A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng

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DECLARATION

I, Chantelle Etsebeth, declare that this research project is my own work. It is being submitted for the degree Master of Medicine in the branch of Biokinetics at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other university.

Chantelle Etsebeth

1st day of June 2020

ABSTRACT

BACKGROUND: Rugby is one of the most popular sporting types around the world with a total amount 2.82 million players in 2015 and 3.2 million in 2016. The association between cervical spine muscle weakness, range of motion, and an increased risk for cervical injuries needs to be established, particularly in a South African context, where injury incidence seems to be higher compared to global incidence. The occurrence of these cervical spine injuries has the potential to have a major influence on the quality of life, of rugby players following injury as well as a potential loss of life.

AIM: This study was aimed to identify the prevalence and frequency at which cervical spine injuries occurred within a South African rugby population. It also aspired to identify whether weak neck musculature, limitation in cervical range of motion, and poor posture are associated with an increased risk for cervical spine injuries. This study also aimed to establish sport-specific norms for neck strength for this population, which has the potential to aid in return to sport clearance.

OBJECTIVES:

1. To determine the occurrence of cervical spine injuries amongst senior rugby players.
2. To determine the posture of senior rugby players.
3. To determine the cervical range of motion of senior rugby players.
4. To determine isometric neck strength of senior rugby players.
5. To determine if there is a relationship between cervical muscle weakness and poor posture.
6. To determine sport-specific strength norms, for the cervical spine, for senior rugby players.

METHODS: A descriptive, cross-sectional study were a total of 139 male (mean age 20.42 ± 3.29 years) senior rugby players participated in this study. A personal detail and injury screening questionnaire, and Neck Disability Index (NDI) questionnaire was completed prior to testing taking place. The Multi-Cervical Unit (MCU) was used to test the cervical range of motion as well as isometric neck strength in multi-plane patterns of movement for the players. Cervical ROM was tested in flexion, extension, lateral flexion, and rotation. This was followed by cervical spine strength tests for flexion, extension, and lateral flexion. Angles used were neutral (0°), 25° and 45° for left and right. A Mc Neymar's, Fisher's exact and a Pearson's correlation test was used to draw comparisons. Statistical significance of 95% ($P < 0.05$) was deemed as acceptable.

RESULTS: All 139 participants were included in the final analysis of the study. ***Injury occurrence rate***: 83 players stated that they had previously sustained a concussion of which the majority were classified as mild (63%) (n = 52 players). ***Posture***: A mean overall posture rating score of 7.38 ± 1.05 (out of 10) was recorded for the players. The anatomical body site indicating the highest/best overall score was the hips (8.35 ± 2.36 out of 10) while the lowest score was found for the ankle region (6.26 ± 2.26 out of 10). ***Cervical ROM***: Comparisons made with the general population norms indicated that the population tested below or less than the specified cervical ROM norms for flexion 4.32% (n = 6), extension 15.83% (n = 22), left lateral flexion 7.19% (n = 10), right lateral flexion 4.32% (n = 6), left rotation 27.34% (n = 38), and right rotation 25.18% (n = 35). ***Isometric neck strength***: Seventy-two percent (n = 100) of the participants identified that they had never participated in neck strengthening protocols throughout their rugby careers. Neutral cervical neck flexion for senior rugby players indicated an average of 13.26 ± 5.78 (kg) with 60.43% (n = 84) of the players testing above the general population norm. Strength measured for flexion at 25° for the left and right side indicated averages of 12.07 ± 4.79 (kg) and 11.80 ± 4.23 (kg) respectively. Strength at 25° for left and right, the bulk of players tested stronger than the population norm (left n = 84; right n = 81). Flexion at 45° left and right showed an average of 11.28 ± 3.71(kg) and 11.56 ± 5.41(kg), with most players also measuring stronger than the general population norm, (left n = 82; right n = 84). ***Neck strength and posture***: a statistical significance was found between posture and cervical: flexion at 25º left and right; 45º left and right; neutral extension (0 º); extension at 25º left and right; extension at 45º left and right; Left and right lateral flexion at neutral (0º); left and right lateral flexion at 25º, and left and right lateral flexion at 45º. The rating of the neck, hips, spine, and lower back were the four body regions that identified the correlation results. Overall posture rating score also resulted in significant results for four of the angles tested. ***Sport-specific strength norms***: Strength norms were developed for the population.

CONCLUSION: This study concluded that there is a positive association between the limitations in cervical ROM and posture abnormalities, and an increased risk of cervical spine and head injuries in senior South African rugby players. It also found that even though the majority of rugby players tested above the general population norm for cervical spine strength, at least one of the angles tested, fell below the general population norm which for the biggest majority was for cervical extension. No significant association was found between poor posture and strength and an increased risk of obtaining cervical spine- and head injuries in this population.

DEDICATION

In loving memory of my grandparents: Jacoba van Gastel, Herman van Gastel and Jan Etsebeth.

In honour of all rugby players who had to give up their dreams of participating in the game of rugby or lost their lives due to cervical spine injuries.

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TABLE OF CONTENTS

Page no.

DECLARATION ii
ABSTRACT iii
DEDICATION v
ACKNOWLEDGEMENTS vi
TABLE OF CONTENTS vii
LIST OF FIGURES x
LIST OF TABLES xi
LIST OF DEFINITIONS xiii
LIST OF ABBREVIATIONS xvi
LIST OF APPENDICES xvii
CHAPTER 1: PROBLEM IDENTIFICATION 1
1.1 INTRODUCTION 1
1.2 MOTIVATION 3
1.3 RESEARCH QUESTION 3
1.4 AIM 4
1.5 OBJECTIVES 4
1.6 HYPOTHESIS 4
1.7 NULL HYPOTHESIS 4
CHAPTER 2: LITERATURE REVIEW 5
2.1 INTRODUCTION 5
2.1.1 CERVICAL SPINE INJURIES IN RUGBY PLAYERS 5
2.1.1.1 Occurrence of cervical spine injuries 5
2.1.1.2 Risk factors related to an increased prevalence of injuries 7
2.1.1.3 Mechanisms of injury leading to an increased rate of injury 8
2.1.1.4 Concussions in rugby players 12
2.1.2 ANATOMICAL STRUCTURES OF THE CERVICAL SPINE 18
2.1.3 RELATIONSHIP BETWEEN POSTURE AND CERVICAL SPINE INJURIES 20
2.1.4 CERVICAL ROM AND STRENGTH RELATED TO INCREASED RISKS FOR INJURIES 21
2.1.4.1 Cervical ROM 21
2.1.4.2 Cervical strength 22
2.1.4.3 Multi-cervical unit 23
CHAPTER 3: METHODOLOGY 25
3.1 STUDY DESIGN 25

3.2 SITE OF STUDY 25
3.3 STUDY POPULATION 25
3.3.1 Selection / Recruitment of subjects 25
3.3.2 Sample size 25
3.3.3 Inclusion and exclusion criteria 26
3.4 TESTING PROCEDURES AND EQUIPMENT 26
3.5 DATA COLLECTION METHODS 31
3.6 DATA ANALYSIS 31
3.7 ETHICAL CONSIDERATIONS 32
CHAPTER 4: RESULTS 33
4.1 INTRODUCTION 33
4.2 DEMOGRAPHIC INFORMATION 33
i. Age 33
ii. Playing years and level of play 34
iii. Playing gear 35
iv. Neck disability index (NDI) 35
4.3 OBJECTIVE 1: 37
OCCURRENCE OF CERVCIAL SPINE INJURIES AMONGST SENIOR RUGBY PLAYERS 37
4.4 OBJECTIVE 2: 41
POSTURE OF SENIOR RUGBY PLAYERS 41
CERVICAL RANGE OF MOTION OF SENIOR RUGBY PLAYERS 43
4.6 OBJECTIVE 4: 45
TO DETERMINE ISOMETRIC NECK STRENGTH OF SENIOR RUGBY PLAYERS 45
4.6.1 Cervical spine strength in flexion 46
4.7 OBJECTIVE 5: 52
TO DETERMINE IF THERE IS A RELATIONSHIP BETWEEN CERVICAL MUSCLE WEAKNESS AND POOR POSTURE 52
4.8 OBJECTIVE 6: 56
SPORT SPECIFIC CERVICAL SPINE STRENGTH NORMS FOR SENIOR RUGBY PLAYERS 56
4.8.1 u/19 rugby players – Forwards 56
4.8.2 u/19 rugby players - Backs 57
4.8.3 u/21 rugby players - Forwards 58
4.8.4 u/21 rugby players - Backs 59
4.8.5 Senior rugby players - Forwards 59
4.8.6 Senior rugby players - Backs 60

CHAPTER 5: DISCUSSION 62
5.1 INTRODUCTION 62
5.1.1 Demographic information 62
5.1.2 Occurrence of cervical spine injuries in senior rugby players 63
5.1.3 Posture of senior rugby players 65
5.1.4 Cervical ROM of senior rugby players 67
5.1.5 Isometric neck strength of senior rugby players 68
5.1.6 Relationship between cervical muscle weakness and posture 69
5.1.7 Sport-specific strength norms 70
CHAPTER 6: CONCLUSION, STRENGTHS & LIMITATIONS OF STUDY AND RECOMMENDATIONS 72
6.1 CONCLUSIONS 72
6.2 STRENGTHS OF STUDY 74
6.3 LIMITATIONS OF STUDY 74
6.4 RECOMMENDATIONS FOR FUTURE STUDIES 74
REFERENCES 77
APPENDICES 86

LIST OF FIGURES

Figure 3.1: Battery of tests conducted on senior male rugby players (n = 139) 27

Figure 4. 1: Protective gear used by South African senior rugby players (n = 139) 355
Figure 4.2: Number of players identifying headaches as a symptom using the NDI (n = 139) 36
Figure 4.3: Number of senior rugby players that identified having difficulty with concentrating using the NDI (n=139) 36
Figure 4.4: Total number of reported concussions sustained by senior male rugby players (n=139) 399
Figure 4. 5: Concussion symptoms reported by senior South African rugby players (n = 83) 40
Figure 4.6: Reported musculoskeletal injuries, per body region, occurring in the same year as a concussion in senior male rugby players (n = 26) 41
Figure 4.7: Posture profiles of senior South African rugby players according to the NYP rating scale (n = 139) 42
Figure 4.8: Classification of cervical ROM (degrees) for senior rugby players according to the general population norms (n = 139) 44
Figure 4.9: Percentage of senior male rugby players who had and had not participated in cervical spine strength protocols prior to this study (n=139) 46
Figure 4.10: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in flexion for senior rugby players in South Africa (n = 139) 47
Figure 4.11: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in extension for senior rugby players in South Africa (n = 139) 49
Figure 4.12: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in lateral flexion for senior rugby players in South Africa (n = 139) 50

LIST OF TABLES

Table 2.1: Game- and player related risk factors predisposing senior rugby players to injuries 7
Table 2.2: Signs and symptoms associated with concussion 13
Table 2.3: Summary of studies investigating the use of protective gear for the prevention of sports-related concussion 17

Table 4.1: Age distribution of senior South African rugby players participating in the study (n=139).....333
Table 4. 2: Concussions sustained per age group, per team for senior South African rugby players (n = 139) 344
Table 4.3: Number of players per playing position participating in the study 344
Table 4.4: Summary of the scores recorded by senior rugby players in South Africa for scenarios on the NDI (n = 139)……37
Table 4.5: Type and frequency of reported concussion and cervical spine injuries sustained by South African senior rugby players (n=139) 388
Table 4.6: Mean posture scores per body sites as recorded on the NYP rating scale in South African senior rugby players (n=139).....41
Table 4.7: Mean cervical spine ROM (degrees) for South African senior male rugby players tested on the MCU (n= 139) 453
Table 4.8: Comparison of mean cervical range of motion scores (per movement) between forward and back South African senior rugby players (n = 139) 45
Table 4.9: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for flexion of the cervical spine for senior rugby players in South Africa (n = 139).....47
Table 4.10: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for flexion of the cervical spine for senior rugby players in South Africa (n = 139).....48
Table 4.11: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for lateral flexion of the cervical spine for senior rugby players in South Africa (n = 139)……50
Table 4.12: Comparison of mean cervical strength per movement between forwards and backs in South African senior rugby players (n=139) 51

Table 4.13: Correlation between isometric neck strength for flexion with the overall and score(s) per body region in senior rugby players (n = 139).....53
Table 4.14: Correlation of isometric neck strength per angle in extension with overall and individual posture body site score(s) in senior rugby players (n = 139)……..54
Table 4.15: Correlation of isometric neck strength per angle in lateral flexion with overall and individual posture body site score(s) in senior rugby players (n = 139).....55
Table 4.16: Number of players per age category for the development of cervical spine strength norms (n = 139)…….……..……..….56
Table 4.17: Cervical spine strength norms for u/19 male rugby players - forwards (n = 37)..56
Table 4.18: Cervical spine strength norms for u/19 male rugby players - backs (n = 32)…...57
Table 4.19: Cervical spine strength norms for u/21 male rugby players - forwards (n = 14)..58
Table 4.20: Cervical spine strength norms for u/21 male rugby players - backs (n = 11).....59
Table 4.22: Cervical spine strength norms for senior male rugby players - backs (n = 22)…60

LIST OF DEFINITIONS

Catastrophic injury:	Severe injuries to the spinal cord or brain which can include spinal – or skull fractures [1, 2].
Cervical:	Relating to the neck [2].
Cervicalgia:	An injury at the neck region that causes pain. Can be caused by poor posture [2].
Cognitive function:	The ability of the brain to process information received [2].
Concussion:	A violent jarring or shaking type injury to a soft structure, such as the brain, often caused from a direct blow to the head. Has the potential to result in partial or complete loss of function [2].
Encephalopathy:	A disorder affecting the functioning of the brain, caused by viral infections or toxins in the blood [2].
Haematoma:	A mass of blood found within an organ or tissue. The blood is usually clotted and may manifest in various degrees or organization and decolourization, depending on how long it has been present [2].
High tackle:	A form of tackle where the ball carrier is tackled by the tackler above the line of the shoulders. Most regularly it occurs around the neck, jaw, or chin. These types of tackles can result in penalties, and yellow or red cards [3].
Hooker:	By tradition they wear the number two shirt. This player is found in the centre position of the front row of the scrum and uses his feet to hook the ball back. This position requires the player to bind both arms around other players and is considered the most dangerous position on the field. They are also often seen as the most skilful player amongst the forwards [3].
Hyperflexion:	An isolated flexion force leading to movement of a limb or body part beyond the normal limit [2].
Hypertrophy:	Increase in muscle size [4].

