinting technique is provided below. These components will be discussed in section 2.9.5 followed by a conclusion of the systematic review in section 2.9.6.

2.9.4.1 VELOCITY

A total of 6 studies show that velocity is an important aspect in determining sprint performance. Findings show that velocity is influenced by other kinematic aspects. Firstly, velocity is increased at lower speeds by increasing step length and at higher speeds by increasing the step frequency (Coh, Tomazin & Stuhec, 2006; Paradisis & Cooke, 2000; Weyand, Sternlight, Bellizzi & Wright, 2000). As velocity is increased it is noted that contact length decreases, aerial or flight time is increased along with step length and step frequency and the overall time taken for the athlete to step is decreased (Coh, Tomazin & Stuhec, 2006; Dugan & Bhat, 2005; Weyand, Sternlight, Bellizzi & Wright, 2000). Johnson and Buckley (2001) found that the velocity is increased during the stance phase of the step. One study states that as the maximum velocity is reached it is important for the athlete to maintain their stability, reduce the amount of brake forces acting on their speed and maximize the amount of force used to propel the body forward (Young, n. d.).
2.9.4.2 STEP LENGTH AND STEP FREQUENCY

Six of the studies state that step frequency and step length are greater for faster sprinters when compared to their slower counterparts. They also found that for all sprinters step length is more important in determining the velocity during the drive and acceleration phase, as the step length becomes more consistent and the athlete reaches the maximum velocity phase, velocity can be increased mainly by increasing step frequency (Martinopoulou, Argeitaki, Paradisis, Katsikas & Smirniotou, 2011; Moir, Sanders, Button & Glaister, 2007; Weyand, Sternlight, Bellizzi & Wright, 2000). In contrast Paradisis & Cooke (2000) states that velocity is primarily increased by increasing step length. Studies show that faster sprinters can develop step lengths of up to approximately 2.5 m long with a step frequency as high as 50 steps per 100 m (Young, n. d). The acquisition of step length and step frequency is largely influenced by ground reaction forces; it is also shown that step frequency is influenced by the reduction in contact time (Coh, Tomazin & Stuhec, 2006; Young, n. d.)

2.9.4.3 GROUND REACTION FORCES, AERIAL AND CONTACT TIMES

Five studies found that when there is an increase in ground reaction forces it results in a decrease in contact time and an increase in aerial time. More proficient sprinters have greater ground reaction forces than sprinters who are slower and therefore faster runners have shorter contact lengths than slower runners (Weyand, Sternlight, Bellizzi & Wright, 2000; Young, n. d.). Ground reaction forces are said to increase velocity. According to Johnson and Buckley (2000) that ground reaction forces that are applied in an anterior direction produces forces in the hip musculature that increased the power produced by the hip extensors therefore producing higher
velocities. The direction of the ground reaction force applied directly influenced the athlete’s step length (Moir Sanders, Button & Glaister, 2007). When the ground reaction force is applied, directing the centre of massive in a greater horizontal than vertical direction, it increases the step length of the athlete (Moir Sanders, Button & Glaister, 2007). Two studies found that with increase in velocity there is a decrease in the contact time and as a result an increased amount of aerial time (Dugan & Bhat, 2005; Harrison, 2010).

2.9.4.4 STABILITY
Young (n. d.) states that stability is an important biomechanical factor in sprinting because poor stability leads to incorrect movement patterns and thus negatively impacts the sprinters performance. Correct posture ensures sufficient stability and promotes relaxed movement and freedom of movement in the trunk and upper limb reducing energy expenditure and improving sprint performance. Aspects of proper posture that influences sprinting technique include core stability, adequate alignment of spine and major joints and postural control. If either of the above mentioned aspects are insufficient, the sprinters’ performance can be hindered (Seagrave, Mouchbahani & O’Donnell, n. d.; Young, n. d.). Alignment during the sprint influences the athlete’s ability to generate sufficient ground reaction forces and the correct step length. When the sprinter has poor stability and alignment they are unable to correctly place the foot below the centre of gravity thus decreasing the step length and the ground reaction forces (Bezodis, Salo & Trewartha, n. d.; Dugan & Bhat, 2005; Hughes, n. d.; Moir, Sanders, Button & Glaister, 2007; Paradisis & Cooke, 2000).
2.9.5 DISCUSSION

The aim of the systematic review was to determine the factors that influence a sprinters’ running technique. The review found that there are a number of biomechanical factors that influences an athlete’s technique and thus ultimately their performance. The most influential biomechanical factors that influence the sprinters ability to achieve their optimal sprinting technique include the following aspects: the sprinters step length, the frequency of steps the sprinter takes during the race, the amount of ground reaction force that occurs when the athlete pushes off the surface to step forward and the postural stability of the athlete during the race.

2.9.5.1 CONTACT TIMES

Contact times for running differ according to the distance that is covered during the race. A number of studies found that the time a sprinter’s foot is in contact with the ground is significantly less than those athletes who participate in distance running (Dugan & Bhat, 2005). These times also differ according to the experience and performance of the sprinter. Weyland, Sternlight, Bellizzi & Wright (2000) found that at top speeds the sprinter spends less time in contact with the ground than at slower speeds. More proficient sprinters tend to have minor contact times compared to their slower counterparts (Weyand, et al, 2000; Young, n. d.). This occurs due to greater ground reaction forces that propel the athlete into the swing or aerial phase. More proficient runners makes use of better postural mechanics and movement patterns that allow them to place their limbs in positions that decrease the muscle work load, prevents compensation and trick movements from occurring.
2.9.5.2 GROUND REACTION FORCES

One important aspect an athlete needs to master or improve on in order to produce their optimal sprint performance is increase the amount of force at which they push off from the ground during the stance phase of their sprint. Studies show that poorer performing athletes generate forces that are lower to those who have an optimal sprint technique (Weyand, et al, 2000; Young, n. d.). These lower ground reaction forces could be attributed to weaker lower limb muscles and incorrect placement of the sprinters foot when initial contact is made with the ground as the athlete steps and begins the stance phase (Seagrave, Mouchbahani, & O'Donnell, n.d.). Experienced sprinters’ point of initial contact is made by the forefoot of the stance leg. Long distance runners and novice sprinters use the hind foot or heel as the point of initial contact (Dugan & Bhat, 2005). In sprinters this placement of the foot hampers the sprinter’s ability to generate sufficient ground reaction forces to maintain or speed up momentum by increasing the contact time with the ground and the work of the lower limb muscles in order to shift the athlete’s centre of gravity forward over the foot to move the athlete forward (Seagrave, Mouchbahani, & O'Donnell, n. d.). When the forefoot is used as the point of initial contact the centre of gravity is placed directly above of the base of support, the forefoot, thus decreasing the rate of work the lower limb muscles are required to use to move the centre of gravity and allowing the generation of greater ground reaction forces.
2.9.5.3 STEP LENGTH AND FREQUENCY

In sprinting step length is created with a great ground reaction force, long aerial time and correct foot placement. When an athlete is weaker and less stable the placement of the foot is compromised leading to an inefficient step length. Step length and step frequency are two important aspects that influence the velocity or speed at which the sprinter covers the required distance (Martinopoulou, et al, 2011). Ideally a sprinter needs to have a lower step frequency with a large step length in order to generate an appropriate velocity. The step length required should not be large enough to create brake forces, which occurs when an athlete has an incorrect foot placement thus impeding the momentum created by the ground reaction forces of the previous steps (Coh, Tomazin, & Stuhec, 2006). Thus the prime step length is the distance covered from the forefoot of the lead leg to the forefoot of the contralateral leg. This length is estimated to be approximately 1.14 times the length of the athlete’s height. The step length directly influences the amount of steps the athlete takes during the race. When a sprinter has a step length that is shorter or longer than the optimal length it increases the amount of steps required to cover the distance. This increases brake forces, lowering the momentum and decreasing the velocity of the sprinter therefore increasing the time it takes for the sprinter to cover the distance (Weyand, et al, 2000).
2.9.5.4 POSTURAL STABILITY

A sprinter requires proficient postural stability in order to optimize other biomechanical factors (Young, n. d.). When one has poor postural stability one requires a greater base of support when sprinting, in order to maintain a forward momentum and minimize later translation of forces and energy. This means that sprinters with poor postural stability will make use of the hind foot as the point of initial contact therefore decreasing the step length and lowering the ground reaction forces that are generated (Seagrave, Mouchbahani, & O'Donnell, n. d.). Lower centre of gravity produces a poor stable posture, thus athletes tend to decrease the amount of vertical momentum, and this is created by decreasing the aerial time and ultimately shortening the step length (Hughes, n. d.).

2.9.6 CONCLUSION

In conclusion, the systematic review found that step length, step frequency, the generation of velocity, ground reaction forces, contact time and postural stability are the factors that influence and athletes sprinting technique. Thus in order to develop the correct or ideal sprinting technique and enhance a sprinter's performance, these factors needs to be assessed and improved on.
CHAPTER 3
METHODOLOGY

3.1 INTRODUCTION
The following chapter is aimed at describing the methods used to conduct the research study. It will include a description of the research setting, study design, population and instruments used. The chapter also explains the data collection and analysis used, as well as all ethical considerations made for the study.

3.2 RESEARCH SETTING
The University of the Western Cape Athletics Club was chosen, due to convenience, to participate in the study. The club was founded in 1974 and became affiliated with Western Province Athletics (WPA) in 1993. In 1982 an international standard stadium was built on the grounds of the university equipped, with a tartan outdoor track. The club offers various athletics events such as sprints, long jump, high jump, long distance running, etc. (Time-to-run, 2011).

3.3 STUDY POPULATION AND SAMPLE
The population included in the study was short distance (100m and 200m) sprinters who were registered athletes at The University of the Western Cape Athletics club during the 2012 athletics season. According to Western Province Athletics there are four junior age categories namely under 23, under 20, under 18 and under 16 years. Participants at junior level were selected for the research study, due to the fact that they were learning how to optimize their technique. All sprinters at the University of
the Western Cape Athletics Club between the ages of 16 and 23 years were invited to participate in the study.

The study sample consisted of all the junior athletes who were available for and who consented to be part of the study. Both male and females were included. There are a total of approximately 50 junior sprinters registered for the 2012 season at The University of the Western Cape Athletics club.

3.4 STUDY DESIGN
The research study was conducted in two parts; the first phase of the study was done using a systematic review. This review was used in this study to provide the researcher with a better background into what factors influences the development of correct technique (Kitchenham, 2004). The second phase of the study was done as a quantitative descriptive study design. A quantitative descriptive cross sectional research design was chosen in order to objectively describe the relationship between variables (Jones & Bartlett Learning, n. d.; Taylor, 2005).

3.5 DATA COLLECTION AND INSTRUMENT
The study consists of two phases. The first phase was completed using a systematic review in order to determine the biomechanical factors that influence an athlete’s ability to attain their optimal sprinting technique. The second phase consisted of various assessments such as the Disability Neck Index used to ascertain the prevalence of neck discomfort among the sprinters, the Craniocervical Flexion Test to determine the functional strength and endurance of the deep neck flexors and finally a video analysis of the participant’s sprinting technique in order to
identify the relationship between the functioning of the deep neck flexors and the athletes sprint technique.

3.5.1 SYSTEMATIC REVIEW

A systematic review was conducted in order to determine outcome measures used to assess the sprinting technique of short distance sprinters to better understand variations in technique and biomechanical aspects that would influence the athletes’ ability to attain proper technique. A systematic review protocol was designed prior to conducting the systematic review [APPENDIX 9]. All available literature was used in the review, both local and international. The methods of the Systematic Review are discussed in Chapter two (2). Research terms used in the review included the biomechanics of sprinting, biomechanics of running and factors influences sprinting technique. Databases used to conduct the research for the systematic review included Science Direct, EBSCOHOST, Pubmed central, etc. Articles included were English, focused on short distance athletes and included outcome measure related to sprint technique, such as velocity. All relevant articles were assessed by two independent reviewers using the CASP critical appraisal tool [APPENDIX 2] as well as the Stanford University critical appraisal tool [APPENDIX 1]. Subsequent consensus by both reviewers of all relevant articles was reached and analyzed.

3.5.2 DISABILITY NECK INDEX

The Disability Neck Index [APPENDIX 3] is currently the most commonly used index for assessing patients who suffer from neck pain and how the pain leads to disability in these patients (Rebbeck, 2005). It measures 10 categories namely the intensity of the pain felt, whether the patient experiences any headaches and how the neck pain
affects the patient’s everyday life with regard to lifting of objects, driving, sleeping, concentrating, reading, sleeping, personal care and the effect the pain has on the patient’s ability to work.

3.5.2.1 VALIDITY AND RELIABILITY OF THE DISABILITY NECK INDEX

Baseline data was captured using The Disability Neck Index [APPENDIX 3]. This is a valid and reliable questionnaire that has been standardized to assess the degree to which a patient's neck pain impact on their life (Vernon & Mior, 1991). According to Sterling (2005) demonstrates a high test-retest reliability for a time period where the test is performed and repeated within two (2) days a Pearson’s r of 0.89 was found. Over a three (3) month period a Pearson’s r of 0.95 was found showing test-retest reliability (Sterling, 2005). The Disability Neck Index was created in 1991 and was developed from the Oswetry disability index, which is an outcome measure questionnaire used in the assessment and treatment of patients with spinal injuries (Fairbank & Pynsent; 2000). Reliability coefficients ranging between 0.83 and 0.99 were found for the Oswetry Disability Index, showing that the questionnaire is valid and reliable (Davidson & Keating, 2005).

3.5.2.2 ANALYSIS OF THE DISABILITY NECK INDEX

The information attained from the Disability Neck Index was analyzed by tallying the participant’s responses and calculating a percentage for each participant. This percentage gives the examiner or clinician an idea of the percentage to which the neck pain affects the patient’s everyday life therefore indicating the degree of disability caused by the pain (Macdermid, Walton, Avery, Blanchard, Etruw, McApline & Goldsmith; 2009). Points can also be allocated that corresponds to a
particular category which describes the amount of disability caused by the pain, for example if the patient scores between five (5) and 14 of a total 50 points the disability would be considered as mild (Fairbanks, Couper, Davies & O’Brien, 1980). Below are the various categories along with the score according to the Neck Disability Index:

Table 3.1: Scoring for Disability Neck Index

<table>
<thead>
<tr>
<th>Points for Neck Disability Index Questionnaire</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 4</td>
<td>No disability</td>
</tr>
<tr>
<td>5 – 14</td>
<td>Mild disability</td>
</tr>
<tr>
<td>15 – 24</td>
<td>Moderate disability</td>
</tr>
<tr>
<td>25 – 34</td>
<td>Severe disability</td>
</tr>
<tr>
<td>&gt; 34</td>
<td>Complete disability</td>
</tr>
</tbody>
</table>

(Vernon & Mior; 1991)

3.5.3 CRANIOCERVICAL FLEXION TEST

A Craniocervical Flexion Test (CCFT) [APPENDIX 4] was done to assess the deep neck flexor activation and isometric endurance of each participant. Initially the test was performed by instructing the patient to raise the head from the bed approximately two (2) cm, this was found to be an invalid assessment when the deep cervical/neck flexors in isolation from superficial neck flexors, the sternocleidomastoid and the anterior scalenes. It was thus concluded through clinical and laboratory research that the most effective way to activate the deep neck flexors in isolation was the tuck in the chin thereby performing upper cervical flexion only (Magee, Zachazewski & Quillen; 2009).
The current test procedure was done by placing the biofeedback machine below the neck. The pressure in the biofeedback machine needed to be increased by 10 mmHg, from 20 mmHg to 30 mmHg in increments of two (2) mmHg at a time (Magee, Zachazewski & Quillen; 2009). The increase in pressure within the cuff is due to the slight flattening of the cervical lordosis which is a normal observation when activating the deep neck flexors (Jull, O’Leary & Falla; 2008).

Starting position: The participant was in supine crook lying with the biofeedback machine placed below the lordotic curve of the cervical spine. No pillow was placed below the athlete’s head.

Procedure: A Chattanooga biofeedback machine was used for the assessment. The biofeedback machine was checked prior to the assessment and was calibrated to 0mmHg. The athlete was instructed, by the clinician, to performed upper cervical flexion – this is done by tucking in the chin without raising the head off the bed, opening the mouth and without performing lower cervical flexion which is demonstrated by placing their chin on their chest. The pressure gage was held by the athlete in order to provide visual feedback to him/her regarding the amount of contraction needed. During the first contraction the athlete was required to move the needle from 20 mmHg to 22 mmHg by tucking in the chin. This demonstrates the activation of the deep neck flexors. The isometric endurance was shown by the athlete’s ability to hold the needle at 22 mmHg for 10 seconds. The athlete then relaxed, the needle returned to 20 mmHg. The procedure was then repeated, the athlete was then required to increase the pressure by tucking in the chin and moving the needle to the 24 mmHg mark, this position was then held for 10 seconds. The
athlete relaxed once more and the procedure continued by allowing the athlete to increase the pressure to the 26 mmHg. This procedure was followed to the 28 mmHg and finally to the 30 mmHg mark. If the athlete was unable to reach the next level the procedure was stopped. If the athlete was unable to hold any position for 10 seconds the procedure was stopped (Fernandez-De-Las-Penas, Perez-De-Heredia, Molero-Sanchez, & Miangolarra-Page, 2007).

3.5.3.1 VALIDITY AND RELIABILITY OF THE CRANIOCERVICAL FLEXION TEST

The Craniocervical Flexion Test is a known valid assessment which was developed due to findings by clinicians that there was a need to assess and treat the muscles that stabilize the spine particularly in those patients suffering from neck pain (Falla, Jull, & Hodges, 2004). Olson, Millar, Dunker, Hicks & Glanz (2006) showed that the Craniocervical Flexion Test using biofeedback has good inter-rater and intra-rater reliability. The test was conducted by the researcher for all the participants ensuring inter-rater reliability by eliminating disagreement between multiple examiners. All participants received the same instruction assuring the reliability the assessment was performed 3 times at each level to ensure whether the participant was able to achieve the contraction or not. If the participant was unable to contract two (2) or more times the level was not a achieved and the test stopped. This ensured intra-rater reliability of the assessment.

3.5.3.2 ANALYSIS OF THE CRANIOCERVICAL FLEXION TEST

The participants ability to achieve each of the 10 levels listed in the Craniocervical Flexion test were tallied and a percentage awarded, for example, if the patient is able to contract the deep neck flexors and move the needle to 22 mmHg but unable to
hold the position for 10 counts a percentage of 10 is allocated. This indicates the participants deep neck flexors are functioning at 10% of the muscle group’s capability. This is repeated for 24mmHg, 26 mmHg, 28mmHg and finally for 30mmHg. This was further coded according to the percentage range for statistical analysis; this is shown in Table 3.2 below. If the participant was able to contract the deep neck flexors, moving the needle to the level of 30 mmHg and hold the contraction for 10 counts, their deep neck flexors are said to be functioning at full capacity and would have received a score of 100%.

Table 3.2: Code assigned to percentage range for CCFT

<table>
<thead>
<tr>
<th>Percentage range</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 10</td>
<td>1</td>
</tr>
<tr>
<td>11 – 20</td>
<td>2</td>
</tr>
<tr>
<td>21 – 30</td>
<td>3</td>
</tr>
<tr>
<td>31 – 40</td>
<td>4</td>
</tr>
<tr>
<td>41 – 50</td>
<td>5</td>
</tr>
<tr>
<td>51 – 60</td>
<td>6</td>
</tr>
<tr>
<td>61 – 70</td>
<td>7</td>
</tr>
<tr>
<td>71 – 80</td>
<td>8</td>
</tr>
<tr>
<td>81 – 90</td>
<td>9</td>
</tr>
<tr>
<td>91 – 100</td>
<td>10</td>
</tr>
</tbody>
</table>

3.5.4 SPRINTERING TECHNIQUE

In order to assess the sprinting technique for each participant, a video recording of the technique of each sprinter was done on the University track. Two (2) Panasonic HDC HS 300 high definition cameras were used. The first camera was placed posteriorly 10 m from the 100 m start line. The second camera was placed mid-way between the 60 m and 70 m mark at the 65m mark, approximately 10m from the 8th
lane. Cones were placed at the 60m and 70m marks. Two (2) cones were placed one (1) m away from either side of the 65m mark. The latter was used to gage the athletes’ stride length during the maximum velocity phase. White sticker markers were placed on the left side of the athletes’; at mastoid process, the acromion process, midline of the elbow joint, radial styloid process, greater trochanter of the hip, midline of the knee joint and over the later malleolus, shown in figure 1 below.

Each athlete performed two 100 m sprints with two (2) minutes rest in between.

**Fig 1:** Demonstration of the placement of the stickers used to identify the joints during the sprint

### 3.5.4.1 VALIDITY AND RELIABILITY OF SPRINTING TECHNIQUE

The Dartfish ProSuite v. 4.0.9.0. is a reliable type of computer software that allows individuals such as physiotherapists and biokinettists to analyze an athlete’s movements while performing specific tasks such as gait. Its reliability has been tested and proven by a number of studies. Pike (2008) conducted three tests on the software and compared it to another well-known reliable type of computer software and found that the programme was very reliable.
3.5.4.2 ANALYSIS OF SPRINTING TECHNIQUE

After recording of the sprint, the videos were downloaded from the Panasonic camera hard drive onto a computer and converted from DivX to an AVI format. This is a format compatible with Dartfish Pro. The technique analysis was done using the Dartfish ProSuit Programme, which is used to identify the correct and incorrect aspects of an athlete’s technique. The analysis using the Dartfish Programme was completed by test – re test methods, where an independent expert in the field assessed the technique to ensure accurate findings.

Aspects analyzed using Dartfish include the step length for each athlete during the Maximum Velocity phase of the sprint (60-70 m), the speed for each step taken in this phase, as well as the angle of the head during each phase of the gait cycle for each step. The latter was done at the point of initial contact, mid stance, toe off and mid swing; demonstrating the movement of the head during the each phase of the step cycle. For statistical purposes, the amount of head movement was calculated by subtracting the largest angle of the head from the smallest angle and coding the amount of change, shown in Table 3.3. This was repeated for each step taken during the Maximal Velocity phase of the sprint. The angle of the head was calculated by drawing a straight line through the midline of the torso connecting to a line that passes from the chin to the mid-point of the shoulder joint. Each of the above mentioned aspects were calculated for both sprints performed by the participants, the average each aspect of the two sprints was taken. Step length was calculated by measuring from the tip of the foot at the point of initial contact between each step taken. The speed covered in each step was calculated by taking the time taken to
move from the point of initial contact of one step to the point of initial contact to the
next step.