Maximal strength:	Largest amount of force generated by a specific muscle [4].
Insomnia:	Inability to sleep which may vary in degrees of restlessness. This occurs in the absence of any external implications [2].
Isometric:	Muscular contraction against resistance with no noteworthy shortening of the muscle fibres, however, has a noticeable increase in muscle tone [2].
Line-out:	Forwards line up parallel with each other consisting of a minimum of three or a maximum of seven players. The hooker will throw the ball straight into the field of play. Jumpers are elevated by their teammates below the waist, while not obstructing the opposition team's jumpers [3].
Maul:	When a ball carrier is held up by both fellow team players and opposition players [3].
Multi-Cervical Unit:	The most objective and complete method for the assessment and rehabilitation from individuals experiencing neck pain, general cervical spine disorders or whiplash associated disorders [5].
Phonophobia:	Related to an anxiety disorder where the individual has a fear of loud sounds [2].
Photophobia:	Extreme light sensitivity [2].
Post-concussion syndrome:	A multifaceted disorder where numerous symptoms of concussion lasts for weeks and in some cases months after obtaining a concussion. This can also continue for a year afterwards [6, 7].
Prop:	Players wearing the number one and three shirts. Their main role is to provide support to the hooker in the scrum and provide support to jumpers within a lineout. They are the main source of power to push the scrum forwards. For this reason, they are exceptionally strong [3].
Power:	Rate at which one performs a task [4].

Scrum:	Eight forwards from each team bind together to push against the opposing team's forwards [3].
Seizure:	Defined as an attack with the sudden onset of certain signs and symptoms [2].
Spear tackle:	A tackling method where the tackler wraps his arms around the thighs of the ball carriers and lifts him into the air before forcibly driving him into the ground [3].
Spinal cord:	A long cylindrical portion of the central nervous system, which is found within the spinal or vertebral canal [2].
Stiff arm tackle:	Classified as dangerous play and occurs when an individual strikes a player of the opposing team with a straight arm. Can be yellow or red carded when this occurs in combination with a high tackle [8].
Tetraplegic:	Synonym for quadriplegia and pertains to the paralysis of all four limbs [2].

LIST OF ABBREVIATIONS

AROM	–	Active Range of Motion
Etc.	–	Etcetera
FHP	–	Forward head posture
HREC	–	Human Research Ethics Committee
MCU	–	Multi Cervical Unit
NDI	–	Neck Disability Index
NYP	–	New York Posture
NPRS	–	Numeric Pain Rating Scale
ROM	–	Range of Motion
SCI	–	Spinal Cord Injury
TBI	–	Traumatic Brain Injury

LIST OF APPENDICES

Appendix A:

Letter requesting permission to use facility for data collection

Appendix B:

Permission to use facility for data collection

Appendix C:

Invitation to participate in study

Appendix D:

Personal information and injury screening questionnaire

Appendix E:

Neck Disability Index (NDI)

Appendix F:

Consent Form

Appendix G:

Invitation to participate in questionnaire validation

Appendix H:

Invitation to participate in pilot study

Appendix I:

New York Posture rating scale

Appendix J:

Example of MCU result sheet

Appendix K:

NPRS scale

Appendix L:

HREC clearance certificate

Appendix M:

Turn it in report

Appendix N:

Data disc

CHAPTER 1: PROBLEM IDENTIFICATION

1.1 INTRODUCTION

Rugby is one of the most popular sporting types around the world, which is participated in by both males and females [9]. World Rugby confirmed that the total number of registered rugby players worldwide increased from 2.82 million players in 2015 to 3.2 million in 2016 [10]. A news article published in 2016, identified rugby as one of the five biggest sporting codes preferred by the South African population to participate in [11]. According to this report, South Africa had 405 438 registered rugby players in 2016, which has since increased [10]. When focusing on senior players 143 722 male rugby players are registered in South Africa. This indicates the continued worldwide growth and interest in the participation of rugby as a sport [10, 11]. Therefore, the need arises to identify the reasons behind the high injury incidence rates observed within the sport as well as ways in which they can be mitigated.

Injuries associated with rugby can be categorized into the following three subdivisions: Overuse injuries; traumatic injuries and concussion [9]. Overuse injuries frequently occur due to the large amounts of running demanded by the sport, which commonly affects the knees and ankles. Furthermore, since rugby is a collision sport, traumatic injuries often follow, and typically include fractures, dislocations, ligament sprains and strains, contusions, and cuts [9]. Lastly, concussions make up the last category of injuries and have a high prevalence in the game. Injuries associated with the head and neck account for between 14 – 29% of all rugby injuries [9]. Collision sports, such as rugby, is responsible for a significant number of catastrophic events or injuries [1]. This indicates the importance of formalising specific protocols or training regimes with the aim of decreasing these incidence rates of these events [9].

Rugby is a full-contact and extremely demanding sport that is associated with a high risk of injuries. This risk has also increased as the professional participation in the sport intensified [12]. Throughout recent years, the incidence rates of head and cervical spine injuries in the rugby population has caused enormous concern in the rugby population. Rugby is rapidly evolving, not just in South Africa, but worldwide. Attracting more interest from a young age. It is therefore deemed significant to aim and reduce the risk of life-threatening and catastrophic injuries. An emphasis needs to be placed on correct and

safe techniques and therefore improve technical effectiveness however decreases the injury risk [13].

Considering the general population, poor posture has been identified as one of the major components that contribute to neck pain. Forward head posture (FHP) occurs when the neck moves forwards, positioning it in front of the shoulders rather than directly above it [14]. This increases the stress placed on the cervical spine, muscle overloading, anterior shoulder rotation with kyphosis of the thoracic spine, and hyperflexion of the cervical spine while the upper cervical spine moves into hyperextension [14]. It has been found in previous research that forward shoulder and head position, and lumbar lordosis were some of the most frequently found deviations when considering posture deviations in rugby players. These deviations did not indicate any direct correlation to lower limb injuries [15].

Clinical research based on strength training of the neck musculature has proven to be effective in increasing neck strength as well as decreasing neck pain [16]. The Multi-Cervical Unit (MCU, BTE Technologies, Inc., Hanover, MD) is the most efficient way of assessing and rehabilitating the cervical spine [5]. The main function for which the MCU was designed was for cervical muscle strengthening and exercises. The use of the MCU eliminates the subjectivity that is associated with manual testing as well as enhances the rehabilitation plan or the individual [1]. The MCU can successfully measure cervical ROM and isometric neck strength.

Measurements of cervical ROM have formed a crucial aspect of all investigations regarding cervical spine disorders or whiplash injuries [17]. It is also used with disease classification as well as assessing the effectiveness of a rehabilitation programme. Flexibility of the cervical spine is often described as ROM, which can be measured as either active or passive [17].

It is largely accepted that muscular structures perform an important role in providing protection and support of the joints within the human body [18]. The deep neck flexors have been described to play the most important role when considering the prevention of unwanted head and cervical spine movements [18]. The muscles positioned just below the surface of the skin, are however still regarded as important in overall neck strength.

Cameron West, who specialises in prescribing training programmes for rugby unions has stated that isometric exercises included in neck specific training for rugby players increase neck positional awareness and proprioception [19]. This study will be measuring cervical spine strength and range of motion with analyses of player posture to aim to draw conclusions with regards to the risk of suffering a cervical spine injury.

1.2 MOTIVATION

To the researcher's current knowledge there is no identifiable research to establish the primary reason behind the high cervical spine injury rates in rugby players. Literature confirms the high occurrence rates of cervical spine injuries in rugby players; however, no consensus has been reached on the reason for the occurrence or specific prevention methods. Due to the high prevalence rate and momentous outcome of cervical spine injuries that can have on the lives of rugby players, it is imperative to establish the cause of these life changing incidences, which may in turn aid to decrease the occurrence of these potentially life- and career threatening injuries. These life changing injuries can potentially be catastrophic, which indicates the involvement of the spinal cord which can be classified as either a complete or incomplete injury. Complete spinal cord injuries indicate that no motor or sensory function is present below the site of the injury, while incomplete spinal cord injuries indicate that some function is still present below the injury site. It has been stated that catastrophic injuries occur at a rate of 0.8 for every 1000 playing hours [1]. Although the risk factors for cervical spine and head injuries are quite clear, no formal relationships have been established between posture, cervical spine weakness, and cervical range of motion. For this purpose, it is deemed important to establish whether a relationship does exist between the above-mentioned factors to assist in the prevention of cervical spine and head injuries. If a relation is found between the weaker neck musculature, cervical spine injuries, and posture, it may aid in reducing the re-injury risk and overall head and neck injury prevention. Comparing to the sport's specific strength norms, performing regular tests, and returning the player to pre-injury strength levels can also directly reduce these injury risks.

1.3 RESEARCH QUESTION

Does poor posture, limited neck range of motion (ROM) and weak cervical neck strength increase the risk for cervical spine injuries in senior rugby players?

1.4 AIM

This study was aimed to identify the prevalence and frequency at which cervical spine injuries occurred within the rugby population. It also aspired to identify whether weak neck musculature, limitation in cervical range of motion and poor posture increases the risk for cervical spine injuries. It also aimed to establish sport specific norms for neck strength. This in turn will assist in return to sport clearance which has the potential to decrease the re-injury risk for senior rugby players.

1.5 OBJECTIVES

1. To determine the occurrence of cervical spine injuries amongst senior rugby players.
2. To determine the posture of senior rugby players.
3. To determine the cervical range of motion of senior rugby players.
4. To determine isometric neck strength of senior rugby players.
5. To determine if there is a relationship between cervical muscle weakness and poor posture.
6. To determine sport specific strength norms, for the cervical spine, for senior rugby players.

1.6 HYPOTHESIS

Low muscle strength for neck flexion, extension, and lateral flexion as well as a limitation in neck range of motion in combination with a poor posture increases the risk of cervical spine injuries.

1.7 NULL HYPOTHESIS

Low muscle strength for neck flexion, extension, and lateral flexion as well as a limitation in neck range of motion in combination with a poor posture does not increase the risk of cervical spine injuries.

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter has the intention to describe the components which may be involved in increasing the risk of cervical spine- and head injuries in rugby players. These components will be presented and discussed in four main sections, namely the: occurrence of cervical spine injuries in rugby players; anatomy of the cervical spine; posture as an increased risk for cervical spine injuries; and lastly cervical ROM and muscle strength. To the researcher's knowledge, these factors have not been investigated in-depth in terms of the possible associations between cervical posture, ROM, muscle strength, and potential injury incidence. Thus, a clear understanding of each will provide better insight into the potential causative factors possibly leading to increased cervical injury incidence.

2.1.1 CERVICAL SPINE INJURIES IN RUGBY PLAYERS

Participation in rugby is directly associated with the most serious injuries sustained to the cervical spine [20]. The result of these injuries varies in degrees of severity which ranges from complete recovery to even death. These injuries can have overwhelming effects on not only the player but also his or her family as well as the community [20]. This high risk of the incidence rates of injuries with the increasing popularity, regardless of gender, age, and skill level is indicative that focus needs to be placed on decreasing these occurrence rates and aim in making rugby a safer sport [10, 21].

2.1.1.1 Occurrence of cervical spine injuries

A systematic review indicated that studies in South Africa and New Zealand an increased occurrence rate of cervical spine injuries which is most likely due to the cervical spine being exceptionally susceptible to injury possibly due to weaker muscle protection at the upper end where a heavier weight is carried [22]. The biggest concern in a study performed by Hermanus et al. (2010) on spinal cord injuries in South African rugby, is the fact that there is not a register that is comprehensive enough to indicate Spinal Cord Injury (SCI) amongst players, as well as the vagueness with regards to the number of registered players in order for a proper indication of incidence rates [23]. This is indicative of the major gap that currently exists in research and the high risk associated with participation in rugby as a sport.

A study performed by Michael S. Swain et al. (2010) in Australia found that out of 262 participants, 74 players obtained cervical spine injuries during a rugby season. Amongst these

74 players, a total of 90 neck injuries were reported [24]. The injury rate in this cohort was calculated to be 2.9 injuries per 1000 playing hours with a recurrence injury rate of 0.26 injuries per 1000 playing hours. It was also reported that neck injuries occurring during matches were much higher when compared to those occurring during a training session [24].

Vital and Laporte (2015) stated at the International Conference on Biomechanics in sport that injuries to the cervical spine not only result in considerable financial costs, they may also affect the individual on social, physical, and psychological levels [25]. They also identified that the playing position does not seem to be associated with the risk of injury [25]. This is possibly because most of the cervical spine injuries that occurred were during the engagement or collapsing of the scrum. In these types of scenarios, it was the hooker who had a greater risk of sustaining an injury. When considering the rule changes, it has been found that the majority of injuries these days occur during a tackle [25].