Table 3.3: Amount of head movement during the maximum velocity phase

<table>
<thead>
<tr>
<th>Degree of fluctuation</th>
<th>Code</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 – 10</td>
<td>1</td>
<td>Minimal amount of fluctuation of the head</td>
</tr>
<tr>
<td>11 – 15</td>
<td>2</td>
<td>Moderate amount of fluctuation of the head</td>
</tr>
<tr>
<td>16 – 20</td>
<td>3</td>
<td>Severe amount of fluctuation of the head</td>
</tr>
<tr>
<td>&gt; 20</td>
<td>4</td>
<td>Extreme amount of fluctuation of the head</td>
</tr>
</tbody>
</table>

3.6 PROCEDURE

3.6.1 STAGE ONE:

A systematic review was completed; a detailed description and results can be found in Chapter two (2).

3.6.2 STAGE TWO:

The head coach of The University of the Western Cape Athletics Club was approached regarding the participation of his athletes in the research study [APPENDIX 7]. The study was explained in detail to each coach involved with sprinters at the club and verbal permission for participation was granted. Each athlete was then approached regarding their participation; they were informed about the purpose of the study the possible risks and benefits in their participation, after which written consent [APPENDIX 5 & 6] was obtained from each willing athlete. Every athlete interested in the study was asked to complete a Disability Neck Index Questionnaire which was returned to the researcher the following day. Thereafter, all athletes that completed the Disability Neck Index questionnaire were invited to participate in an
assessment of the functioning of their deep neck flexors using the Craniocervical Flexion Test. The assessment was explained in full, including the possible outcomes of the test. Each assessment was completed independently by the researcher by placing a biofeedback below the athlete’s neck in supine lying and recording the athlete’s ability to contract their deep neck flexors and hold the contraction at 22, 24, 26, 28 and finally 30 mmHg. The sprint data was collected by recording each athlete during a 100 m sprint. The recording was done by placing two video cameras along the length of the track. The first was placed at 60 m recording the maximum velocity phase of the sprint from a lateral view point. The second at 70 m point, this captured the sprint from the anterior aspect. The technique tests reliability was performed by re analyzing the sprinting technique to ensure the tests repeatability. The athlete was instructed to wear tights along with a tight fitted top. A felt tip marker was used to identify the joint and white stickers were placed over the joints in order to correctly identify postural aspects.

3.7 DESCRIPTIVE STATISTICAL DATA ANALYSIS

Data from the Disability Neck Index and Craniocervical Flexion Test was tallied and tabled in Microsoft Excel 2010 and thereafter captured in SPSS version 20, this ensured a double entry of the data, and the data was then analyzed to ascertain the relationships between variables. A descriptive analysis of the results was then done by using Pearson’s Chi-squared tests, to ascertain the significance of the relationship. Significant relationships were found were the p-value was less than or equal to 0.05.
Significant relationships between the Craniocervical flexion test and sprint technique were calculated. This was done by calculating the p-value between the Craniocervical Flexion test and the aspects found using Dartfish, namely step length, speed for each step as well as the angle of the head at the point of initial contact for each step. The angle of the head was also compared to step length and speed to determine whether any correlations exist.

3.8 ETHICAL CONSIDERATIONS

Permission to conduct the study was granted from the Higher Degrees Committee and the Research Grant and Study Leave committee at the University of the Western Cape [APPENDIX 8]. Permission was obtained from the head coach at The University of the Western Cape Athletics Club, the parents as well as the athletes that were included in the study for assessment and intervention. Written, informed consent was obtained from all parties, such as athletes and coaches, prior to assessment of each athlete [APPENDIX 5 & 6].

All athletes were informed that their participation in the study was voluntary and they may withdraw from the study at any time. The purpose of the study was clearly explained to each athlete and coach. Ethical clearance was granted from the Ethical Clearance Board of the University of the Western Cape in May of 2011. Personal information such as race, gender and age was not obtained. All results from the study such as the video analysis of the athletes sprinting technique along with the findings was made available to the participants as well as the coaches or parents.
3.9 LIMITATIONS OF THE STUDY

Due to the small amount of participants available for the assessment, the results cannot be generalized. This study cannot be backed up entirely by literature due to a lack of or very little available literature to support the hypothesis of the study. There is a risk of attrition due to the possibility that some athletes might not be able to complete all the components of the study. The results of the study could have been influenced by factors that were not looked at in the study.
CHAPTER 4
RESULTS

4.1 INTRODUCTION
The following chapter is aimed at representing the results found from the second stage of the research study. This chapter will demonstrate the results from the Disability Neck Index, the Craniocervical Flexion Test and the results of the sprinting analysis. A description and representation, by use of tables and graphs as well as of the linear relationship between the variants will be presented in this chapter.

4.2 DEMOGRAPHICS
Of the 50 sprinters registered at the University Western Cape Athletics Club, 18 consented to participate in the study, 17 participants provided written consent to the study, with one participant providing implied consent to the study by completing every phase of the study. A total of eight (8) females and 10 males consented to participate, shown in Table 4.1.

Table 4.1: Demographics of the participants

<table>
<thead>
<tr>
<th>Gender</th>
<th>No of participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>8</td>
<td>44</td>
</tr>
<tr>
<td>Male</td>
<td>10</td>
<td>56</td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coloured</td>
<td>18</td>
<td>100</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Under 23</td>
<td>18</td>
<td>100</td>
</tr>
</tbody>
</table>
4.3 DISABILITY NECK INDEX

A total of 16 participants, 10 males and six (6) females, completed the Disability Neck Index questionnaire. Each questionnaire was numbered. The scores for each questionnaire were tallied and coded according to the guidelines set out by Vernon and Moir (1991). The total score for each questionnaire is placed in a range and assigned a code. There are five (5) codes for each score range this is represented in Table 3.1 in chapter 3. Of the 16 participants 75% (n = 12) scored a one (1) thus indicating no disability, 19% (n = 3) scored a code two (2) indicating mild disability, 0% (n = 0) had moderate disability, 6% (n = 1) were found to have severe disability, with 0% (n = 0) complete disability. The raw score along with the code is shown in Table 4.2.

Table 4.2: Results of DNI for each participant

<table>
<thead>
<tr>
<th>DNI Scale</th>
<th>Number of participants</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>No disability</td>
<td>12</td>
<td>75</td>
</tr>
<tr>
<td>Mild disability</td>
<td>3</td>
<td>19</td>
</tr>
<tr>
<td>Moderate disability</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Severe disability</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Complete disability</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

4.4 CRANIOCERVICAL FLEXION TEST

A total of 13 out of the 16 participants that completed the Disability Neck Index completed the Craniocervical Flexion Test; this included eight (8) males and five (5) females. All participants were able to achieve the first pressure level at 22 mmHg, 31% (n= 4) were able to hold the deep neck flexor contraction at 22 mmHg. At 24 mmHg, 31% (n= 4) of participants were able to achieve this level with only 15% (n=
2) of participants able to maintain the muscle contraction for 10 counts. At 26 mmHg, 15% (n= 2) of participants could contract the deep neck flexors strong enough to allow the needle to reach this level with only 8% (n= 1) able to maintain the position. Thereafter, at level 28 mmHg and 30 mmHg, only 8% (n= 1) of participants were able to achieve and maintain the muscle contraction. The above is shown in Table 4.3

Table 4.3: The percentage of participants that achieved each level of the CCFT

<table>
<thead>
<tr>
<th>Level</th>
<th>Ability</th>
<th>% of Males</th>
<th>% of Females</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 mmHg</td>
<td>Able to achieve level</td>
<td>100 (n = 8)</td>
<td>100 (n = 5)</td>
</tr>
<tr>
<td></td>
<td>Able to hold for 10 seconds</td>
<td>13 (n = 1)</td>
<td>60 (n = 3)</td>
</tr>
<tr>
<td>24 mmHg</td>
<td>Able to achieve level</td>
<td>13 (n = 1)</td>
<td>60 (n = 3)</td>
</tr>
<tr>
<td></td>
<td>Able to hold for 10 seconds</td>
<td>0</td>
<td>40 (n = 2)</td>
</tr>
<tr>
<td>26 mmHg</td>
<td>Able to achieve level</td>
<td>0</td>
<td>40 (n = 2)</td>
</tr>
<tr>
<td></td>
<td>Able to hold for 10 seconds</td>
<td>0</td>
<td>20 (n = 1)</td>
</tr>
<tr>
<td>28 mmHg</td>
<td>Able to achieve level</td>
<td>0</td>
<td>20 (n = 1)</td>
</tr>
<tr>
<td></td>
<td>Able to hold for 10 seconds</td>
<td>0</td>
<td>20 (n = 1)</td>
</tr>
<tr>
<td>30 mmHg</td>
<td>Able to achieve level</td>
<td>0</td>
<td>20 (n = 1)</td>
</tr>
<tr>
<td></td>
<td>Able to hold for 10 seconds</td>
<td>0</td>
<td>20 (n = 1)</td>
</tr>
</tbody>
</table>

4.5 SPRINTING TECHNIQUE

A total of eight (8) sprinters, five (5) males and three (3) females, participated in the video recording of their sprint. Seven (7) sprinters completed two (2) sprints and one (1) athlete completed one sprint. It was found that on average female sprinters took five (5) steps between the 60 and 70 m marks, the maximal velocity phase of the sprint. Male sprinters only took four (4) steps during this phase. Table 4.4 shows the step length for each step taken for each sprinter. The average step length for the maximum velocity phase is 0.93 m. The average step length for the 5th step is 0.798 m this is the shortest step taken and can be attributed to the fact that only the female
sprinters took five (5) steps during the 10 meters. For step one (1) 37.5% (n = 3) has a step length greater than 1 m, 25% (n = 2) had a step length between 0.9 m and 1 m, 25% (n = 2) had a step length between 0.8 m and 0.9 m and 12.5% (n = 1) had a step length less than 0.8 m.

Step two (2), 50% (n = 4) has a step length greater than 1 m, 12.5% (n = 1) had a step length between 0.9 m and 1 m, 25% (n = 2) had a step length between 0.8 m and 0.9 m and 12.5% (n = 1) had a step length less than 0.8 m. With step three (3) 37.5% (n = 3) has a step length greater than 1 m, 25% (n = 2) had a step length between 0.9 m and 1 m, 25% (n = 2) had a step length between 0.8 m and 0.9 m and 12.5% (n = 1) had a step length less than 0.8 m. For step four (4) 37.5% (n = 3) has a step length greater than 1 m, 25% (n = 2) had a step length between 0.9 m and 1 m, 37.5% (n = 3) had a step length between 0.8 m and 0.9 m. Three (3) athletes required a fifth step, 12.5% (n = 1) had a step length between 0.8 m and 0.9 m and 25% (n = 2) has a step length less than 0.8 m.