On average it has been found that about 25% of all injuries sustained in a rugby season are cervical spine injuries [26]. This is more often in props and hookers, which is possibly explained due to the fact that they are involved in more physical collisions, tackles, and in scrums were these injuries are most often obtained [26]. Props are defined as the players at the front of the scrum while a hooker is found in the middle of the front row in the scrum. These activities not only involve collisions but occur at high speeds which include multi-directional forces [27]. Typical injuries to the head and neck include concussion and damage to the cervical structures, particularly ligaments and intervertebral discs [27].

When considering the various aspects of rugby, a combination of muscle endurance and strength is required. Aaron Bolton (2012), a strength and conditioning coach, stated that hypertrophy of the muscles is believed to be associated with strength and power production [28]. This is including and not limited to: Scrums and mauls, tackling, rucks, lineouts, and explosive running. Participating in rugby at a professional level has shown to carry a high injury incidence rate. However, recent studies have shown that there has been an increase in these rates for youth rugby players as well [1]. The risk for injury has however been directly related to age [1].

The prevalence rates of injuries should be reviewed to find an understanding as to why the occurrence of these cervical spine injuries is so extremely high. However, this understanding

has not been reached due to player information and injury history not being kept up to date. The importance of the anatomy of the cervical spine should also be analysed which might provide a more in-depth understanding as to why these injuries occur.

2.1.1.2 Risk factors related to an increased prevalence of injuries

Risk factors are divided into two different types: 1) Game related - extrinsic factors and 2) Player-related factors [29]. Even though the risk factors can be divided into these categories, it is often found that they can be related to one another [29]. Table 2.1 below identifies the differences between the game-related extrinsic factors and the player-related factors.

Table 2.1: Game- and player related risk factors predisposing senior rugby players to injuries [29]

Game related – extrinsic factors	***Player-related factors – intrinsic factors***
❖ Rules of the game of rugby	❖ Level of play, age of player and experience
❖ Phase of play (scrum; ruck/maul tackle);	❖ Position and skill
❖ Time period within the season;	❖ Anthropometric composition
❖ Environmental conditions;	❖ Hereditary conditions of the spine
❖ Field condition;	❖ Strength and/or anaerobic fitness
❖ Referee's management of the game;	❖ Psychological characteristics
❖ Instructions from coaches;	❖ Information processing ability
❖ Type of match (friendly; trials; finals;).	❖ Visual alertness and Impairment (fatigue, drugs, alcohol)
	❖ Profession
	❖ Gender
	❖ Ethnicity

The rules and rules of the game set out the structure and format in which play is permitted and also aims to promote positive play [29]. Therefore, regular rule changes occur intending to reduce the incidence rates of injuries, but more specifically spinal cord injuries. However, the influence of these specific rules laid out has been quite difficult to monitor due to a variety of factors [24, 29].

The position of the player can probably be the greatest player-related risk factor for obtaining a cervical spine injury. Michael S. Swain et al. (2010) found that 78.9% of neck injuries were obtained by the front row players, while only 21.1% affected the backs [24].

2.1.1.3 Mechanisms of injury leading to an increased rate of injury

According to a study performed by Kuster et al. (2012), multiple factors that contribute to cervical spine injuries classified as either anatomical to biomechanical [30]. Case studies have however identified that anatomical features including hypermobility of the facet joints, the smaller size of the vertebral body, in addition to weak neck musculature leads to an increased risk for injuries. Studies performed on cadavers indicated that when the head encounters an object, the cervical spine is forced to decelerate the significant mass of the moving torso. This leads to the buckling of the spinal column [30]. However, research studies from the 1970s have indicated that the bulk of cervical spine injuries occur due to hyperflexion [30, 31, 32].

Hyperflexion in association with rugby is described as an isolated flexion force leading to rapid anterior movement of the head over the torso which exceeds the normal anatomical range of 90°, which often occurs during a scrum. This theory is however discouraged by more recent studies, where Kuster et al. (2012) concluded that it appeared that cervical spine injuries were mostly caused by buckling of the cervical vertebral column. Buckling, however, happens in less than 20 milliseconds. These researchers did state that further studies were needed to confirm their findings [30].

The mainstream of studies investigating cervical spine injuries are case studies, which indicated that the evidence provided could not be proven to be 100% certain. However, since rugby is a high contact sport, three actions take place during the game that places the players at an increased risk for injuries. These include scrums, tackles, and the forming of rucks and mauls.

A) *Scrums and cervical spine injuries*

When considering a scrum in rugby, the players have had specific training to apply essential principles of biomechanics, which is mainly dependent upon the length tension, force-velocity -, and torque velocity relationships [33]. These principles are applied with the purpose of a forceful engagement of the pack of forwards, which should be quicker and with more force than their oppositions. The main aim is not to allow the opposition

team to move the pack of players in a backward motion [33]. Upon investigation, rugby case studies dating back to the 1970s have shown that neck hyperflexion occurs most often during a scrum engagement or the collapsing of a scrum [30]. This allows for rapid movement of the head onto the torso which exceeds the maximal anatomical range (90°) for the cervical spine [30].

An article written by Robert Neil Dunn (2010) stated that the significant decrease of cervical injuries during scrums can most probably be linked to the recent rule changes [34]. A retrospective study done by Wetzler et al. (1998) indicated that between 1970 to 1996, 58% of players obtained cervical spine injuries during a scrum and 36% occurred injuries during the collapse of a scrum [35]. A study performed by Quarrie et al. (2002) identified that players who are not prepared for the engagement into the scrum will often pull out while the other forwards, who are also actively involved in the scrum, will apply a force to drive directly into their opponents. This has been perceived as one of the most common mechanisms of injury when considering scrumming [20].

Hermanus et al. (2010) investigated spinal cord injuries amongst the South African Rugby Unions between 1980 to 2007 and concluded that 37% of SCI occurred during scrums [23]. Posthumus et al. (2008) stated that a scrum carries a 60% higher risk of obtaining an injury when comparing it to a tackle situation [13]. The hooker and prop are at the greatest risk of obtaining injuries. For this reason, it is deemed extremely important to teach safe and proper techniques to follow when these events occur. More than 90% of injuries that occur during a scrum is either during the engagement (47%) or collapse (46%). The resulting 7% occurred when forwards actively extended their necks as well as driving the opposition front-row player upwards, leading them to pop-up or scrum upwards. In schoolboy rugby players, scrums lead to 42% of neck and head injuries [13].

The recent rule changes which related specifically to scrumming lead to a decrease in the total amount of scrumming that occurs during the game by 40% [34].

B) *Tackles and cervical spine injuries*

More recent case studies studied in the year 2000 have identified that most often cervical spine injuries occur during open play, predominantly during a tackle [30]. Comparing studies investigating injuries caused by tackles varied between 38.2% to 77.2% [36]. Even

though they have been able to identify a more specific manner of injury, they are still unable to determine which phase of play is more probable in leading to more serious neurological outcomes [30]. This is in agreement with Quarrie et al. (2002), as there was a difficulty to form a conclusion between the work of different researchers to specifically identify the mechanism for injury during a tackle [29]. Wetzler et al. (1998) found in their retrospective study involving 62 players, that 64% of injuries transpired during the engagement [35]. Due to tackling being a more dynamic movement type and includes high amounts of collisions, it appears that players have a smaller amount of attentiveness to the situation when compared to scrumming [35].

There also appears to be a difference between the incidence rate of injuries to players carrying out the tackle, or the player being tackled. A review article done in New Zealand involved a search strategy to source all the related literature regarding cervical spine injuries in rugby players. The statistics drawn from these reviews indicated no statistical significance in data with regards to injuries obtained by the tackler to the player being tackled with regards to obtaining neck injuries [29]. Different types of tackles have been identified that have different injury incidence rates. Tackles can be classified as either high, double, and spear. Recent rule changes have been very strict on prevention and appropriate types of punishment for these types of tackles made [29]. When considering open play, the player in possession of the ball is protected by the rules of the game from high- and stiff-arm type tackles. This has the probability to lead to serious injuries, however, it is still dependant on the skill of the tackler [29, 37].

Much focus has been placed on teaching correct technique and skills; however, no prevention strategy has been established [38]. If a player goes into a tackle reluctantly or unenthusiastically, he increases the risk of obtaining an injury [13]. The difference in force between the tackler and player being tackled is deemed as the main injury risk factor for the weaker individual or having less momentum than his opponent [13]. Emphasis is placed on going into a tackle with dominance and to achieve movement soon after the completion of a phase of play. This will create maximum momentum and reduce the possibility of obtaining an injury in the next tackle [13].

A study performed by Robert Dunn (2009) indicated that many spinal cord injuries now actually occur during open field play, specifically referring to tackles [34]. South African,

Tim Noakes reported that between 1990 – 1997, a total of 8.3 spinal cord injuries were recorded per season in the Western Cape alone [29]. Between 1980 – 2007 a total of 264 spinal cord-injuries were reported from a total of 183 players that were rugby related. This included 30 players who had died from their injuries [23]. Rugby participated in at school level resulted in 20% of injuries, with 8% resulting in death and 48% being classified as tetraplegic. Only 35% recovered significantly [39].

Head positioning during a tackle has been shown to significantly influence the incidence rate of injuries. A study performed by Sobue et al. (2018) indicated the injury ratio was 69.4 per 1000 tackles made when the head placement was incorrect. While there were only 2.7 per 1000 tackles that lead to injuries while using the correct head placement [38].

Tackles that occur from the front have resulted in the largest amount of injuries when considering 1000 playing hours. This is quite possible given that front-on tackles occur during the greater part of the game [13].

Posthumus and Viljoen (2008) identified the injury rate as per body part as it occurs during a tackle. Injuries to the upper trunk are 57% while injuries to the lower trunk amounted to only 43%. However, during a match, about 130 tackles occur around the trunk while only 30 are considered to be low tackles [13].

C) *Rucks, mauls, and cervical spine injuries*

Three different movement patterns have been identified that lead to injuries during rucks and mauls by Scher (1983). These are: 1) Forward flexion of the cervical spine of the player at the bottom of the ruck; 2) Forward flexion of the cervical spine of the ball carrier's neck, and 3) Head and cervical spine injury caused by charging into a maul [40]. These types of mechanisms only contribute about 17% to the injury incidence rate however, very few studies have focused on these as injury risks [29]. A case study performed by Quarrie et al. (2002) also found that 17% of all catastrophic injuries occur during rucks and mauls [29]. This might be because during these events the neck is forced into flexion of either the ball carrier or the player finding himself at the bottom of the ruck [29]. The second mechanism is a vertex impact where a player will charge headfirst into a mass of players. Lastly, forced hyperflexion and rotation can result due to a vertex impact which is associated with the contact phase of rugby [13].

A study investigating injuries occurring during ruck and mauls identified that between 1956 and 1982, 20 players were injured [41]. Fifteen of these players were forced to the ground by their own players to bring the ball to a stop. One player described a click sensation as his head made contact with the ground, which was followed by severe pain and paralysis [41]. Two players were injured when their heads made direct contact with other players. One player was kicked while one was intentionally strangled [41].

D) Lineouts

The incidence rates of injuries associated with this event during the game have recorded the least amount of concern [13]. Even though the injuries recorded are the lowest when considering the amount of playing hours, it is an event that should be taken into consideration. Injuries to the facet joints of either the lumbar or cervical spine are mostly recorded during a lineout when considering professional rugby players. This is a possibility due to jumpers losing their balance or resulting in a fall [13].

2.1.1.4 Concussions in rugby players

A concussion is defined as a traumatic brain injury (TBI), which is associated with headaches, reduced alertness, or in extreme cases, unconsciousness. However, the long-term consequences of sustaining a concussion are generally unknown to the public. These symptoms may affect memory, speech, coordination, sleep patterns, balance, and judgement [42]. Gardner et al. (2014) who aimed to identify the occurrence rates of concussions in the Rugby Union by performing a meta-analysis found that, across 37 studies, over a period of 1000 match hours, 4.73 players generally get concussed [43]. Gardner et al. (2014), also found that during training, the amount was lower, with 0.07 concussions in 1000 training hours [43]. Due to the high re-injury rate of head- and neck related injuries, it is important to develop return – to – sport protocols which is specific for the senior rugby population. Symptoms typically include confusion, blurred vision, forgetfulness, headaches, and dizziness [43, 44].

When a player is concussed or is expected that the player has sustained a concussion, they should immediately be removed from the field, whether it is during a match or training, however this sometimes does not occur often resulting in further injury and delayed treatment. If a neck injury is suspected, the emergency management procedures should be followed [4]. A clearance test should also be performed by a medical professional prior to returning to the sport [9]. Malanga states that return to sport clearance should also consider

that the player should have minimal or no tenderness of the injured region; full active range of motion, optimal neck strength against resistance, neuroglial and posture examination within normal limits as well as the absence of neurological symptoms [45, 46].

Concussion can also be described as a trauma-induced change or a result from a direct blow to the head which has the potential to lead to a loss of consciousness as well as cause changes within the brain [44, 47]. Brown et al. (2016) defines concussion as: "A complex pathophysiological process affecting the brain, induced by biomechanical forces, and is an evolving injury in the acute phase with rapidly changing clinical signs and symptoms" [48]. Concussions are graded into one of three categories depending on the severity. Classification is grade 1 which is considered mild, grade 2 is moderate and grade 3 is severe. The pathophysiology remains unknown, however current available research has shown that a concussion classified as either moderate or severe leads to complex neuromuscular changes in the brain [44]. The symptoms of concussion are classified into four different categories according to the effect on physical, cognitive, emotional and sleep [6]. Table 2.2 below identifies the different symptoms and signs associated with concussions.

Table 2.2: Signs and symptoms associated with concussion [6, 44, 47, 49]

Physical	***Cognitive***	***Emotional***	***Sleep***
Headaches	Concentration difficulties	Depression	Lethargy
Dizziness	Memory disturbances	Aggressiveness	Sleeplessness
Blurred vision	Foggy feel	Mood disturbances	Feel they require more sleep
Photophobia	Feeling slow	Irritability	
Phonophobia			
Nausea			
Tingling / Numbness			
Vomiting			
Fatigue			
Visual changes			
Balance disturbances			

The complications of concussions are also divided into early stage – and late complications. Concussions have the potential to involve damage or injury to the cerebral veins and arteries. This can cause bleeding from the vessels which has the potential to become a haematoma. Cerebral swelling does not occur frequently, however is recognised as a complication in mainly children and teenagers. This can however occur, if the player returns to play hastily before full recovery has taken place. Seizures appear to be a more familiar response following a head injury. It is however classified as a dramatic event and can occur within 2 seconds after impact. This is however not associated with brain damage [6, 44, 47]. Late complications include post-concussion syndrome, chronic traumatic encephalopathy, and risk of a second concussion.

World Rugby identified guidelines for the management of concussions which all rugby playing nations need to comply with. BokSmart is South Africa's national safety programme specifically aimed at the management of concussions as well as the clearance to return to play and was established in 2009 [48, 50]. The BokSmart programme educates coaches and referees about the best practices to reduce the risk of injury. This has not only reduced the injury incidence rate but has also led to an increased knowledge under rugby players as well as their behaviour towards injury [50]. By August 2010, BokSmart had presented more than 506 rugby safety workshops across the 14 South African rugby unions. A total of 11 023 referees and coaches has been certified since the initiation of the protocol in July 2009 [51].

BokSmart's purpose is to train, instruct and prepare every coach and referee at all levels of play around the country, aiming to create and reinforce safe rugby techniques as well as medical and injury prevention practices. The aim to create a safer environment for rugby players to participate in by reducing injuries. After training has been completed, every attendee is licensed for a two-year period. After this period has expired, they will have to attend another workshop in order to receive the most recent evidence-based rugby safety information at that particular time [52].

A) *Prevalence of concussions in rugby*

Concussions are mostly found within sports that involve a high-frequency of high-impact collisions. Certain aspects of the game include a higher risk of obtaining a concussion with tackles being the highest predisposing factor [53]. According to Rafferty et al. (2019) the incidence rates of concussion varies amongst club or international level of playing,

however no study has specifically focused on providing statistical comparison data between these two levels of participation [54]. They also found that players who sustained a concussion has a 38% greater risk for obtaining a subsequent injury. These injuries included muscles and tendons as well as those that occur to the head and neck, upper limb, pelvic region, and lower limbs [54].

Considering professional senior rugby, research indicates that an incidence rate of 4.1 – 4.5 concussions per 1000 playing hours has been noted [48]. The South African Youth week that occurs annually, identified that between 2011 – 2014, 31% of players obtained concussions. Only 14% received follow up treatment before returning to play, which is thought to be due to the high medical costs [48]. The prevalence of head and neck injuries are estimated to be between 29 – 35% [12]. Minor or non-catastrophic cervical spine injuries are common and ranges from between 0.26 – 9.17% when taking a 1000 playing hours into consideration [12]. With amateur players, 69% of neck injuries are minor, 17% mild and 7% is classified from moderate to severe. These injuries usually include neck symptoms, increased amount of healthcare costs as well as reduced playing time. Consecutive injuries lead to premature degeneration and advanced degenerative changes associated with the cervical spine [12].

Rafferty et al. (2019) concluded that a rugby player had a higher risk of sustaining a concussion after playing 25 matches [54]. The occurrence rate of concussions in his cohort of study was three times higher than the second highest injury that was indicated. The results indicated that due to the long lengths of the seasons over which rugby players participate, it may expose players to a higher risk of obtaining a concussion [54].

It is important that coaches and referees undergo necessary training in order to be able to identify the possible incidence and immediate management of concussion which will in turn lead to a reduction in the incidence rate and severity of injuries related to rugby [50].

B) *Concussion baseline tests for rugby players*

Concussion baseline tests (Neuropsychological testing) are designed to assess the cognitive function of the brain by determining any presence of cognitive dysfunction. These tests originated as pen and paper tests which were not as accurate as the newly developed computerised testing that is performed. These tests have been designed to

identify minor changes in cognitive function and measure response variability. The baseline concussion tests are performed pre-season, and assess the players' brain function, and in most instances balance. It is an assessment of the player's ability to pay attention to a specific matter and how swiftly they can solve problems [42, 55]. This test assists healthcare professionals to make decisions regarding return to play post-concussions by comparing the results of the baseline concussion test to the post-injury screening. This is not a concussion prevention method however is more a useful tool in diagnosing concussions and prevention players from returning to play prematurely and being exposed to the risk of post-concussion syndrome. The computerised testing has advantages including that: it is quick and easy to be carried out -particularly for large groups such as sports teams; the language of the test can be modified to suit the participants' needs, it can provide an accurate measurement for time- or reaction based responses; and it allows for consistent measurements [56]. The disadvantages however include that: the adapted computer test may not be of the same high standard as the traditional neuropsychological measurements; there is a high probability for technological errors and testing in group settings might lower cognitive function. Caccese et al. (2019) investigated whether the concussion baseline testing aided in the identification of the possibility of obtaining a concussion in the future and concluded that there was no indicative matter that a baseline test can predict a future sports related concussion [57].

C) *Playing gear in the prevention of concussions*

Multiple studies have investigated the efficiency of protective equipment-based methods used for the prevention of sports-related concussions. Majority of research studies concluded that wearing protective equipment does not protect against the occurrence of a concussion. However one study found that wearing a properly fitted mouthguard has the potential to protect against mild concussions when compared to mouthguards purchased over-the-counter [58]. While another found that wearing, a proper mouthguard and clenching their masseter and sternocleidomastoid muscles reduced the speed of the head [59]. Table 2.3 below summarizes the different studies as well as a conclusion of their results. Overall, it seems there is minimal benefit in wearing protective equipment in rugby, hence alternative options to reduce injury risk within this population need to be established. Some examples may include improving cervical ROM, cervical muscular

strength and or posture – yet the efficacy of these has not been established which this study deems to remedy.

Table 2.3: Summary of studies investigating the use of protective gear for the prevention of sports-related concussion

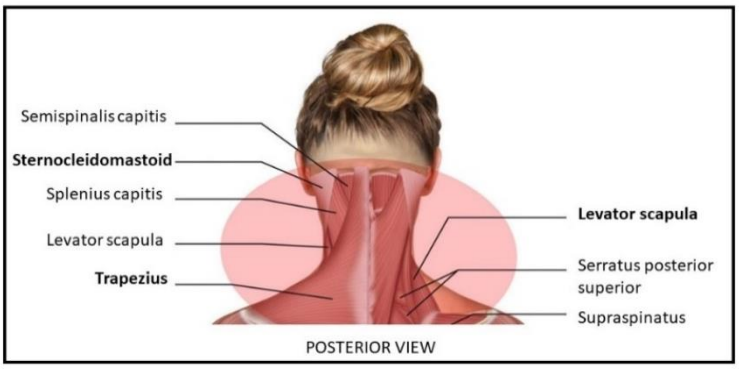
Study	***Country***	***Study population***	***Protective gear***	***Conclusion***
Benson et al. (2009) [60]	Various	12 electronic databases, 51 studies were included in the review.	Helmet	No compelling evidence that this reduces head injuries and the effect on concussion is inconclusive.
			Mouthguard	No exact evidence exists that mouthguards reduces concussions. Full face masks may reduce the severity of a concussion.
Hollis et al. (2009) [61]	Sydney, Australia	3207 male non-professional rugby players.	Headgear	The utilisation of headgear and appropriate management of previous concussions can reduce the risk of a mild traumatic brain injury.
McIntosh et al. (2009) [62]	Australia	1128 boys participating in school level rugby.	Standard (10mm thick, 45kg.m^{-3} foam) and modified headgear (16mm thick, 60kg.m^{-3} foam)	Padded headgear does not decrease the incidence rate of a concussion or head injury.
Daneshvar et al. (2011) [63]	United States	294 rugby players under the age of 15	Headgear	No evidence indicating the protection of headgear against concussions.
Hasegawa et al. (2014) [59]	Japan	12 high school rugby players	Clenching masseter and sternocleidomastoid muscles	Clenching lead to a marked decrease in head acceleration.

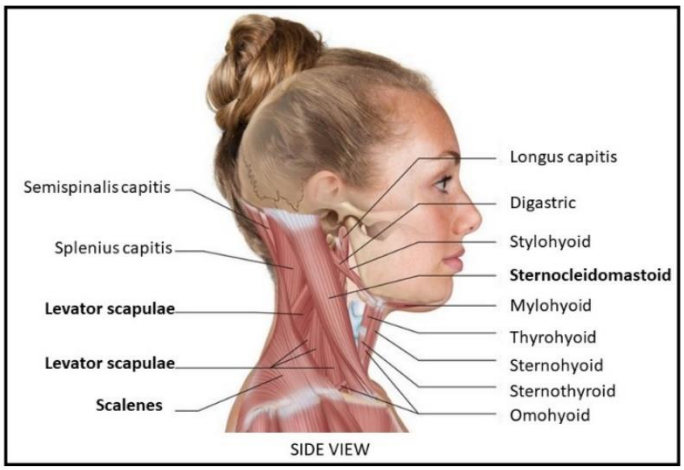
Winters and DeMont (2014) [58]	Pennsylvania	412 high school athletes	Mouthguard	Wearing a custom-made mouthguard (≥3mm in thickness) reduces the incidence of mild concussions.
Menger et al. (2015) [64]	United States of America	122 responses from an internet survey including males with an average age of 19.5 years old.	Headgear	40% of participants believed that headgear aided in concussion prevention. Consensus of literature does not support this view. Players were also four times more probable to play aggressive than those who did not believe that headgear prevents concussions.

In summary, this chapter identified that the occurrence rate of cervical spine injuries increase on a yearly basis as there are both extrinsic (game-related) and intrinsic (player-related) factors that need to be taken into consideration when attempting to reduce the injury rates. The mechanisms of injury are contributed to either an anatomical or biomechanical reason and scrums, tackles, rucks and mauls, and lineouts are the actions that take place during rugby that hold the highest injury risk. Concussions are sustained by numerous players participating in rugby and multiple processes have been identified to deal with these situations and to benefit the player who has sustained a knock to the head.

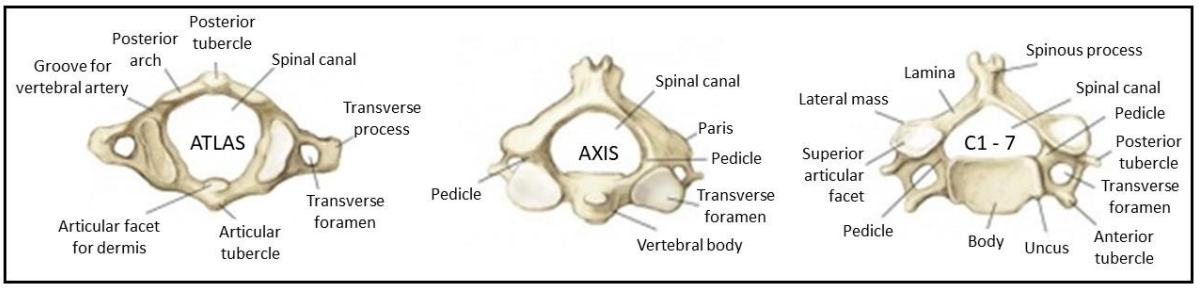
2.1.2 ANATOMICAL STRUCTURES OF THE CERVICAL SPINE

Musculature of the head and neck perform cervical spine flexion, extension, lateral flexion, and rotation. It assists in chewing, swallowing, speech, facial expressions, and movement of the eyes [65]. These various movements demand strong, forceful movements with the finest, most precise, and delicate alterations in the human body. The main muscles associated with neck flexion, extension, rotation and lateral flexion include: Sternocleidomastoid; Scalene muscles group; Rectus Capitis Posterior Major and Minor; Upper Trapezius, and Levator Scapula [65].





The spine consists of bone, muscles nerves tendons and ligaments [65]. The main functions of the cervical spine can be described as: Proving 'shelter' and safeguarding of the spinal cord; Supporting the head and its movements; and Enabling blood flow to the brain. The cervical spine is made up of seven vertebrae and abbreviated by the letter C. C1 and C2 are known as the atlas and axis and created mobility for the skull [65, 66]. It is estimated that about 50% of neck flexion and extension of the cervical spine occurs at C1 while 50% of rotation of the neck takes place at C1 and C2. C3 to C7 are vertebras that consist of a body, pedicles, laminae, spinous processes, transverse processes, and facet joints. The thoracic and lumbar regions provide more mobility in comparison to the cervical region. The transverse foramina found in the vertebra in the cervical spine also contains arteries that supply blood to the brain [66].