Table 4.4: The average stride length per step during maximum velocity phase

<table>
<thead>
<tr>
<th>Participant</th>
<th>1st Step (m)</th>
<th>2nd Step (m)</th>
<th>3rd Step (m)</th>
<th>4th Step (m)</th>
<th>5th Step (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.045</td>
<td>1.07</td>
<td>1.06</td>
<td>1.02</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>0.945</td>
<td>1.065</td>
<td>0.96</td>
<td>1.055</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>0.925</td>
<td>1.065</td>
<td>0.945</td>
<td>0.965</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1.02</td>
<td>0.99</td>
<td>1.02</td>
<td>0.98</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1.005</td>
<td>1.03</td>
<td>1.025</td>
<td>1.015</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>0.805</td>
<td>0.795</td>
<td>0.795</td>
<td>0.82</td>
<td>0.815</td>
</tr>
<tr>
<td>7</td>
<td>0.82</td>
<td>0.83</td>
<td>0.84</td>
<td>0.82</td>
<td>0.78</td>
</tr>
<tr>
<td>8</td>
<td>0.795</td>
<td>0.815</td>
<td>0.8</td>
<td>0.815</td>
<td>0.795</td>
</tr>
</tbody>
</table>
Tables 4.5 shows the speed at each sprinter takes each step within the maximal velocity phase of the sprint. Step one (1) 25% (n = 2) had a speed greater than 4 m/s with 37.5% (n = 3) with a speed greater and 3 m/s and greater than 2 m/s. For step two (2) 12.5% (n = 1) ran greater than 4 m/s, 75% (n = 6) ran a speed greater than 3 m/s and 12.5% (n = 1) ran a speed greater than 2 m/s. For step three (3) 87.5% (n = 7) ran a speed greater than 3 m/s and 12.5% (n = 1) ran greater than 2 m/s. during step four (4) 12.5% (n = 1) ran greater than 4 m/s, 62.5% (n = 5) ran greater than 3 m/s and 25% (n = 2) ran greater than 2 m/s. Finally five (5) 12.5% (n = 1) ran greater than 3 m/s and 12.5% (n =1) ran greater than 2 m/s.

Table 4.5: The average speed per step

<table>
<thead>
<tr>
<th>Participant</th>
<th>Step 1 (m/s)</th>
<th>Step 2 (m/s)</th>
<th>Step 3 (m/s)</th>
<th>Step 4 (m/s)</th>
<th>Step 5 (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.39</td>
<td>3.585</td>
<td>3.785</td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>3.55</td>
<td>4.115</td>
<td>3.885</td>
<td>3.71</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3.315</td>
<td>3.8</td>
<td>3.215</td>
<td>3.47</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3.64</td>
<td>3.54</td>
<td>3.64</td>
<td>4.08</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>4.19</td>
<td>3.82</td>
<td>3.66</td>
<td>3.625</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>2.695</td>
<td>2.955</td>
<td>3.315</td>
<td>2.93</td>
<td>3.02</td>
</tr>
<tr>
<td>7</td>
<td>2.93</td>
<td>3.07</td>
<td>3.11</td>
<td>2.74</td>
<td>2.79</td>
</tr>
<tr>
<td>8</td>
<td>2.67</td>
<td>3.015</td>
<td>2.755</td>
<td>3.44</td>
<td>2.335</td>
</tr>
</tbody>
</table>

Table 4.6 shows the angle between the head and the neck at initial contact of each step during the maximal phase of the sprint. At first contact for step one (1) 37.5% (n = 3) had and angle between the head and the neck greater than 50°, 50% (n = 4) had an angle greater than 45° and less than 50° and 12.5% (n = 1) had and angle less than 45° greater than 40°.
At step two (2) 50% (n = 4) had an angle between the head and the neck greater than 50°, 25% (n = 2) had an angle greater than 45° and less than 50° and 25% (n = 2) had an angle less than 40°. At step three (3) 37.5% (n = 3) had an angle between the head and the neck greater than 50°, 25% (n = 2) had an angle greater than 45° and less than 50° and 25% (n = 2) had an angle less than 40° and 12.5% (n = 1) with an angle less than 30°. For step four (4) 12.5% (n = 1) has an angle greater than 60°, 25% (n = 2) had an angle between the head and the neck greater than 50°, 12.5% (n = 1) had an angle greater than 45° and less than 50° and 37.5% (n = 3) had an angle greater than 40° and 12.5% (n = 1) with an angle less than 30°. For step five (5) 25% (n = 2) had an angle greater than 45°.

Table 4.6: The angle of the head at first contact

<table>
<thead>
<tr>
<th>Participant</th>
<th>1st Step (°)</th>
<th>2nd Step (°)</th>
<th>3rd Step (°)</th>
<th>4th Step (°)</th>
<th>5th Step (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45.35</td>
<td>34.2</td>
<td>59</td>
<td>60.7</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>46.7</td>
<td>46.85</td>
<td>51.45</td>
<td>45.25</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>41.75</td>
<td>32.15</td>
<td>27.75</td>
<td>28.35</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>56</td>
<td>50.6</td>
<td>56.8</td>
<td>58.7</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>49.5</td>
<td>55.25</td>
<td>36.3</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>46.05</td>
<td>47.85</td>
<td>38.75</td>
<td>50.3</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>55.4</td>
<td>56.25</td>
<td>46.45</td>
<td>41.65</td>
<td>45.2</td>
</tr>
<tr>
<td>8</td>
<td>53.85</td>
<td>52.2</td>
<td>45.3</td>
<td>42.6</td>
<td>47.3</td>
</tr>
</tbody>
</table>

The degree of head movement during the maximal velocity phase of the sprint was measured by calculating the difference between the highest and lowest angles between the head and the neck. This was coded according to the range of change shown in Table 4.7.
Table 4.7: Code assigned to change in head position

<table>
<thead>
<tr>
<th>Amount of fluctuation for head</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>5˚ – 10˚</td>
<td>1</td>
</tr>
<tr>
<td>11˚ – 15˚</td>
<td>2</td>
</tr>
<tr>
<td>16˚ – 20˚</td>
<td>3</td>
</tr>
<tr>
<td>&gt; 20˚</td>
<td>4</td>
</tr>
</tbody>
</table>

4.6 INDIVIDUAL STATISTICS

Participant number one (1) was a male sprinter that scored one (1) on the Disability Neck Index (DNI) indicating no disability. During the Craniocervical Flexion test he was able to contract his deep neck flexor moving the needle to 22 mmHg but unable to maintain this contraction for 10 counts, thus only obtaining 10% for the assessment. This means that he has poor endurance of his deep neck flexors. During the analysis of his sprint technique it was found that he had an extreme degree of fluctuation in the angle of his head, the difference between the highest and lowest angle between the head and neck was 26.5˚. The video analysis also showed a short step length with an average of 1.05 m.

Participant number two (2) was a male that scored a code one (1), no disability, for the Disability Neck Index and 30% for his Craniocervical Flexion Test. He was able to achieve a contraction of his deep neck flexors at 24 mmHg but unable to maintain the contraction. In terms of his sprinting technique the angle of his head fluctuated by 6.2 degrees during the maximal velocity phase, his step length was shorter than 1.14 time his height and the point of initial contact was made by the hind foot. The 3rd participant was also male and scored a code four (4) indicating severe disability according to the Disability Neck Index and 10% for the Craniocervical Flexion Test indicating the possibility that the lack of sufficient endurance is impacting his
everyday functioning. He had an 18.95° fluctuation of the head during the maximal velocity phase with a short step length and also used the hind foot as the point of initial contact with the ground. Participant number 4 was a male that recorded a code one (1) (no disability) for the Disability Neck Index and 10% for the Craniocervical Flexion Test. In terms of sprinting technique, his step length was very poor averaging a length of 0.97 m using the hind foot as the point of initial contact. The degree of fluctuation of the head was 14°. At the end of the maximal velocity phase the athlete tended to increase the amount of upper cervical flexion by attempting to hold the head in a chin tucked position. His step length and speed per step was at its lowest with the greatest degree of upper cervical flexion. The 6th participant was also male scoring a code one (1) with the Disability Neck Index and 10% for the Craniocervical Flexion Test. He had a consistent but short step length of 1 m and an 8.1° fluctuation of the head. The first of the female participants, number five (5), had no disability for the Disability Neck Index and 10% for the Craniocervical Flexion Test. She had a short inconsistent step length with an average of 0.81m and an 11.55° of head angle fluctuation.

Participant number seven (7) was a female who had code one (1) for the Disability Neck Index and scored a 30% for the Craniocervical Flexion Test. She had a short step length of 0.82m and 14.6° head fluctuation. The last participant, number eight (8), scored a code two (2) for the Disability Neck Index indicating mild disability and 10% for the Craniocervical Flexion Test. The amount of fluctuation of her head was 11.52°; her step length was on average 0.8m. All participants used their hind foot as the point of initial contact during the maximal velocity phase and had a step length
shorter than 1.14 times their own height. The above mentioned data is summarized in Table 4.8.

Table 4.8: The DNI, CCFT and sprinting technique for each participant

<table>
<thead>
<tr>
<th>Participant</th>
<th>Gender</th>
<th>DNI</th>
<th>CCFT</th>
<th>Outcomes of sprinting technique</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Step Length</td>
</tr>
<tr>
<td>1</td>
<td>Male</td>
<td>1 = no disability</td>
<td>1 = Poor endurance</td>
<td>1.05</td>
</tr>
<tr>
<td>2</td>
<td>Male</td>
<td>1 = no disability</td>
<td>3 = Poor endurance</td>
<td>1.01</td>
</tr>
<tr>
<td>3</td>
<td>Male</td>
<td>4 = severe disability</td>
<td>1 = Poor endurance</td>
<td>1.02</td>
</tr>
<tr>
<td>4</td>
<td>Male</td>
<td>1 = no disability</td>
<td>1 = Poor endurance</td>
<td>0.97</td>
</tr>
<tr>
<td>5</td>
<td>Female</td>
<td>1 = no disability</td>
<td>1 = Poor endurance</td>
<td>0.81</td>
</tr>
<tr>
<td>6</td>
<td>Male</td>
<td>1 = no disability</td>
<td>1 = Poor endurance</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>Female</td>
<td>1 = no disability</td>
<td>3 = Poor endurance</td>
<td>0.82</td>
</tr>
<tr>
<td>8</td>
<td>Female</td>
<td>2 = mild disability</td>
<td>1 = Poor endurance</td>
<td>0.8</td>
</tr>
</tbody>
</table>

4.6.1 THE INFLUENCE OF GENDER ON VARIOUS ASSESSMENTS

Chi-squared tests indicates that the gender had no significant relationship with the Disability Neck Index ($p = 0.315$). No significant association between gender and the Craniocervical Flexion Test ($p = 0.673$) thus indicating no significant relationship between the gender of the athlete and the assessments done on the deep neck flexors. A $p$-value of 0.187 was found between the gender and the degree of movement of the head observed, indicating no significant association. Similarly, between gender and the step length ($p = 0.333$), gender and speed ($p = 0.333$). Thus, no significant relationship was found between the gender and the sprinting technique.
4.6.2 THE INFLUENCE OF THE DISABILITY NECK INDEX ON VARIOUS ASSESSMENTS

A p-value of 0.641 was found between the Craniocervical Flexion Test and the Disability Neck Index; this shows no significant relationship between the two assessments. No significant association exists between the Disability Neck Index and the fluctuation of the movement of the head ($p = 0.174$), and the Disability Neck and step length ($p = 0.313$), as well as the Disability Neck Index and speed ($p = 0.313$). These results indicate no significant relationship between Disability Neck Index and the athletes’ sprinting technique.