The cervical spine vasculature has been described as an 'extensive arterial anastomotic network' [66], and is made up of pairs of anterior and posterior arteries leading from the vertebrae to the base of the skull. The cervical spine consists of six main ligaments. The following three ligaments are present throughout the entire vertebral column and are known as: Anterior and posterior longitudinal ligaments that run the entire length of the vertebral column; Ligamentum flavum that connects laminae of the neighbouring vertebrae; and Interspinous ligaments that connect adjacent vertebrae [67]. There are also three ligaments that

are exclusive to the cervical spine. These are recognised as: Nuchal ligament and the transverse ligament of the atlas. The nuchal ligament forms a connection between the base of the external occipital posterior-inferior part of the human skull to the spinous process of C7 [67].

Kuster et al. (2012) explored the primary mechanisms of cervical spine injuries that occur in rugby and concluded that facet dislocations and bilateral facet dislocations were identified as the two most prevalent types of cervical spine injuries [37]. Buckling of the cervical spinal column is believed to be the primary reason for these two specific injuries. Trauma occurs at the lower cervical spine level, C4/5 and C5/6, which is where most motion takes places [37]. It was also stated that this was independent from age or position of the player. Vital and Laporte (2015) defined buckling as a combination of compression and flexion [25].

2.1.3 RELATIONSHIP BETWEEN POSTURE AND CERVICAL SPINE INJURIES

According to Gavin Morrison, a physical therapist, when considering neck pain, posture is a major component as part of the underlying causes of injuries [14]. A forward head posture (FHP) is one of the most prevalent causes that contribute to neck pain. The forward position of the head places additional strain on the vertebrae of the lower neck, which in turn contributes to the development of degenerative disc disease [14]. Muscles directly related to posture includes: Scalenes; Suboccipital, Pectoralis minor, Subscapularis and Levator scapulae muscles. If the alignment of the spine is not in equilibrium, it does not allow for optimal functioning and increases the risk of an injury as well as degenerative effects, which directly placed the player at an increased risk for obtaining an injury [14].

Optimal posture can be described as the perfect combination between a minimal loaded muscle and loading of a joint, which distributes force over a larger area [32, 68]. This in turn reduces compression on the joints and decreases the risk associated with degenerative changes.[21] Imbalances between strength, flexibility, and malalignment are intrinsic risk factors that can lead to injuries in any type of sporting code [32].

Limited research exists regarding the biomechanical and postural trademarks of rugby players and the effect that it may have on the occurrence of injuries [32]. A study performed by Bruwer (2006) however found that there is a correlation between postural imbalances and injuries obtained in the lower extremities [32]. It is however believed that a forward head

posture and an increase in kyphosis in the thoracic region is associated with glenohumeral joint injuries, which is related to the shoulder [68]. This is related to having a poor posture with an anterior rotation of the shoulders and placing the neck at a compromised forwards position. Moss et al. (2013) aimed to profile the thoracic posture of professional rugby players and combining it with the muscle firing patters of the rotator cuff muscle [69].They used the New York Posture (NYP) rating scale to evaluate thoracic posture and found that more than half of the participants displayed a slightly abnormal or abnormal forward head posture. However, when considering the back, it was classified as normal [69]. Remarkably, 67% of the participants were classified as slightly abnormal or abnormal when regarding their forward shoulder position [69]. They were classified as having a kyphotic posture.

2.1.4 CERVICAL ROM AND STRENGTH RELATED TO INCREASED RISKS FOR INJURIES

Different approaches may be considered to decrease the risk for rugby players to obtain cervical spine injuries and concussions. Robert Naish et al. (2013) describes rule changes, correct tackling techniques, strengthening of neck musculature and individualised, position specific injury prevention programmes can be included in order to reduce this injury risk [70]. Nicholas Strimpakos (2011) indicated that the effect of strength, endurance, ROM and proprioception of the cervical spine has been shown to have an increased interest amongst researchers when considering treatment and rehabilitation of conditions or injuries [17].

2.1.4.1 Cervical ROM

The reliability and validity in measuring cervical spine ROM is unequivocally related to the structure and function of the neck. A limited cervical ROM, specifically in rugby players, has been believed to increase the probability of injuries and to aggravate age-related cervical spine conditions [71]. Lark and McCarthy (2007) found that professional rugby players who retire after participating in rugby for many years can expect to have a cervical range of motion which is similar to individuals who have acute whiplash [71].

Lark and McCarthy (2007) found that forwards had considerably less cervical ROM when comparing them to the backs as well as non-playing controls [71]. A direct association was found between decreased cervical ROM, age and the number of years that the player has been participating in rugby [71]. The effects of a single game of rugby on ROM indicated a reduction for cervical flexion, extension, bilateral lateral flexion as well as bilateral rotation.

Position specific effects indicated that forward had a more significant reduction in extension and lateral flexion while the backs had a reduced ROM for flexion [67].

A substantial reduction in active cervical range of motion was found when rugby players were analysed over an entire season. It was however found that the backs had a greater ROM than the forwards at any point of time within the season, even though they suffered the similar amounts of head and cervical spine injuries [67].

2.1.4.2 Cervical strength

Cervical spine injuries occurring during rugby are a concerning matter at all levels of participation. Diverse methods have been implemented with the aim to decrease the incidence rate of neck injuries [70]. These have included rule changes, proper tackling techniques while Highland et al. (1992) Brooks et al. (2005), Peek and Gatherer (2005), Frounfelter (2008), Brooks and Kemp (2010) and Swain et al. (2011) all agreed in their research studies that strengthening of the neck muscles seems to be the most logical method to decrease cervical spine injuries [31, 72, 73, 74, 75, 76]. It is widely accepted throughout literature that muscles play an imperative role in protecting and supporting of the joints. Muscles that directly attach to the vertebrae are responsible for stability and control in neutral while the deeper lying muscles maintain stability of the neck [77]. Neck pain has however been strongly associated with cervicalgia.

Thomas et al. (2004) stated that dynamic muscle strengthening protocols of the cervical spine followed for 6 – 11 weeks in individuals with chronic neck pain, decreased pain experienced significantly while there was a decrease in disability and increase in muscle strength [77].

Greater neck musculature strength has proven to decrease the deceleration of the neck into end-range positions which can cause the most harm. Comparison of cervical spine strength of rugby players by position indicated that front-row players comprise of higher levels of strength when compared to the back players. This might be due to their larger build and higher loads they get exposed to during training and matches [70].

Naish et al. (2013) performed a retrospective pre-test, post-test cohort study which analysed the data between 2007 – 2009 from a Sports Medicine database which was made up out of professional rugby players who participated in the Super 14 competition [70]. The

aim was to establish whether isometric neck strengthening protocols were efficient in reducing the number of cervical spine injuries in rugby players. They found a statistically significant decline in the amount of neck injuries that occurred during matches however a non-significant decrease in training related injuries [70].

Salmon (2014) concluded in her study that participating in neck specific strengthening protocols can provide a logical approach in reducing the amount of cervical spine injuries in rugby players [78]. It also has the possibility to enhance long-term health outcomes which is directly related to neck disability and improved functionality once they have retired from rugby [78].

To the researcher's current knowledge after reviewing literature, there are no neck strength norms for the senior rugby population. The Multi-Cervical Unit provides norms for the general population [5] and Du Toit et al. (2005) established norms for schoolboy rugby forwards [39], however would not be accurate to compare a professional high risk sporting population to these above mentioned established norms.

2.1.4.3 Multi-cervical unit

The Multi-Cervical Unit (MCU) is a computerized programme that records cervical spine range of motion as well as isometric strength which occurs in three planes of movement [5]. Using this measuring device eliminates subjective analyses which improves accuracy as well as re-test and inter-rater reliability. The MCU has been shown to have valid and reliable test results for both normal individuals as well as those who have previously experienced injuries or is currently experiencing neck pain [5]. This unit is not only used for assessments or obtaining baseline measurements, it also serves part of rehabilitation for individuals who have conditions of the cervical spine or who require treatment for whiplash associated injuries [16]. A study performed by Chiu and Kai Lo (2002) concluded in their study that the MCU provided reliable and valid testing for both cervical range of motion as well as isometric neck strength results. The correlation coefficients for active range of motion (AROM) ranged from between 0.81 to 0.96 while for isometric strength measurement it was between 0.92 – 0.99. This indicated a level of high-level reliability for both measurements [77].

Taylor et al. (2006) performed a study investigating the effects on isometric and dynamic strength training by using the MCU. Significant improvements were found in isometric- and dynamic strength between a 4 – 12-week period [79]. Chiu et al. (2005) performed a randomized controlled trial on the efficacy of exercise using the MCU for patients with chronic neck pain [80]. At week six it was found that patient already had a benefit from participating in the programme with a 28.8% decrease in disability rates, 34.9% reduction in the amount of pain and in increase of between 26.1 – 45.7% in cervical spine strength [80]. Burnette et al. (2005) found that strength training using the MCU was nearly 50% more effective than using a TheraBand for cervical spine strengthening [81].

CHAPTER 3: METHODOLOGY

3.1 STUDY DESIGN

A descriptive, cross-sectional study was used where data was analysed from a specific cohort using mixed methods (both qualitative and quantitative data).

3.2 SITE OF STUDY

All data for this study was completed at Adriaan van der Merwe and Associates Biokinetic practice at iMude Sport & Wellness. Permission was requested (Appendix A) and obtained to conduct this study (Appendix B).

3.3 STUDY POPULATION

3.3.1 Selection / Recruitment of subjects

Recruitment of participants took place in 2018 after ethical approval was granted (Protocol number M180381). The medical staff and coaches of the respective teams were contacted, and a meeting was arranged to explain the reasoning behind the research. The medical staff consisted of either sport physicians, physiotherapists and Biokineticists as well as strength and conditioning coaches. They were provided with a copy of the proposal of the research as well as an information sheet (Appendix C). The invitation also included the explanation of the research study and how the testing would be conducted. The invitation to participate was sent to the Golden Lions Rugby Union, Valke rugby Union, Blue Bulls rugby union, the University of the Witwatersrand as well as the University of Johannesburg. A weekly timetable was sent through to the teams with the possible testing times, where the players booked a slot that was most convenient for them. The booked timeslot did not interfere with any team training and was done mostly in the late evenings during the week, their off days as well as over weekends.

3.3.2 Sample size

It was estimated that the three rugby unions would have at least three teams of 30 - 35 players each, while the respective universities would have two teams each of 25 players.

Establishing strength specific norms requires a large sample. A study performed by du Toit et al. (2005) aimed to set up neck strength norms for school boy rugby forwards and had a study size of 208 [82]. While Brown and Miller (1998) had a sample size of 304 women to determine normative data for strength and flexibility of women throughout their life [83].

Batt et al. (2007) investigated the physical capacity norms for Australian non-elite football players and included 143 participants [84]. A study investigating isometric hip muscle force values evaluated using a manual dynamometer included only 52 participants [85]. For this reason, this study aimed to have a sample size of between 355 - 385 players. Allowing for a dropout rate of 50 players. At the completion of this study a total of 139 senior rugby players were tested and included. The reason for the reduced number of participates in this study was due to training schedules and transport of the players to the facility where testing was conducted. Even though transport for the players were arranged, busy player schedules did not allow for availability. The inability of the MCU to be transported was the main reason as to why the study was completed with a smaller sample size. No exclusions occurred during the final analysis of the data and there were also no dropouts.

3.3.3 Inclusion and exclusion criteria

3.3.3.1 Inclusion criteria

- Professional or club rugby player.
- Senior players, turning 19 (in 2018) and older.

3.3.3.2 Exclusion criteria

- Current cervical spine- or head injuries, by using the Neck Disability Index (NDI) and medical clearance from team physician.
- Any player that presents with a medical condition, identified by the Personal Information and Injury Screening, that has the potential to be aggravated by the testing performed on the Multi Cervical Unit.