4.6.3 THE INFLUENCE OF THE CRANIOCERVICAL FLEXION TEST ON SPRINTING TECHNIQUE

Chi-squared test the Craniocervical Flexion Test and aspects of the sprint technique were calculated. No significant relation exists between the Craniocervical Flexion Test and step length with a p-value of 0.333. A p-value of 0.333 were found for the Craniocervical Flexion Test and the speed per step taken by each athlete. For the chi-squared between the Craniocervical Flexion Test and the degree of fluctuation of the angle of the head during the maximal velocity phase of the sprint, the p-value is 0.721. These findings indicate no significant relationship between the Craniocervical Flexion Test and the degree at which the head fluctuates during sprinting. The degree of change in head position was compared to the average step length for each step taken by the athlete; the chi-squared test indicates a value of 0.293, thus no significant relationship between the two variables. A p-value of 0.293 was also found between the average speed per step and the degree of fluctuation of the head.
4.7 CONCLUSION

In conclusion, the result of the chi-squared tests indicates no significant relationships between variables found in the study. All null hypotheses were rejected.
CHAPTER 5
DISCUSSION

5.1 INTRODUCTION

The purpose of the chapter is to discuss the results of the research study and how it relates to the aims and objectives described in chapter one (1). The aim of the study was to determine the effect deep neck flexor endurance and stability has on a sprinter’s running technique. The objectives of the study was to determine the factors that influence sprinter’s technique through a systematic review of literature, to determine the prevalence of neck discomfort among selected sprinters, to determine the functional strength and endurance of these sprinters, as well as analyse their sprinting technique; and finally to determine whether a relationship exists between their technique and the functioning of their deep neck flexors.

5.2 FACTORS THAT INFLUENCE SPRINTING TECHNIQUE

A systematic review was used to determine the factors that influence sprinting technique. The review found that velocity is the most important biomechanical factor that influences sprinting technique. Optimal step length, step frequency, ground reaction forces, aerial times, contact times and the sprinter’s postural stability are other factors that were identified which impacts and determines the acquisition of a sprinter’s technique. The systematic review found that all of the factors identified are dependent on one another, for example when an athlete has an insufficient sprint step length it results in an increase in contact time, a subsequent decrease in ground reaction force and finally a decrease in velocity. Therefore in order for an athlete to optimize their sprinting technique each of these factors needs to be evaluated and,
where the athlete lacks, those factors needs to be improved on. In this study step length and postural stability were the only biomechanical factors analysed in terms of the sprint technique during the maximal velocity phase. The results of the study was negatively influenced due to the inability to assess factors such as overall step frequency for the sprint, contact times and ground reaction forces during the maximal velocity phase, this was attributed to the lack of equipment needed to assess these factors.

5.3 NECK DISCOMFORT AMONG SPRINTERs

The neck discomfort among sprinters was defined by use of the Disability Neck Index. The majority of sprinters (75%) that participated in the study reported that they do not suffer from neck discomfort. Thus, neck discomfort among the participants included in the study was not prevalent. The prevalence of neck discomfort among the participants included in the study is important to note due to the impact neck discomfort has on posture and stability in day to day life, hence the assumption that neck discomfort can influence a sprinters' technique.

Statistical analysis showed that there was no significant relationship between the athletes’ sprinting technique and their scores for the Disability Neck Index. This indicates the athletes’ neck discomfort had no impact on their acquisition of correct sprinting technique. Domenesh, Sizer, Dedrick, McGilliard and Brismee (2011), describe that continued dysfunctional cervical postures, such as the forward head posture the participants displayed during the run, could lead to chronic neck pain. Therefore although the there is no prevalence of neck pain among the sprinters it is important to prevent the development thereof.
5.4 DEEP NECK FLEXOR ENDURANCE AND STABILITY

In patients who present with low test scores for the Craniocervical Flexion Test, the majority of researchers find that these patients complain of tension type headaches and chronic neck pain. According to Chiu, Law and Fai Chiu (2005), subjects who do not suffer chronic neck disorders and tension type headaches on average are able to achieve and hold muscle deep neck flexor contraction at 28 mmHg compared to those who suffer from neck conditions who are only able to achieve a contraction at 24 mmHg. The results of this research study found that although the majority of the athletes scored a code one (1), i.e. no disability with the Disability Neck Index, they performed poorly with the Craniocervical Flexion Test. According to the results, 69% of participants were only able to contract the deep neck flexors and increase the pressure to 22 mmHg producing a score of 10% for the Craniocervical Flexion Test. This indicates that even though it did not impact their activities of daily living, their deep neck flexors were not functioning at an optimum level and possibly impacting their sprinting technique. This result corresponds to a finding by Falla, Jull and Hodges (2004), that participants demonstrated a dysfunction in the activation of the deep neck flexors during functional activity indicating an inability of the deep neck flexors to stabilise the cervical spine and thus poor strength and endurance of the deep neck flexors. These participants all scored no or minimal disability scores when completing the Disability Neck Index. Further research is required to explore the possible reasons why patients who have deep neck flexor dysfunction score, present with low scores when completing a Disability Neck Index.
5.5 SPRINTING TECHNIQUE

The study found that all participants had an incorrect sprinting technique during the maximal velocity phase. At the point of initial contact all sprinters who participated in the video analysis made use of their hind foot or heel at the point of initial contact with the ground, allowing the step length for all sprinters to be less than sufficient. In terms of step length an amateur sprinter has a step length of approximately 1.14 times their height. Considering that the average male height in South Africa is 1.68 m and the average female height is 1.59 m, all athletes were above average height: the average step length for the female participants equates to 0.80 m and the males was approximately 1.01 m, therefore indicating that the step length for all participants was insufficient (South African Department of Health, 2003). According to Young (n. d.), a sprinter’s step length should approximately equate to 2.5 m. This supports the conclusion that the participants’ step length during the maximal velocity phase was inadequate.

The posture of the athlete during the race changed consistently for each step that was taken. During the first steps the female sprinters had the greatest head to neck angle at the point of initial contact, i.e. there was an increase in the use of the upper cervical extensors as the sprinter made contact with the ground. The study found that the male sprinters had the greatest degree of a forward head position, upper cervical extension at push off. The amount of upper cervical extension varied from step to step for all the participants. The average amount of fluctuation was 13° and ranging between 6.2° and 26.5°. The relaxed head and neck position described by Cissk (n. d.) was not achieved by any of the participants, which allows brake forces to occur causing a decrease in step length ultimately limiting the velocity during the
sprint. The position of the neck, which for these sprinters was mostly upper cervical extension, limits the amount of forward lean by placing the sprinter in an anterior pelvic tilt to compensate limiting the step length by limiting the ability of the athlete to optimize their hip flexion the swing the leg forward during the aerial phase (Novacheck, 1998).

The results from the individual statistics shows that among male sprinters the larger the step length the larger the degree in fluctuation of the head. This corresponds to findings from Hirasaki, Moore, Raphan and Cohen (1999) where they found that during locomotion there is an increase in the angle of the head as the velocity of gait is increased which was achieved by increasing the step length of the participant. This result was not found among the female participants. Hirasaki, Moore, Raphan and Cohen (1999) state that the increase in the angle of the head during increases in velocity could be due to the increase in forward lean of the trunk at higher velocities. Thus the head movement is due to compensation of the neck in order to regain stability. The systematic review found that instability causes a decrease in step length (Bezodis, Salo & Trewartha, n. d.; Dugan & Bhat, 2005; Hughes, n. d.; Moir, Sanders, Button & Glaister, 2007; Paradisis & Cooke, 2000). The goal of the maximum velocity phase of sprinting is to maintain the maximum speed obtained during the drive phase. Thus based on the above mentioned literature sprinters should have a consistent step length during the maximum velocity phase, when they are unable to maintain this step length due to instability it results in brake forces, requiring a greater amount of ground reaction forces to increase the velocity. This shows that instability in the head and trunk can negatively influence the sprinters performance, the results of the current study does not support to this finding.
5.6 THE RELATIONSHIP BETWEEN DEEP NECK FLEXOR FUNCTIONING AND SPRINTING

No significant relationships were found between variables of the sprinting technique and the Craniocervical Flexion Test; these results could be as a result of the small sample size included in the study. When doing chi-squared tests sample sizes could generate a false rejection of the null hypothesis due to a type II error. When analysing data for individuals those who performed poorly in the Craniocervical Flexion Test those athletes had a high degree of fluctuation of the angle of the head and an unsatisfactory step length. In one athlete, who had the shortest step length for all the male participants at the push off the angle of the head decreased to approximately 27˚, he showed an angle of less than 90˚ at the elbow and the slowest average speed per step for the male participants and it could be hypothesized that due to a lack of ability to stabilize the head and neck the athlete was unable to produce an efficient step length and sprint technique. Clinical data from the study suggest that poor endurance in the deep neck flexors influences a sprinter technique but this hypothesis could not be confirmed by use of statistical analysis. According to Domenesh, Sizer, Dedrick, McGilliard and Brismee (2011), state that dysfunction in the ability for the deep neck flexors to stabiliser the head is shown when the patient performs functional tasks using the upper limb. The use of the upper limb causes a delayed activation of the deep neck flexors resulting in an increase in cervical lordosis and thus a forward head posture. The participants in the current study reported that they had no head and neck pain however presented with poor deep neck flexor endurance and a fluctuating forward head posture during maximum velocity sprint. This demonstrates a possible delay in the activation of the deep neck flexors during the maximum velocity phase due to the rapid upper limb movement.
5.7 CONCLUSION

The discussion chapter described the possible reasons for the results of the study and validated or negated this finding with literature. The systematic review found various factors that influence sprinting technique, velocity was the most influential. All the factors identified are dependent on one another, thus assessing all factors that influence technique is important. The results found that even though the patients have poor deep neck flexor endurance the participants report that they did not suffer from disability. This result is consistent with literature found; it limited the study’s results due to the lack of participants that suffer from disability due to neck discomfort. This indicates the need for further research to determine that factors that influences a patients perception on the affect neck discomfort has on everyday life.

Although no statistically significant associations were found; clinical data shows that participants with poor deep neck flexor functioning have poor sprinting technique in terms of step length, posture and stability. The insignificant findings can attributed to the small sample size used in the study which influences the results of the Chi-squared test. Further research is needed in many aspects of this research study and these will be discussed in chapter six (6).
CHAPTER 6
SUMMARY, CONCLUSION, LIMITATIONS, RECOMMENDATIONS

6.1 INTRODUCTION
This chapter provides a summary of the research study which will highlight all important aspects. The chapter includes the conclusions of the study, the study limitations and finally the recommendations for further research.

6.2 SUMMARY
The aim of the study was to determine the effect deep neck flexor endurance has on sprinting technique. The deep neck flexors play an important role in maintaining stability of the head and neck and influences an individual's proprioceptive ability. The systematic review found that velocity, step length, step frequency, contact time, aerial time and ground reaction forces are biomechanical factors that influence a sprinters technique, and it also showed that these factors are dependent on one another. The study found that there was no prevalence of neck discomfort among the participants in terms of the Disability Neck Index with the majority of participants recording code one (1) or no disability. Despite this finding, participants performed poorly with the Craniocervical Flexion Test indicating reduced deep neck flexor endurance and stability for their deep neck flexors. This is consistent with a finding from by Falla, Jull and Hodges (2004) where their participants presented with poor stability in the upper cervical spine but following the Disability Neck Index the participants had a perceived disability score of one (1).
The analysis of the sprinting technique showed that all sprinters had an insufficient step length as well as poor posture and stability during the maximum velocity phase of the sprint. The average step length for all participants is approximately 1m in length. Young (n. d.) states that the average step length for a sprinter should be approximately 2.5 m, thus confirming that the step length for the participants in this study is insufficient. An average of 13° was the amount of change in head position during the maximum velocity phase showing that the athletes had poor stability throughout this phase. Descriptive statistics was used to determine the relationship between variables assessed in the study by using chi-squared testing. No significant relationships were found between the functioning of the deep neck flexors and the athletes sprinting technique. Data for each individual shows that there is a possibility that the deep neck flexors impacts the sprinting technique in terms of step length and posture but further research is required to either negate or confirm this finding.