3.4 TESTING PROCEDURES AND EQUIPMENT

Participants completed a personal detail, injury screening questionnaire (Appendix D) and NDI (Appendix E) prior to testing taking place. It was also expected of them to sign a consent form (Appendix F) to form part of the study. The test consisted of one cervical range of motion test as well as one isometric strength test. The test consists of three repetitions after which the average will be calculated. Figure 3.1 described the battery of tests conducted:

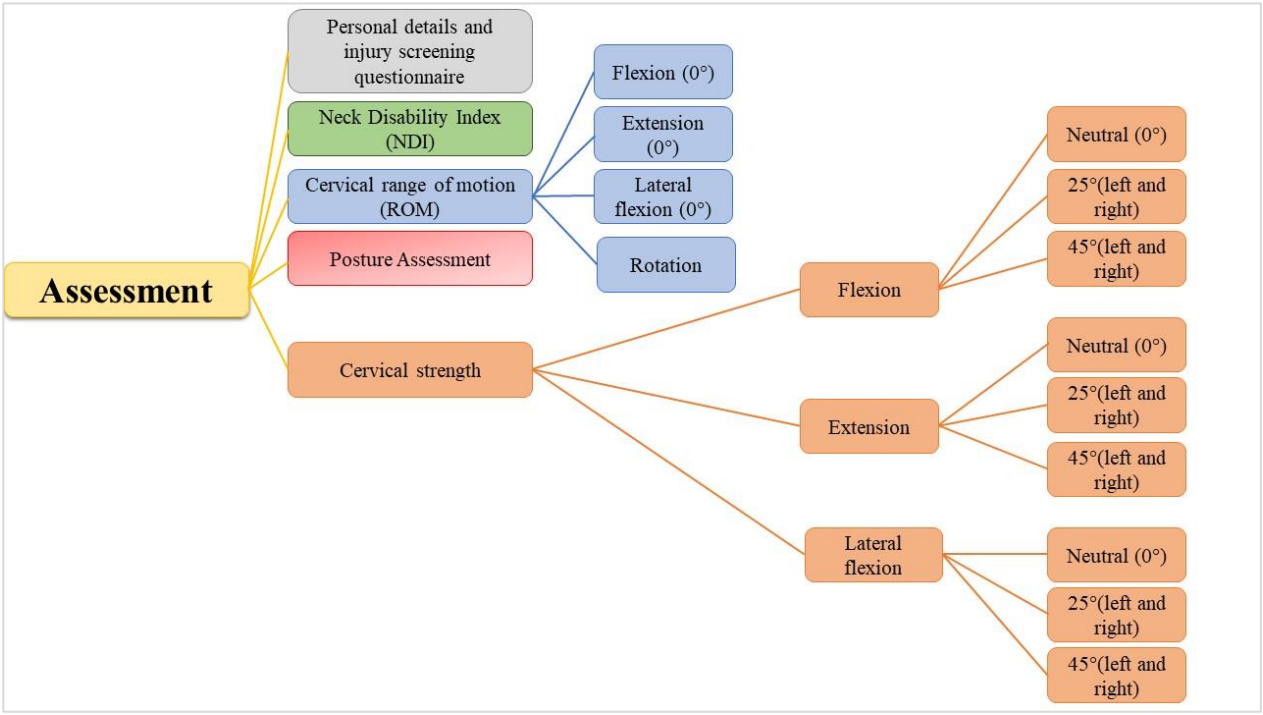


Figure 3.1: Battery of tests conducted on senior male rugby players (n = 139)

1. Testing process

The participants were expected to complete the personal details, injury screening and NDI questionnaire prior to the start of the test. This was followed by a description of the test by the Biokineticist to the participant and then the signing of the consent form for them to be included in the study. The assessment started off with taking a photograph of the participant for analysis of their posture. These were taken from anterior, posterior, and side views. A profile was created on the MCU computer system for the testing to commence. The participant was seated, and the seat height accordingly adjusted for the head pads to be perfectly positioned on the forehead of the individual. The test started with the cervical range of motion for flexion, extension, lateral flexion left and then right. This was concluded with rotation to the left and right. The isometric strength testing was then performed for flexion, extension, and lateral flexion. These were divided up into three different angles for each side namely neutral (0°), 25°, and 45°.

2. Personal information and Injury screening questionnaire

This questionnaire was used to obtain valuable information with regards to previous head and neck injuries that the players have sustained. Due to all available questionnaires only focussing on current injuries, this questionnaire had to undergo a

validation process through a panel of experts. The questionnaire was drawn up on Google drive and was sent through to the experts by email for the validation and recommendation to occur. The panel of experts included Sports Physicians, Biokineticists, Physiotherapists, as well as Orthopaedic specialists based in South Africa, Australia, and New Zealand. A total of 20 invites were sent out with the link to participate in the validation of the questionnaire and they were given 12 days to complete. The invitation can be seen in Appendix G. By the last day there were 8 responses with recommendations for changes or additional questions to be included. After thorough analysis of the suggestions, the necessary changes were made on the questionnaire and it was sent out for the pilot study. This involved inviting 20 rugby players to participate in the study. It was also created on Google drive and the invitation was sent out via email. The players were given 8 days to respond. This invitation can be found in Appendix H.

Data was coded and captured onto an excel spreadsheet. The data gathered will allow for comparison purposes between players to determine if certain positions are at an increased risk for injury. It will also be used in conjunction with the MCU test results to form a conclusion with regards to a higher risk of injury that is associated with neck weakness.

3. Neck disability index (NDI)

This questionnaire is described as successful in measuring neck pain and disabilities in either chronic or acute cases [86, 87]. Therefore, it was deemed appropriate to measure any current ailments that might still cause some discomfort for the participant. It also has the potential to assist in excluding the participant from the study if there are any injuries present.

This questionnaire provides a score which can be presented as a percentage. It is divided into ten different sections measuring the ease of or how difficult the individual performs an activity of daily life. Zero indicates no problem or pain in performing the task, while five indicates that the task cannot be performed due to the pain associated with it. The analysis of this subjective questionnaire total (out of fifty) can be interpreted as the following:

i. 0-4 points – no disability;

ii. 5-14 points – mild disability;
iii. 15-24 points – moderate disability;
iv. 25-34 points – severe disability, and
v. 35-50 points – complete disability.

The questionnaire has a fair to moderate test-retest reliability in those diagnosed with a mechanical neck pain. It is also valid to measure neck pain and disabilities associated with neck pain in either acute or chronic conditions [88].

4. Posture Analysis

This test allowed for objective information with regards to the participants' standing posture. A posture grid was placed against a wall and a camera (Samsung Galaxy Tab S3; 13MP; Samsung; South Korea; 2017) was set up to capture the entire body of the subject. The participant was instructed to stand in front of the posture grid in anatomical position as he would in a daily comfortable position. A picture from the front, back and the side views were taken. Three photos of each position were taken and the best of each was used for analysis purposes.

Pictures were loaded onto Kinovea software (Kinovea open source project; 2004) for objective analysis of the subject's posture. The posture of the participant was scored out of 10 after analysis of the following areas: head; neck; shoulders; back; spine; trunk hips, and ankles. This was done by using the New York Posture (NYP) rating scale (Appendix I). The higher the score obtained by the participant, the better the posture. Their standing posture was recorded on the day by placing them in front of a posture grid. They stood in a comfortable position with their hands next to the sides and shoes removed. Posture was analysed in anterior and posterior regions as well as having them facing sideways. A score was given per body region that was analysed and a total score out of 10 was obtained. Three players did not give consent for their photographs to be taken due to religious reasons, however their posture analysis was completed in the practice and their results were included in the study results.

The NYP rating scale's reliability is dependent upon the experience and consistency of the assessor. For this reason, only the main researcher was performing the analysis [89].

5. Cervical range of motion

Limitation in neck range has the potential to cause pain or discomfort in the cervical region. This allows subjective information with regards to range of motion of the neck.

The participant was placed into the chair and the correct set-up was done. The participant was instructed to push the neck into flexion, extension, and lateral flexion as far as possible. With this test the MCU moved with the patient to their end range for the movement and will be repeated three times. The computer system calculated the average of the three tests for the specific motion and dots the results down on a graph and in table format. The system includes norms for the general population to which it draws a comparison between left and right. Example of the result sheet can be seen in Appendix J. The participant rated discomfort experienced on a Numeric Pain Rating Scale (NPRS), with 0 indicating no pain and 10 being the worst possible pain.

Results of this test demonstrate a high degree of test-retest reliability in both normal subjects and those with neck pain [(5)]. The NPRS indicates a high test-retest reliability as well as construct validity. This scale can be seen in Appendix I.

6. Isometric strength test

Weak neck musculature has the potential, particularly in a high contact sport, to cause cervical injuries [(50)]. This test provides information objectively and was preceded by the Cervical range of motion test.

The participant was placed in the chair and the correct set-up was done to ensure the most optimal test results. They were instructed to apply as much force as possible onto the pads which was held for 5seconds. This was repeated 3 times for each angle. The test angles included the following:

i. Flexion – Neutral (0°), 25° left and right and 45° left and right;
ii. Extension - Neutral (0°), 25° left and right and 45° left and right;
iii. Lateral flexion – Neutral left and right (0°), 25° left and right and 45° left and right.

The system calculated the average of the three results for each test and classified them into a table as either red or green. The results are compared to a general population

norm. When the obtained result is below the general population norm it is indicated as red. If it is indicated in green, it is within or over the expected norm. Example of the result sheet can be seen in Appendix J. The participant rated any discomfort experienced on a Numeric Pain Rating Scale (NPRS), with 0 indicating no pain and 10 being the worst possible pain. The NPRS scale that was used in the study has been included in Appendix K.

This test allows for a high rate of test-retest reliability. This is shown to be valid for both injured and uninjured individuals [5].

Norms will be established that will be specific for professional senior rugby players (19 years and older). The norms were calculated around the median, using the average and standard deviation to create a range of expected strength production.

3.5 DATA COLLECTION METHODS

Data was collected at Adriaan van der Merwe and Associates Biokinetic practice located in Parkmore. Data collection was carried out by the principal researcher and two assistant Biokineticists. The assistants were fully trained and qualified in conducting tests on the MCU machine. Data was obtained between February and July 2019. Results were documented on the relative assessment forms. (Please see Appendix H for an example of the result sheet.) The information obtained from the assessment forms and questionnaires was extracted onto excel spreadsheets.

3.6 DATA ANALYSIS

Data was analysed using Strata version 14. Descriptive data was expressed as means and standard deviations. Data was checked for normality by drawing histograms. Non-parametric tests were used for non-normally distributed variables. To compare continuous variables, the Wilcoxon signed-rank test was used. To compare categorical variables, Mc Nemar's test for symmetry as well as Fisher's exact test was used. A Pearson's test was used to draw comparisons between the New York Posture (NYP) rating score, and scores obtained from the MCU tests for strength. Data was recorded on a data collection sheet (Appendix H). Statistical significance at 95% (P - value < 0.05) was deemed as acceptable.

3.7 ETHICAL CONSIDERATIONS

Ethical clearance was applied for and granted by the Human Research Ethics Committee of the University of the Witwatersrand (Protocol number M180381) (Appendix L). Participants signed a consent form for their results to be used anonymously in the study (Appendix F). All personal and identifying information was kept private and confidential by using a coding system, with only the researcher, research assistants and relevant supervisor having access to the data. A coding system was designed by using the first letter of the team that they were playing for, followed by the age group in which they played and then the number of the test conducted. This assisted in ensuring anonymity. Data was processed and presented in group format and no single player's information was described in isolation.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

This chapter will discuss the results obtained under the main objectives of the study following the presentation of demographic data.

4.2 DEMOGRAPHIC INFORMATION

i. Age

A total of 139 participants participated in this study. The mean age of the participants was 20.42 ± 3.29 years - the youngest player participating in the study was 18, with the oldest being 33 years of age. One player indicated that he had a known heart condition, while 20 indicated that they had a bone or joint condition that had the potential to be worsened by participating in physical activity. All the participants had medical clearance from their respective team doctors and all questionnaires were fully completed, therefore all 139 players where included in the final analysis of the study. Table 4.1 below presents the age distributions of the participants in this study.

Table 4.1: Age distribution of senior South African rugby players participating in the study (n=139)

Age category	***Frequency (n)***	***Percentage (%)***
18	46	33.09
19	37	26.62
20	9	6.47
21	19	13.67
22	5	3.60
23	2	1.44
24	3	2.16
25	6	4.32
26	1	0.72
27	1	0.72
28	1	0.72
29	5	3.60
30	2	1.44
31	1	0.72
32	0	0

33	1	0.72

ii. Playing years and level of play

This population had been playing rugby for an average of 12.61 ± 4.14 years, where 97.12% (n = 135) participated on Provincial level and 41.73% (n = 58) participated at National level. Forty-three players had participated in rugby on Provincial level for longer than 5 years while only 7 where involved in National participation for the same period.

The u/19 group consisted of 83 players and a total number of 16 concussion were recorded for this age category. The u/21 group included 28 players who together sustained a total of 62 concussions, while 28 senior players had a combined number of 66 concussions. Table 4.2 below summarises the amount of concussions that was found per team that is divided into age categories.

Table 4. 2: Concussions sustained per age group, per team for senior South African rugby players (n = 139)

Team	***Number of players per group (n)***	***Number of concussions***	***Range per age group (points)***
u/19	83	16	0-4
u/21	28	62	0-12
Seniors	28	66	0-20

Table 4.3 below summarises the number of players per position that were included in the study. Of the 139 players, 53.96% (n = 75) were forwards while 46.04% (n = 64) were backs.

Table 4.3: Number of players per playing position participating in the study (n=139)

Forwards			***Backs***		
Position	***Number of players (n)***	***Number of players (%)***	**Position**	***Number of players (n)***	***Number of players (%)***
Prop	23	16.55	Scrumhalf	13	9.35
Hooker	10	7.19	Flyhalf	12	8.63
Lock	9	6.48	Centre	20	14.39
Flank	21	15.11	Wing	11	7.91

Eight man	12	8.63	Fullback	8	5.76

iii. Playing gear

Concussion headbands were only used by one player (0.72%), while the use of a mouthguard was most popular. A total of 119 players (85.61%) recorded that they play rugby with mouthguards. Figure 4.1 below identifies the playing gear used by the senior rugby players while participating in rugby.

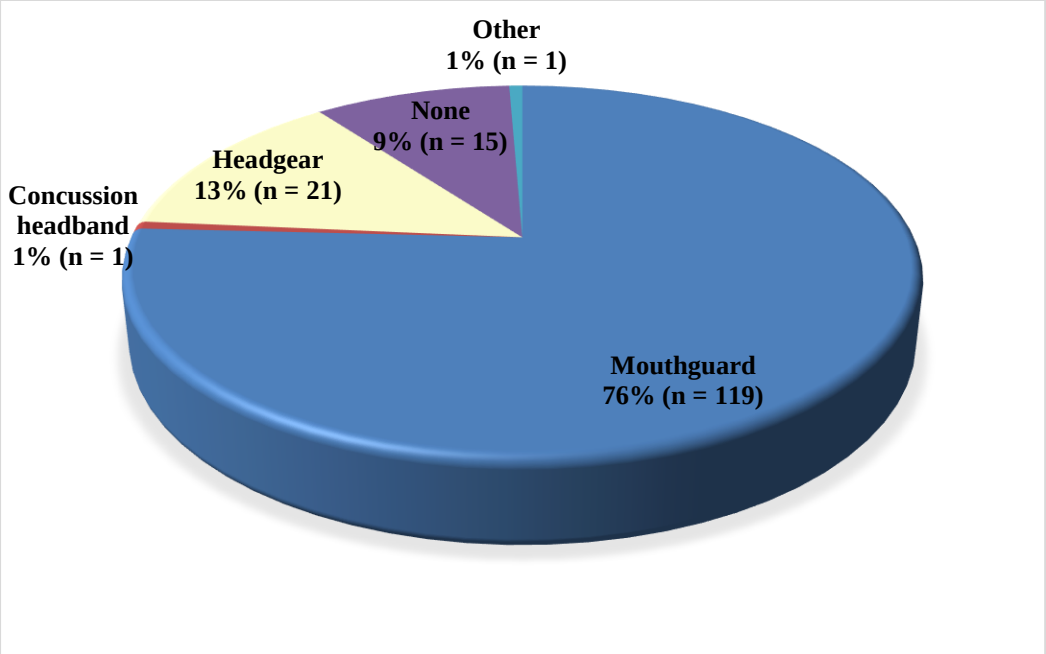


Figure 4. 1: Protective gear used by South African senior rugby players (n = 139)

iv. Neck disability index (NDI)

The NDI was used to clarify whether a participant had any current injuries or discomforts that had the potential to be worsened by participating in the MCU neck ROM and strength tests. Players were given scores from zero to 5 as per the NDI guidelines for every task they were asked to complete. Players were given a 0 score if they did not have any difficulty or discomfort when performing a specific task explained by the NDI. Players were given a score of one, two or three if they experienced mild, moderate, or fairly severe discomfort or difficulty in performing that particular task. Lastly players were given a score of four or five if they experienced a very severe or worst imaginable pain which prevented them from doing a specific task.

It was found that thirteen players experienced a mild form of neck pain, of which 9 played for the senior teams and four for the u/19 rugby team. Seven (53.85%) of these players were backs, and 6 (46.15%) were classified as forwards according to their first choice playing position. Only one player described his current neck pain as moderate in severity- he was a junior u/19 playing in a flank position which is also classified as a forward.

Most of the participants (n = 40) reported that headaches were the most common discomfort experienced when compared to the other scenario's stated by the NDI. The other scenarios included current neck pain intensity and pain related to personal care, lifting of objects, reading, concentration, work, driving, sleeping and participation in recreational activities. A degree of difficulty with concentration was the second highest discomfort reported in the population (n = 30). Figure 4.2 and figure 4.3 below illustrates the number of players identifying headaches and decreased concentration levels as a symptom using the NDI, respectively.

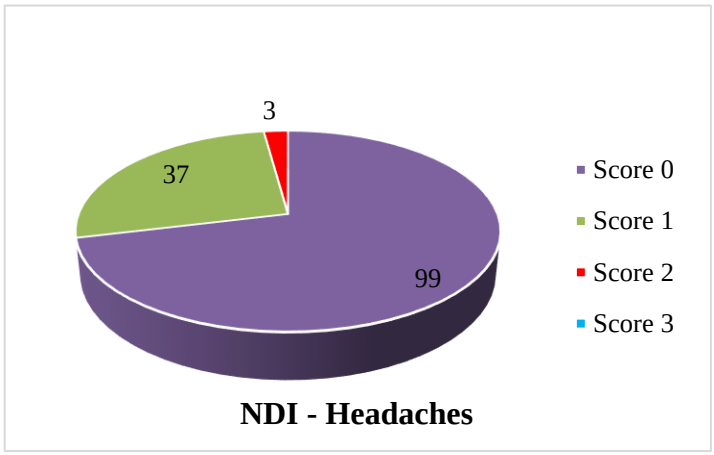


Figure 4.2: Number of players identifying headaches as a symptom using the NDI (n = 139)

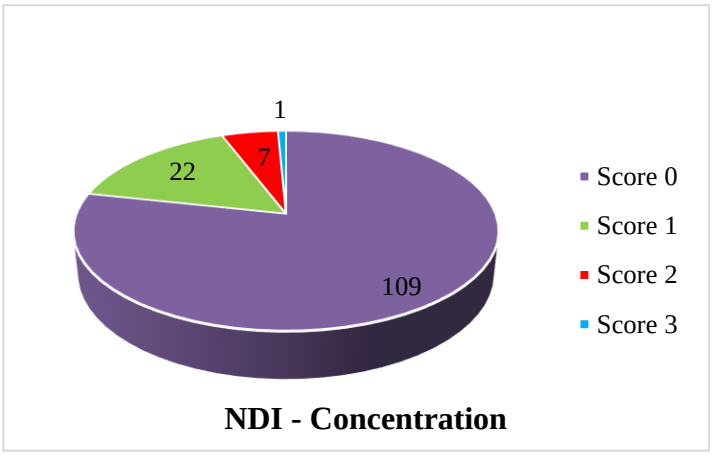


Figure 4.3: Number of senior rugby players that identified having difficulty with concentrating using the NDI (n=139)

Personal care activities recorded to be the scenario with the most rugby players indicating that they experience no neck pain at all during that time period (n = 137), this was followed by participation in recreational activities (n = 135) and lifting of objects (n = 130). Reading caused slight neck discomfort for twenty players, while a disturbed sleeping pattern, being sleepless for of 1 – 2hours, was recorded for nine players. No players recorded a score 3 for any of the scenario's questioned by the NDI. One player indicated that he had a disturbed

sleeping pattern for which he obtained a score of $^{4}/_{5}$ indicating sleeplessness for between three and five hours.

Table 4.4 below summaries the scores as recorded by the players themselves for the different scenario's questioned in the NDI.

Table 4. 4: Summary of the scores recorded by senior rugby players in South Africa for scenarios on the NDI

Score	***Neck Disability index scenario***							
	Pain intensity	***Personal Care***	***Lifting***	***Reading***	***Work***	***Driving***	***Sleeping***	***Recreation***
Score 0	125	137	130	116	127	132	112	135
Score 1	13	2	9	20	12	7	17	4
Score 2	1	0	0	3	0	0	9	0
Score 3	0	0	0	0	0	0	0	0
Score 4	0	0	0	0	0	0	1	0

4.3 OBJECTIVE 1:

OCCURRENCE OF CERVCIAL SPINE INJURIES AMONGST SENIOR RUGBY PLAYERS

An injury screening questionnaire was developed and validated by a panel of medical experts and was provided to the rugby players to complete.

Amongst the 139 participants, 83 players sustained concussions and 19 players obtained other cervical spine injuries. Whiplash was discovered to be the most frequent cervical spine injury to have occurred (n = 8), followed by muscle sprains (n = 5) and muscle strains (n = 4). Table 4.5 below indicates the reported concussion and cervical spine injuries that occurred within this testing population.

Table 4.5: Type and frequency of reported concussion and cervical spine injuries sustained by South African senior rugby players (n=139)

Head injuries	***Number of players sustaining this injury (n)***
Concussion	83
Cervical spine injuries	***Number of players sustaining this injury (n)***
Unilateral facet dislocation	1
Whiplash	8
Fracture	1
Disc prolapse / Slipped disc	1
Muscle sprain	5
Muscle strain	4
Pinched nerve	2
Other	2

* Some players sustained more than one type of cervical spine injury.

A total of 23 concussions were recorded to have occurred within the last two years of play within this study population. It was found that out of the 75 players classified as forwards, 53 (70.67%) had sustained a total of 127 concussions, 50 of which having occurred in the last two years. From the group classified as backs, only 30 (46.88%) out of 64 players had been concussed. Information regarding concussions sustained in the last two years showed that 64.03% (n = 89 players) did not sustain a concussion, 26.62% (n = 37 players) sustained one concussion, 5.04% (n = 7 players) had two concussions, 2.16% (n = 3 players) had three concussions, 1.44% (n = 2 players) had four concussions and 0.72% (n = 1 player) had five concussions. Concussion analysis identified that 63% (n = 52 players) of the concussions sustained were classified as being mild, while 30.49% (n = 25 players) were moderate and only 6.10% (n = 5 players) were classified as being severe. Figure 4.4 below illustrates the reported number of concussions sustained by the players.

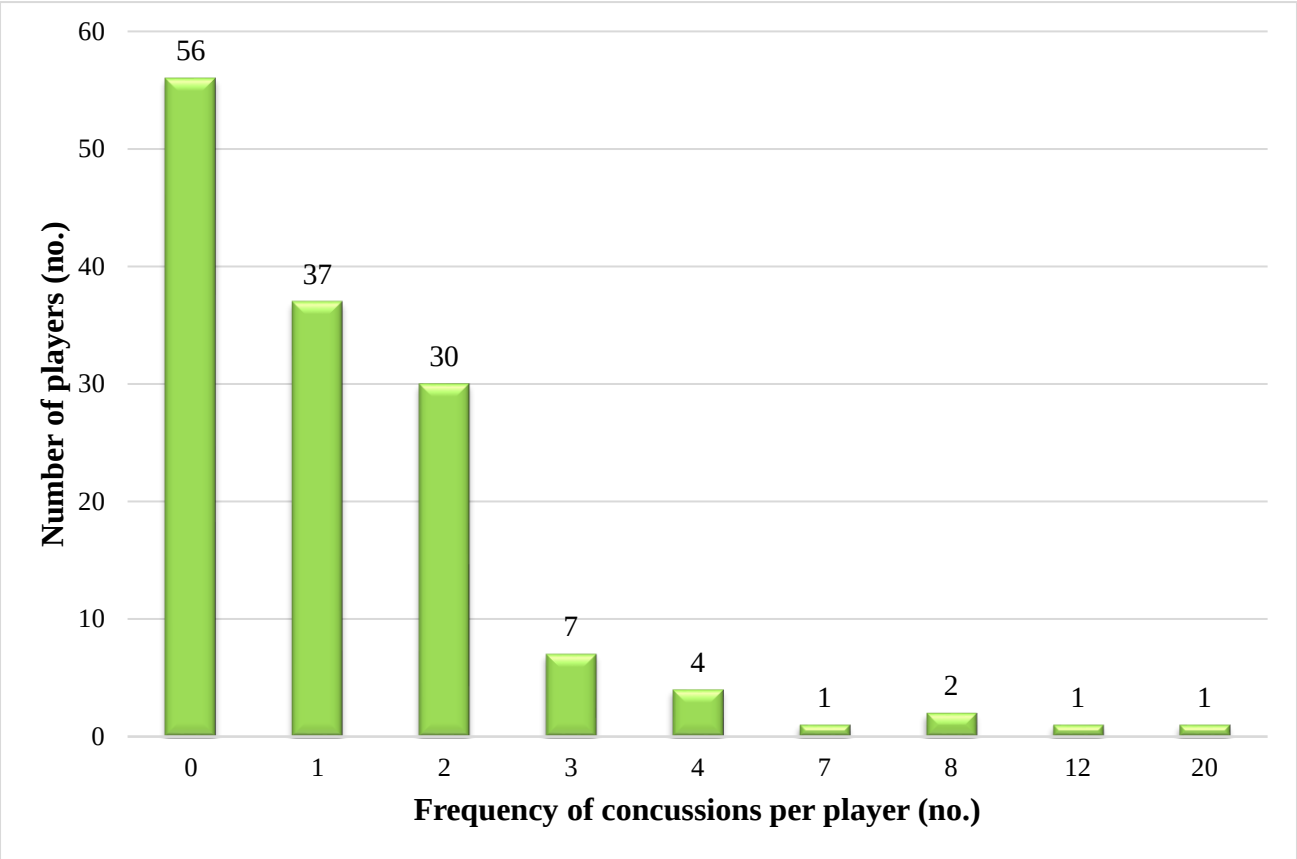


Figure 4.4: Total number of reported concussions sustained by senior male rugby players (n=139)

It was found that 61 concussions were diagnosed by the respective team doctor, 6 by the General Practitioner (GP), 11 by Paramedics, 6 by a Sports Physician, 11 by an Emergency room doctor and 1 by a Physiotherapist. Three Players identified that their concussions were diagnosed by other professionals, however they did not provide a specification as to who this professional was.

A total of 103 players identified that they underwent a concussion baseline test in their pre-season. The BokSmart programme was identified as being the most commonly used (n = 99 players), with the balance testing being the second most popular test (n = 30). The CogState Sport test was used by 14 players and ImPact was only used for 1 player.

The bulk of the players who sustained a concussion reported that headaches (74.7%; n = 62), dizziness (59.04%; n = 49) and memory loss (45.78%; n = 27) were the top three symptoms experienced following their concussion. Sleep disturbances (13.25%; n = 11) and vomiting (12.05%; n = 10) are the two symptoms least experienced by this study population who had

suffered concussions in their playing careers. Figure 4.5 below illustrates the concussion symptoms experienced by the players.