6.3 CONCLUSIONS

From the results it can be shown that the sprinters at the University of the Western Cape athletics Club had and ineffective and incorrect sprinting technique which compromises their ability to perform at their optimum level. The study found that the athletes made use of the hind foot as the point of initial contact; had a short step length and poor stability during the race. The systematic review found that these aspects are factors that influence a sprinters ability to attain the correct sprinting technique. In addition, the study found that the athlete’s had poor endurance of deep neck flexor endurance which did not impact the athlete’s everyday activities.
The aim and objectives of the study was achieved. The study found that there was no prevalence in neck discomfort among the participants. Although the athletes presented with inadequate deep neck flexor function and incorrect sprinting technique no significant relationship exists between the two variables. Thus, concluding that deep neck flexor endurance had no effect on sprinting technique among sprinters at the University of the Western Cape Athletics Club.

6.4 LIMITATIONS

The assessment of the sprinting technique only looked at the maximum velocity phase of the sprint thus calculating the step frequency for the entire sprint was not done. Due a lack of necessary equipment the ground reaction forces could not be determined. Measurements that were not taken that could influence the outcome of the study includes the balance, proprioception, contact and aerial time for each step during the maximum velocity phase, the height of the sprinter as well as the muscle length and strength of the lower limb muscles. The latter could have allowed the researcher to exclude other variables impacting the outcomes. During the analysis of the sprinting technique, the white sticker markers used to identify the major joints were not visible when using the Dartfish Pro programme; this made the location of these joints difficult and impacts the accuracy of the measurements. None of the athletes that completed the assessment of their sprinting technique presented with neck discomfort that cause disability this limited the findings and influences the results of the chi-squared tests that were conducted.
The sample size used in the study was a small number thus allowing the possibility of a type II error when doing chi-squared tests on variables found in order to determine the relationships between them.

6.5 RECOMMENDATIONS

For future study short term recommendations include a repeat of the current study with a larger population. It is also suggested that participants from different levels expertise be included, this could provide a better indication for the importance of the neck in the acquisition of the correct technique. Lastly, all biomechanical aspects that influence sprinting technique namely step length, step frequency, contact time, aerial time, velocity, ground reaction forces and posture should be assessed.

Long term recommendations are that a pre-post-test study design should be used to evaluate the effect improving deep neck flexor function has on sprinting technique. Thus, assessing the effect a deep neck flexor programme has on sprinting technique.
REFERENCE LIST


Browne, J. (2010). Track Coach 191: Motor Control in Sprinting. Available online at: 
http://www.coachr880.com/id85.html


http://journals.lww.com/spinejournal/Abstract/2000/11150/The_Oswestry_Disability_I ndex.17.aspx


**APPENDIX 1**

**Assessing scientific admissibility and merit of published articles**

**Critical appraisal form**

**Section A: Reference of Article**

- Author(s) and Affiliation(s):
- Title of Article:
- Journal:
- Volume and Page Numbers:
- Year of Publication:

**Section B: General Methodological Issues**

For each criterion, check the appropriate box, according to how you think it is addressed: (Y= Yes, S= substandard, N= No, NC= Not Clear, NR= Not Reported, NA= Not Applicable, NQ= Not Qualified to Assess)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>A priori hypothesis clearly stated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Source population identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inclusion criteria described and appropriate (same in all groups)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exclusion criteria described and appropriate (same in all groups)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of excluded or refusal (before study) reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawals (during study) reported, explained, and reasonable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Withdrawals equal in groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample size preplanned to provide adequate statistical power</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Statistical analysis appropriate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjustment for multiple comparisons</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjustment for important variables</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Results verifiable from raw data</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Section C: Check type of study, and follow instructions:**

<table>
<thead>
<tr>
<th>Type of study</th>
<th>Check</th>
<th>Instructions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment of a diagnostic procedure</td>
<td>[ ]</td>
<td>Fill in sections D to F</td>
</tr>
<tr>
<td>Controlled trial of intervention</td>
<td>[ ]</td>
<td>Fill in sections G to I</td>
</tr>
<tr>
<td>Cohort or prognostic study</td>
<td>[ ]</td>
<td>Fill in sections J to L</td>
</tr>
<tr>
<td>Case-control study</td>
<td>[ ]</td>
<td>Fill in sections M to O</td>
</tr>
<tr>
<td>Cross-sectional study</td>
<td>[ ]</td>
<td>Fill in sections P to R</td>
</tr>
<tr>
<td>Clinical or descriptive study</td>
<td>[ ]</td>
<td>Fill in section S</td>
</tr>
<tr>
<td>Other, specify</td>
<td>[ ]</td>
<td>Fill in section S</td>
</tr>
</tbody>
</table>

**Sections D-F: Diagnostic Test**

**Section D: Brief Summary of Paper: Descriptive information (short sentences)**

Diagnostic test being assessed:

Gold standard or criteria for comparison:

Disease being diagnosed:

Main source of subjects:

Inclusion criteria:

Exclusion criteria:

Main source of data:

Time between diagnosis and test being assessed:

Number considered for enrollment:

Number enrolled:

Number included in analysis:

Statistical methods:

Other relevant information:
**Sections D-F: Diagnostic Test**

**Section E: Specific methodological issues**
(Y= Yes, S= substandard, N= No, NC= Not Clear, NR= Not Reported, NA= Not Applicable, NQ= Not Qualified to Assess); cite page number for key comments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Study setting and selection filters described and adequate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study setting and selection filters described and adequate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Appropriate spectrum of controls (disorders confused with cases)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blinded comparison with gold standard</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic criteria of gold standard adequately described</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reproducibility and observer variation of test reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tactics for carrying tests reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity and specificity reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive and negative predictive values reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Section F: Author’s key results and conclusions**

(Include quantitative estimates, e.g. sensitivity, specificity, predictive values, confidence intervals, p values)

**Continue to Section S**
Sections G-I: Intervention Trials

Section G: Brief Summary of Paper: Descriptive information (short sentences)

Treatments being compared:

Check: [ ] two treatment arms [ ] greater than two treatment arms

Design:

Check: [ ] efficacy trial [ ] effectiveness trial

Method of assignment to treatment group:

Outcomes ascertained:

Main source of subjects:

Inclusion criteria:

Exclusion criteria:

Main source of data:

Duration of follow-up:

Number considered for enrollment:

Number enrolled:

Number included in analysis:

Statistical methods:

Other relevant information:
# Sections G-I: Intervention Trials

## Section H: Specific methodological issues

(Y= Yes, S= substandard, N= No, NC= Not Clear, NR= Not Reported, NA= Not Applicable, NQ= Not Qualified to Assess); cite page number for key comments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randomization properly done</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline comparability reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same data collection for all arms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjects blinded to treatment assignment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Care givers blinded to treatment assignment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Treatments clearly described</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co interventions monitored</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compliance monitored and equal in all groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side effects assessed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcomes defined, measurable, and valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blind assessment of outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Section I: Author's key results and conclusions

(Include quantitative estimates, e.g. relative risk, reduction in risk, confidence intervals, and p values)

**Continue to Section S**
Sections J-L: Cohort or prognostic study

Section J: Brief Summary of Paper: Descriptive information (short sentences)

Exposure/prognostic factors:

Design:

Check: [ ] single cohort       [ ] two or more cohorts

Outcomes ascertained:

Main source of subjects:

Inclusion criteria:

Exclusion criteria:

Main source of data:

Duration of follow-up:

Number considered for enrollment:

Number enrolled:

Number included in analysis:

Statistical methods:

Other relevant information:
Sections J-L: Cohort or prognostic study

Section K: Specific methodological issues

(Y= Yes, S= substandard, N= No, NC= Not Clear, NR= Not Reported, NA= Not Applicable, NQ= Not Qualified to Assess); cite page number for key comments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zero time identified</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baseline comparability reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same data collection in all groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Important baseline variables measured, valid and reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure adequately measured (previous, at entry, during study)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Regular visits during follow up</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co exposures monitored</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Duration of follow-up adequate</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcomes defined, measurable, and valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blind assessment of outcomes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Section L: Author's key results and conclusions

(Include quantitative estimates, e.g. relative risk, attributable risk, confidence intervals, p values)

Continue to Section S
Sections M-O: Case Control Study

Section M: Brief Summary of Paper: Descriptive information (short sentences)

Exposure factors:

Design:

Check: [ ] single control group [ ] two or more control groups
[ ] matched [ ] unmatched

Outcomes ascertained:

Main source of subjects:

<table>
<thead>
<tr>
<th></th>
<th>Hospital</th>
<th>Community</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
<tr>
<td>Controls</td>
<td>[ ]</td>
<td>[ ]</td>
<td>[ ]</td>
</tr>
</tbody>
</table>

Inclusion criteria:

Cases:

Controls:

Check: [ ] Incident [ ] Prevalent

Exclusion criteria:

Cases:

Controls:

Main source of data:

[ ] Interviewer [ ] Self-questionnaire [ ] Patient records

Duration of follow-up:

Number considered for enrollment:

Number enrolled:

Number included in analysis:

Statistical methods:

Other relevant information:
### Sections M-O: Case Control Study

#### Section N: Specific methodological issues

(Y = Yes, S = substandard, N = No, NC = Not Clear, NR = Not Reported, NA = Not Applicable, NQ = Not Qualified to Assess); cite page number for key comments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similar population sources for cases and controls (time, place, potential for exposure)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Referral and sampling independent of exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random selection of controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic criteria for cases clear, precise and valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Date of diagnosis for cases operationally defined</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ascertainment of disease similar in cases and controls</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comparison of cases and controls at enrollment reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All aspects of exposure measured (level, dose, duration,...)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure adequately measured (same in all groups; blind)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-exposure measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall bias controlled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data collection valid and reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Analysis according to level of exposure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of matching assessed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

#### Section O: Author’s key results and conclusions

(Include quantitative estimates, e.g. relative risk, reduction in risk, confidence intervals, and p values)

---

Continue to Section S
Sections P-R: Cross-sectional Study

Section P: Brief Summary of Paper: Descriptive information (short sentences)

Exposure factors:

Outcomes ascertained:

Main source of subjects:

Inclusion criteria:

Exclusion criteria:

Main source of data:

Follow-up subsequent to cross-sectional study:

[ ] Yes  [ ] No

Number considered for enrollment:

Number enrolled:

Number included in analysis:

Statistical methods:

Other relevant information:
### Sections P-R: Cross-sectional Study

#### Section Q: Specific methodological issues

(Y= Yes, S= substandard, N= No, NC= Not Clear, NR= Not Reported, NA= Not Applicable, NQ= Not Qualified to Assess); cite page number for key comments.

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Y</th>
<th>S</th>
<th>N</th>
<th>NC</th>
<th>NR</th>
<th>NA</th>
<th>NQ</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Similar sampling procedures for all subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similar ascertainment of exposure for all subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Similar referral and diagnostic procedures for all subjects</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diagnostic criteria for diseased clear, precise, and valid</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Characteristics of subjects at enrollment reported</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All aspects of exposure measured (level, dose, duration)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Co-exposure measured</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recall bias controlled</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Data collection valid and reliable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effect of duration of disease discussed</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Section R: Author’s key results and conclusions

(Include quantitative estimates, e.g. relative risk, reduction in risk, confidence intervals, and p values)

---

Continue to Section S
Section S: Conclusions and assessment of the article

I. Strengths of the paper

II. Weaknesses of the paper

III. Reviewer’s conclusions (if different from author’s)

IV. Clinical relevance

   Highly relevant [ ]
   Relevant [ ]
   Questionable relevance [ ]
   Irrelevant [ ]
   Not qualified to evaluate [ ]

V. Scientific merit

   Very good [ ]
   Good [ ]
   Scientifically admissible [ ]
   Scientifically inadmissible [ ]
Section S: Conclusions and assessment of the article (cont.)

VI. Type of study:

- Randomized controlled trial conducted & interpreted properly [ ]
- Controlled trial with evidence of comparability of groups [ ]
- Well-designed cohort or case-control study [ ]
- Case series or cohort study without controls [ ]
- Opinions of competent authorities based on clinical experience, descriptive studies, research, or studies not classified in the preceding categories [ ]
- Other, including substandard of the above [ ]

VII. Recommendations concerning possible additional specialized reviewer

VIII. Should any article referenced in the article be added to the list of papers to be criticized? If yes, which?
APPENDIX 2

Critical Appraisal Skills Programme (CASP)
making sense of evidence

10 questions to help you make sense of randomised controlled trials

How to use this appraisal tool
Three broad issues need to be considered when appraising the report of a randomised controlled trial:
• Is the trial valid?
• What are the results?
• Will the results help locally?

The 10 questions on the following pages are designed to help you think about these issues systematically.

The first two questions are screening questions and can be answered quickly. If the answer to both is “yes”, it is worth proceeding with the remaining questions.

You are asked to record a “yes”, “no” or “can’t tell” to most of the questions. A number of italicised prompts are given after each question.

These are designed to remind you why the question is important. Record your reasons for your answers in the spaces provided.

The 10 questions are adapted from Guyatt GH, Sackett DL, and Cook DJ, Users’ guides to the medical literature. II. How to use an article about therapy or prevention. JAMA 1993; 270 (21): 2598-2601 and JAMA 1994; 271(1): 59-63

© Public Health Resource Unit, England (2006). All rights reserved.

No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying, recording or otherwise without the prior written permission of the Public Health Resource Unit. If permission is given, then copies must include this statement together with the words “© Public Health Resource Unit, England 2006”. However, NHS organisations may reproduce or use the publication for non-commercial educational purposes provided the source is acknowledged. © Public Health Resource Unit, England (2006). All rights reserved.
Screening Questions

1. Did the study ask a clearly-focused question? □ Yes □ Can’t tell □ No
   Consider if the question is ‘focused’ in terms of:
   — the population studied
   — the intervention given
   — the outcomes considered

2. Was this a randomised controlled trial (RCT) and was it appropriately so? □ Yes □ Can’t tell □ No
   Consider:
   — why this study was carried out as an RCT
   — if this was the right research approach for the question being asked

Is it worth continuing?

Detailed Questions

3. Were participants appropriately allocated to intervention and control groups? □ Yes □ Can’t tell □ No
   Consider:
   — how participants were allocated to intervention and control groups. Was the process truly random?
   — whether the method of allocation was described. Was a method used to balance the randomization, e.g. stratification?
   — how the randomization schedule was generated and how a participant was allocated to a study group
   — if the groups were well balanced. Are any differences between the groups at entry to the trial reported?
   — if there were differences reported that might have explained any outcome(s) (confounding)
4. Were participants, staff and study personnel ‘blind’ to participants’ study group?

☐ Yes ☐ Can’t tell ☐ No

Consider:

— the fact that blinding is not always possible
— if every effort was made to achieve blinding
— if you think it matters in this study
— the fact that we are looking for ‘observer bias’

5. Were all of the participants who entered the trial accounted for at its conclusion?

☐ Yes ☐ Can’t tell ☐ No

Consider:

— if any intervention-group participants got a control-group option or vice versa
— if all participants were followed up in each study group (was there loss-to-follow-up?)
— if all the participants’ outcomes were analysed by the groups to which they were originally allocated (intention-to-treat analysis)
— what additional information would you liked to have seen to make you feel better about this

6. Were the participants in all groups followed up and data collected in the same way?

☐ Yes ☐ Can’t tell ☐ No

Consider:

— if, for example, they were reviewed at the same time intervals and if they received the same amount of attention from researchers and health workers. Any differences may introduce performance bias.

7. Did the study have enough participants to minimise the play of chance?

☐ Yes ☐ Can’t tell ☐ No

Consider:

— if there is a power calculation. This will estimate how many participants are needed to be reasonably sure of finding something important (if it really exists and for a given level of uncertainty about the final result).
8. How are the results presented and what is the main result?

Consider:
- if, for example, the results are presented as a proportion of people experiencing an outcome, such as risks, or as a measurement, such as mean or median differences, or as survival curves and hazards
- how large this size of result is and how meaningful it is
- how you would sum up the bottom-line result of the trial in one sentence

9. How precise are these results?

Consider:
- if the result is precise enough to make a decision
- if a confidence interval were reported. Would your decision about whether or not to use this intervention be the same at the upper confidence limit as at the lower confidence limit?
- if a p-value is reported where confidence intervals are unavailable

10. Were all important outcomes considered so the results can be applied?

□ Yes □ Can’t tell □ No

Consider whether:
- the people included in the trial could be different from your population in ways that would produce different results
- your local setting differs much from that of the trial
- you can provide the same treatment in your setting

Consider outcomes from the point of view of the:
- individual
- policy maker and professionals
- family/carers
- wider community

Consider whether:
- any benefit reported outweighs any harm and/or cost. If this information is not reported can it be filled in from elsewhere?
- policy or practice should change as a result of the evidence contained in this trial
APPENDIX 3

NECK PAIN DISABILITY INDEX QUESTIONNAIRE

PLEASE READ: This questionnaire is designed to enable us to understand how much your neck pain has affected your ability to manage your everyday activities. Please answer each section by circling the ONE CHOICE that most applies to you. We realize that you may feel that more than one statement may relate to you, but PLEASE JUST CIRCLE THE ONE CHOICE WHICH MOST CLOSELY DESCRIBES YOUR PROBLEM RIGHT NOW.

<table>
<thead>
<tr>
<th>SECTION 1 - Pain Intensity</th>
<th>SECTION 6 - Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. I have no pain at the moment.</td>
<td>A. I can concentrate fully when I want to with no difficulty.</td>
</tr>
<tr>
<td>B. The pain is very mild at the moment.</td>
<td>B. I can concentrate fully when I want to with slight difficulty.</td>
</tr>
<tr>
<td>C. The pain is moderate at the moment.</td>
<td>C. I have a fair degree of difficulty in concentrating when I want to.</td>
</tr>
<tr>
<td>D. The pain is fairly severe at the moment.</td>
<td>D. I have a lot of difficulty in concentrating when I want to.</td>
</tr>
<tr>
<td>E. The pain is very severe at the moment.</td>
<td>E. I have a great deal of difficulty in concentrating when I want to.</td>
</tr>
<tr>
<td>F. The pain is the worst imaginable at the moment.</td>
<td>F. I cannot concentrate at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION 2 - Personal Care (Washing, Dressing, etc.)</th>
<th>SECTION 7 - Work</th>
</tr>
</thead>
<tbody>
<tr>
<td>I can look after myself normally without causing extra pain.</td>
<td>A. I can do as much work as I want to.</td>
</tr>
<tr>
<td>A. I can look after myself normally, but it causes extra pain.</td>
<td>B. I can only do my usual work, but no more.</td>
</tr>
<tr>
<td>B. It is painful to look after myself and I am slow and careful.</td>
<td>C. I can do most of my usual work, but no more.</td>
</tr>
<tr>
<td>C. I need some help, but manage most of my personal care.</td>
<td>D. I cannot do my usual work.</td>
</tr>
<tr>
<td>D. I need help every day in most aspects of self-care.</td>
<td>E. I can hardly do any work at all.</td>
</tr>
<tr>
<td>E. I do not get dressed; I wash with difficulty and stay in bed.</td>
<td>F. I cannot do any work at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION 3 - Lifting</th>
<th>SECTION 8 - Driving</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. I can lift heavy weights without extra pain.</td>
<td>A. I can drive my car without any neck pain.</td>
</tr>
<tr>
<td>B. I can lift heavy weights, but it gives extra pain.</td>
<td>B. I can drive my car as long as I want with slight pain in my neck.</td>
</tr>
<tr>
<td>C. Pain prevents me from lifting heavy weights off the floor, but I can manage if they are conveniently positioned, for example, on a table.</td>
<td>C. I can drive my car as long as I want with moderate pain in my neck.</td>
</tr>
<tr>
<td>D. Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.</td>
<td>D. I cannot drive my car as long as I want because of moderate pain in my neck.</td>
</tr>
<tr>
<td>E. I can lift very light weights.</td>
<td>E. I can hardly drive at all because of severe pain in my neck.</td>
</tr>
<tr>
<td>F. I cannot lift or carry anything at all.</td>
<td>F. I cannot drive my car at all.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SECTION 4 - Reading</th>
<th>SECTION 9 - Sleeping</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. I can read as much as I want to with no pain in my neck.</td>
<td>A. I have no trouble sleeping.</td>
</tr>
<tr>
<td>B. I can read as much as I want to with slight pain in my neck.</td>
<td>B. My sleep is slightly disturbed (less than 1 hour sleepless).</td>
</tr>
<tr>
<td>C. I can read as much as I want to with moderate pain in my neck.</td>
<td>C. My sleep is mildly disturbed (1-2 hours sleepless).</td>
</tr>
<tr>
<td>D. I cannot read as much as I want because of moderate pain in my neck.</td>
<td>D. My sleep is moderately disturbed (2-3 hours sleepless).</td>
</tr>
<tr>
<td>E. I cannot read as much as I want because of severe pain in my neck.</td>
<td>E. My sleep is greatly disturbed (3-5 hours sleepless).</td>
</tr>
<tr>
<td>F. I cannot read at all.</td>
<td>F. My sleep is completely disturbed (5-7 hours sleepless).</td>
</tr>
</tbody>
</table>
SECTION 5 - Headaches
A. I have no headaches at all.
B. I have slight headaches which come infrequently.
C. I have moderate headaches which come infrequently.
D. I have moderate headaches which come frequently.
E. I have severe headaches which come frequently.
F. I have headaches almost all the time.

SECTION 10 - Recreation
A. I am able to engage in all of my recreational activities with no neck pain at all.
B. I am able to engage in all of my recreational activities with some pain in my neck.
C. I am able to engage in most, but not all of my recreational activities because of pain in my neck.
D. I am able to engage in a few of my recreational activities because of pain in my neck.
E. I can hardly do any recreational activities because of pain in my neck.
F. I cannot do any recreational activities at all.

SCORING TECHNIQUE FOR NECK DISABILITY INDEX
1. Each of the 10 sections is scored separately (0 to 5 points each) and then added up (max. total = 50).

EXAMPLE:
Section 1. Pain Intensity Point Value
A. ______ I have no pain at the moment 0
B. ______ The pain is very mild at the moment 1
C. ______ The pain is moderate at the moment 2
D. ______ The pain is fairly severe at the moment 3
E. ______ The pain is very severe at the moment 4
F. ______ The pain is the worst imaginable 5

2. If all 10 sections are completed, simply double the patient's score.
3. If a section is omitted, divide the patient's total score by the number of sections completed times 5.

FORMULA:

\[ \frac{\text{PATIENT'S SCORE}}{\text{# OF SECTIONS COMPLETED X 5}} \times 100 = \text{______} \% \text{ DISABILITY} \]

EXAMPLE:
If 9 of 10 sections are completed, divide the patient's score by 9 X 5 = 45; if........

Patient's Score: 22
Number of sections completed: 9 (9 X 5 = 45)
\[ 22/45 \times 100 = 48 \% \text{ disability} \]

APPENDIX 4

Craniocervical Flexion Test

Patient: _______________________________________________________________

Date: _________________________________________________________________

<table>
<thead>
<tr>
<th>Pressure</th>
<th>Achievement</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>22 mmHg</td>
<td>Able to achieve position</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Able to hold position for 10 seconds</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24 mmHg</td>
<td>Able to achieve position</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Able to hold position for 10 seconds</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26 mmHg</td>
<td>Able to achieve position</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Able to hold position for 10 seconds</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28 mmHg</td>
<td>Able to achieve position</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Able to hold position for 10 seconds</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30 mmHg</td>
<td>Able to achieve position</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td></td>
<td>Able to hold position for 10 seconds</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

Score: □
INFORMATION SHEET

Project Title: The effect of deep neck flexor muscle endurance and stability on the sprinting technique of young sprinters at The University of the Western Cape Athletics Club.

What is this study about?
This is a research project being conducted by Andrea Anders at the University of the Western Cape. We are inviting you to participate in this research project because you are a junior sprinter competing at club level for the Western Province athletics in the 2011-2012 season. The purpose of this research project is to determine the effect a muscle group in your neck, the deep neck flexors, has on your sprint technique.

What will I be asked to do if I agree to participate?
You will be required to fill out a form called the Disability Neck Index that shows the researcher if you have any problems with your neck and how it impacts on your everyday activities. Thereafter a muscle function test of your neck muscles will be done. A small amount of the participants in the study will then be selected and your sprint technique will be analyzed. The recording of your technique will be looked at by professionals in the athletics field to identify any problems and this will be recorded on a data collection sheet.

Would my participation in this study be kept confidential?
We will do our best to keep your personal information confidential. To help protect your confidentiality, your name will not be placed on the data collection sheet - you will be allocated a number, this number will refer to your recording and data sheet so that any association. The description of your technique will only look at your movements and no other sensitive information. The findings of the study will report on the results of the programme in general, you will not be personally identified and no sensitive information will be used. If we write a report or article about this research project, your identity will be protected to the maximum extent possible.

Audio taping/Videotaping/Photographs/Digital Recordings
This research project involves making a video recording of your sprint technique. The recordings will be done to analyse the technique in slow motion to look specifically at each component in detail. The recordings will be kept in a safe and secure place.

___ I agree to be videotaped during my participation in this study.
___ I do not agree to be videotaped during my participation in this study.
What are the risks of this research?
There are no known risks involved with the neck assessment that will be performed. There may be some risks involved in the sprinting analysis; these include any injury that could normally occur with sprinting and no added risk can be done.

What are the benefits of this research?
The benefits to you include an analysis of your technique that can help you in understanding which areas should be worked on in order to improve technique and performance. This research is not specifically designed to help you personally, but the results may help the investigator learn more about the effect the neck muscles have on an athlete’s sprinting performance and in turn the information could assist other athletes and coaches. We hope that, in the future, other people might benefit from this study through improved understanding of the importance of the neck muscles and thus create training programmes around this idea.

Do I have to be in this research and may I stop participating at any time?
Your participation in this research is completely voluntary. You may choose not to take part at all. If you decide to participate in this research, you may stop participating at any time. If you decide not to participate in this study or if you stop participating at any time, you will not be penalized or lose any benefits to which you otherwise qualify.

Is any assistance available if I am negatively affected by participating in this study?
If any injury occurs due to the assessments, this will be addressed and the process will be stopped.

What if I have questions?
This research is being conducted by Andrea Anders, at the Physiotherapy Department at the University of the Western Cape. If you have any questions about the research study itself, please contact Andrea Anders at: 074 9307 213 or 2632386@uwc.ac.za

Should you have any questions regarding this study and your rights as a research participant or if you wish to report any problems you have experienced related to the study, please contact:
Head of Department: Prof. A. Rhoda
Dean of the Faculty of Community and Health Sciences:
University of the Western Cape
Private Bag X17
Bellville 7535

This research has been approved by the University of the Western Cape’s Senate Research Committee and Ethics Committee.
CONSENT FORM

Title of Research Project: The effect of deep neck flexor muscle endurance and stability on the sprinting technique of young sprinters at The University of the Western Cape Athletics Club.

The study has been described to me in language that I understand and I freely and voluntarily agree to participate. My questions about the study have been answered. I understand that my identity will not be disclosed and that I may withdraw from the study without giving a reason at any time and this will not negatively affect me in any way.

Participant’s name: ………………………..  
Participant’s signature: ……………………………
Witness: ……………………………………… 
Date: ……………………………

Should you have any questions regarding this study or wish to report any problems you have experienced related to the study, please contact the study coordinator:

Study Coordinator’s Name: Prof. J. M. Frantz  
University of the Western Cape  
Private Bag X17, Belville 7535  
Telephone: (021)959- 2542  
Email: jfrantz@uwc.ac.za
23 May 2011
Athletics club coaches

Dear Sir/Madam

I am a Masters student in physiotherapy currently doing research at the University of the Western Cape which focuses on young short distance sprinter’s technique. The aim of the study is to determine how a group of muscles known as the deep neck flexors influences the technique of short distance athletes at club level in Cape Town.

The athletes who consent to participation in the study will have to complete a questionnaire regarding pain in the neck, as well as an assessment of the neck to determine whether they have discrepancies in this group of muscles. Thereafter a video analysis of their sprinting technique will be done and a relationship between these findings will be drawn up.

The study has been approved by the Higher Degrees and Ethical boards of the University of the Western Cape and thus ensures that the study’s methodology has been approved ethically and no harm or negative consequences will be caused by the research. The athletes’ participation is entirely voluntary and they may withdraw at any time.

Thank you for your time

____________________________________
Andrea Anders
Masters student
Department of physiotherapy
The University of the Western Cape
15 November 2012

To Whom It May Concern

I hereby certify that the Senate Research Committee of the University of the Western Cape has approved the methodology and ethics of the following research project by:
Ms A Anders (Physiotherapy)

Research Project: The effect of deep neck flexor muscle endurance and stability on the sprinting technique of young sprinters at the University of the Western Cape.

Registration no: 11/4/7

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
Research Ethics Committee Officer
University of the Western Cape

Private Bag X17, Bellville 7535, South Africa
T: +27 21 959 2988/2948, F: +27 21 959 3170
E: pjosias@uwc.ac.za www.uwc.ac.za
Appendix 9

PROTOCOL

BIOMECHANICAL FACTORS THAT INFLUENCE’S SPRINTING TECHNIQUE
AMONG SHORT DISTANCE SPRINTER’S: A SYSTEMATIC REVIEW

BACKGROUND AND RATIONALE FOR ASSESSMENT

Sprinting is a track event that requires an athlete to cover a required distance in the shortest amount of time possible. Research has highlighted that athletes have their own individual running or sprinting style, but has noted that there are key aspects that sprinters need to master in order to improve their performance by decreasing their time (Dintiman, et al, 2003). Thus all athletes are shown the basic technique at a young age in order for them to incorporate this technique into their sprinting style. This basic running style is important to master in order to, not only improve performance, but to minimise the risk of injury when running (Dintiman, et al, 2003).

For an athlete to improve their overall performance and reduce the risk of injury they must be aware of the three phases that exist during the sprint race and therefore master all three aspects so that they can achieve their optimal performance.

The race begins with a block start leading into the acceleration phase; it is required that all athletes start with starting blocks therefore the athlete must become familiar with the blocks, the rules and the biomechanics of a sprint start. This is very important because the athlete must feel comfortable in the blocks and must be able to use them effectively. If an athlete is not comfortable within the blocks it hampers their ability to sprint at their best during the rest of the race (The American Sport Education Programme, 2008). The acceleration phase is where the athlete needs to
drive out of the blocks, gradually becoming erect and transitioning into the Maximum Velocity phase - this is where the athlete is at full speed.

Understanding correct sprinting technique and the factors that influences the athletes’ ability to achieve this is vital for both athletes and coaches. Correct technique allows all body systems that determine the individual’s ability to sprint function optimally in order for the individual to perform at the ideal level. The correct sprinting techniques also minimizes the overuse of joints and muscles when placed in the incorrect positions thus limiting injury and directly benefitting the athletes performance. Thus in order for an athlete to perform at their best a clear understanding of the correct posture and biomechanics involved with sprinting is essential for the athlete as well as the coach, so the he/she can guide the athlete (Williams, 2007).

**AIM OF THE REVIEW**

The aim of the systematic review is to determine what factors influences the performance and sprinting technique among short distance sprinters.

**OBJECTIVES OF THE REVIEW**

- To determine what factors that influence the use of correct sprinting technique
- To determine how these factors influence sprinting technique
CRITERIA FOR CONSIDERING STUDIES FOR THIS REVIEW

Type of studies

All articles and theses with experimental design, randomized control trials, controlled trials, pre and post-test designs and descriptive study designs will be included in the systematic review. Studies that will be excluded are systematic reviews and all qualitative research.

Type of participants

The studies should include male and female sprinters of various level of expertise. Studies included must focus on sprinting short distance track events namely 100m and 200m, those that include sprinting for other sports such as soccer or rugby will be excluded. Studies that describe the technique for 400m sprinters will also be excluded.

Types of interventions

Interventions used in the studies must be used in order to improve the technique or to determine the influence muscle groups have in determining performance and technique of the athletes.

Types of Comparison

No comparisons will be made.
Types of outcome measures

Outcome measures that will be included are:

- Stride length
- Step frequency
- Ground contact time
- Speed/velocity
- Lower limb strength

SEARCH STRATEGY FOR IDENTIFICATION OF STUDIES

The databases that will be used in the review include EBSOCHOST, Science Direct, CINHAL plus, Med Scape, Pub Med and Biomed Central. The criteria for inclusion in the study are:

- All publications must be in English (or available in English)
- Must describe the sprinting technique of short distance sprinters
- Will include publications that describe aspects that influences sprint technique

METHODS OF THE REVIEW

Data Selection

Articles will be considered for inclusion firstly based on the title. Thereafter articles key points and abstract will be analysed and relevant articles will be included. Articles will further be analysed based on the methods of the studies.
Data extraction
Data extracted from articles used in the study that are cohort and randomized control trials will be done using the CASP tool. All other articles’ data will be extracted using a critical appraisal tool from Stanford University’s paediatric department. Data will be extracted and summarised from all included articles by two independent researchers. The methods of all the articles will be analysed in terms of study population, inclusion and exclusion criteria, the outcome measures, interventions used, results and the author’s conclusions.

Data synthesis
Results from the systematic review will be analysed and reported on. Articles with a critical appraisal score of 50% and more will be included for analysis in the study. The methods of each article will be broken down and tabulated.

References


This serves to confirm that the Master’s thesis of Andrea Anders entitled: “The Effect of Deep Neck Flexor Muscle Endurance and Stability on the Sprinting Technique of Young Sprinters at the University of the Western Cape Athletics Club” has been proof-read and edited for submission to the University of the Western Cape.

Lieneke Thyssen
Editor
Turnitin Originality Report

MSc Thesis Andrea by Andrea Anders

From Andrea Thesis submission (MSc thesis submission)

- Processed on 14-Nov-2012 10:49 PM PST
- ID: 284829222
- Word Count: 18364

Similarity Index
5%

Similarity by Source
Internet Sources:
  4%
Publications:
  2%
Student Papers:
  2%