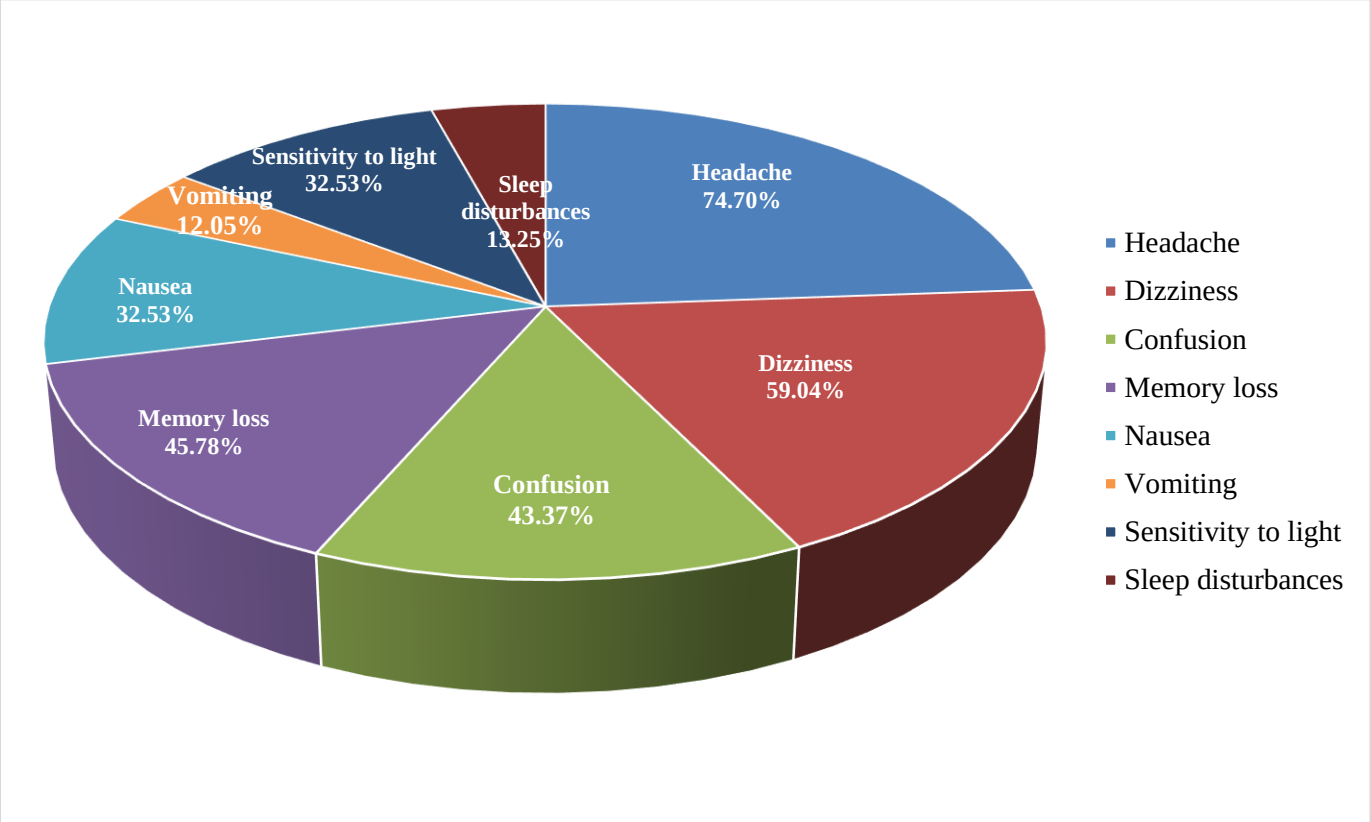


Figure 4. 5: Concussion symptoms reported by senior South African rugby players (n = 83)

A total of 26 players sustained an injury, unrelated to the cervical spine, during the same year as suffering a concussion. A total of 28 musculoskeletal injuries were reported. Figure 4.6 identifies the location of the injury that was sustained as well as the frequency within the group. Majority of players sustained injuries to the knee (n = 7) in the same year as suffering a concussion. The back (n = 1), neck (n = 1) and lower leg (n = 1) was the area least affected by injury in this study population.

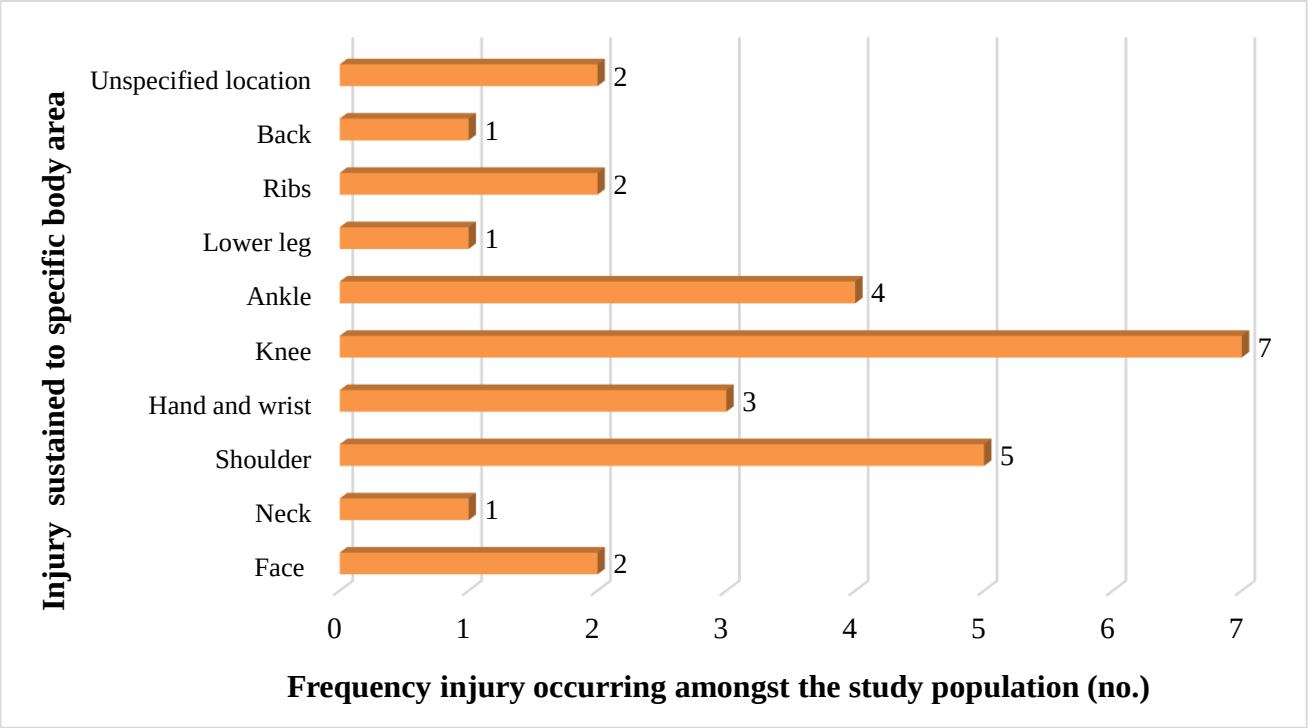


Figure 4.6: Reported musculoskeletal injuries, per body region, occurring in the same year as a concussion in senior male rugby players (n = 26)

4.4 OBJECTIVE 2:

POSTURE OF SENIOR RUGBY PLAYERS

The New York Posture rating chart was used to document posture, interpretation was performed using the Kinovea *analysing software.*

Posture was rated out of a total score of 100, with each body site scored out of a possible 10 points. The score is described as either 0 (poor), 5 (average) or 10 (good). The mean posture score for the total study population was 7.38 ± 1.05 points out of 10. Table 4.6 indicates the overall mean posture score for the sample.

Table 4.6: Mean posture scores per body sites as recorded on the NYP rating scale in South African senior rugby players (n=139)

Body site	***Mean ± Standard deviation (score)***	***Range (score)***
Head	7.33 ± 2.71	0 – 10
Shoulder	5.61 ± 2.12	0 – 10

Spine	8.06 ± 2.45	5 – 10
Hips	8.35 ± 2.36	5 – 10
Ankle	6.26 ± 2.26	0 – 10
Neck	5.40 ± 2.63	0 – 10
Upper back	8.60 ± 2.25	5 – 10
Trunk	6.47 ± 2.29	5 – 10
Abdomen	9.86 ± 1.20	0 – 10
Lower back	7.88 ± 2.48	5 – 10
Overall posture score	7.38 ± 1.05	4.9 – 9.5

The posture profiles of senior rugby players are illustrated in Figure 4.7. Posture is presented as either poor (0), average (5) or good (10) for each body site. The abdomen (n = 137), upper back (n = 100) and hips (n = 93) were the three body regions where the greater part of players demonstrated good posture. Players demonstrated average posture in the shoulder (n = 112), ankle (102) and neck (100) regions. While a total of 25 players presented with a poor rating for the neck region (n = 14).

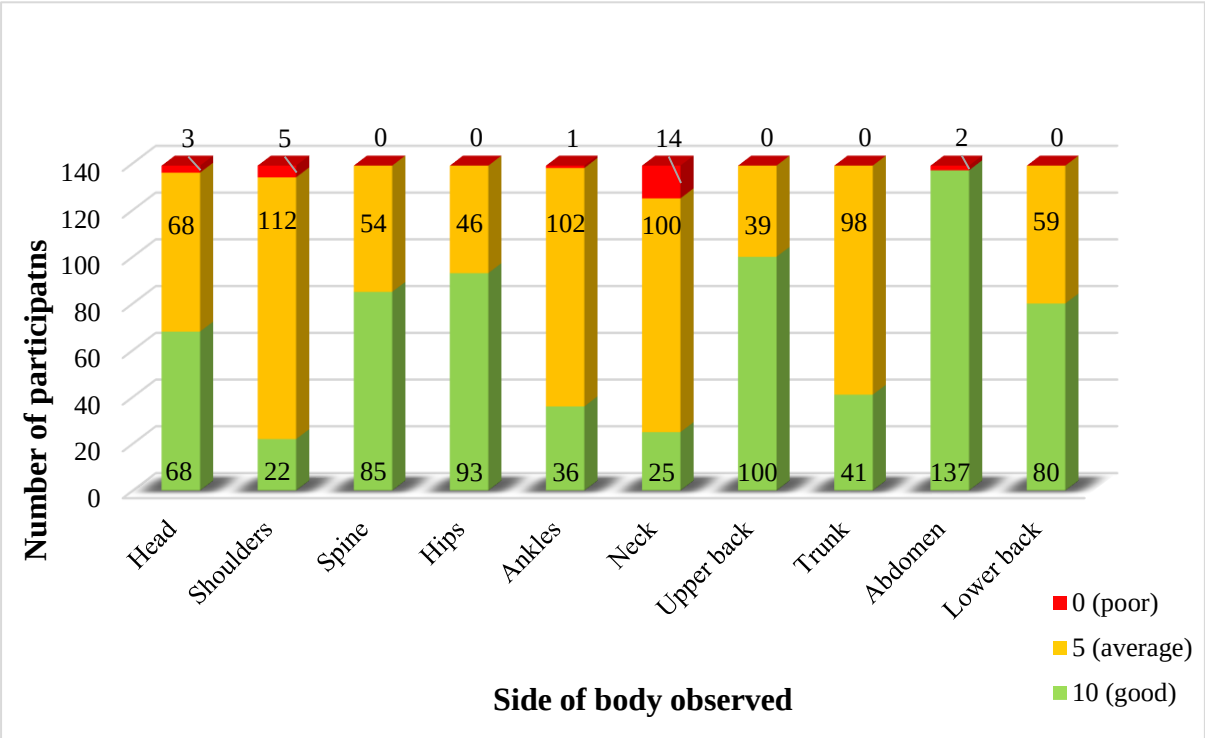


Figure 4.7: Classification of cervical ROM (degrees) for senior rugby players according to the general population norms (n = 139)

4.5 OBJECTIVE 3:

CERVICAL RANGE OF MOTION OF SENIOR RUGBY PLAYERS

The Multi-cervical unit was used to measure this objective.

Players were tested on the MCU to determine their neck range of motion in different planes. The players demonstrated a mean of 68.91 ± 9.34º for flexion and a mean of 68.92 ± 8.78º for extension. Lateral flexion to the left and right recorded a mean score of 58.27 ± 8.09º and 59.75 ± 7.41º, respectively. Left cervical rotation indicated a mean score of 82.79 ± 8.12º while right rotation has a mean score of 83.94 ± 10.46º.

The biggest range in ROM between players was found in the performance of right rotation, where the lowest ROM was 50.8 degrees and the largest range was 98.03 degrees (a difference of 47.2 degrees). The smallest difference amongst the results was found for left lateral flexion, where the maximum ROM was 74.8º and the lowest value 35.3º (a difference of Therefore,39.5º). Table 4.7 below summarises the results recorded for cervical spine ROM on the MCU as well as the general population norm values.

Table 4.7: Mean cervical spine ROM (degrees) for South African senior male rugby players tested on the MCU (n= 139)

Cervical spine ROM	***General population norm (º)***	***Mean ± Standard deviation (score)***	***Range(º)***
Flexion	60	68.91 ± 9.34	53.7- 98.9
Extension	60	68.92 ± 8.78	45.9 – 88.8
Left lateral flexion	45	58.27 ± 8.09	35.3 – 74.8
Right lateral flexion	45	59.75 ± 7.41	35.23 – 75.33
Left rotation	80	82.79 ± 8.12	52.7 – 97.4
Right rotation	80	83.94 ± 10.46	50.8 – 98.03

The results above where further classified as being either below or above the general population norm (norms presented in table 4.7). Most of the players tested above the general population norms for all angles tested.

Considering the players who tested below the general population norm, the following was found flexion 4.32% (n = 6 players); extension 15.83% (n = 22 players); left lateral flexion 7.19% (n = 10); right lateral flexion 4.32% (n = 6); left rotation 27.34% (n = 38), and right rotation 25.18% (n = 35 players).

Left and right cervical rotation indicated the highest number of players who tested below the general population norm, with n = 38 and n = 35 players, respectively. Majority of players tested above the general population norm for all angles. Figure 4.8 illustrates the classification per test as to how many players tested below or above the general population norm when considering cervical spine ROM.

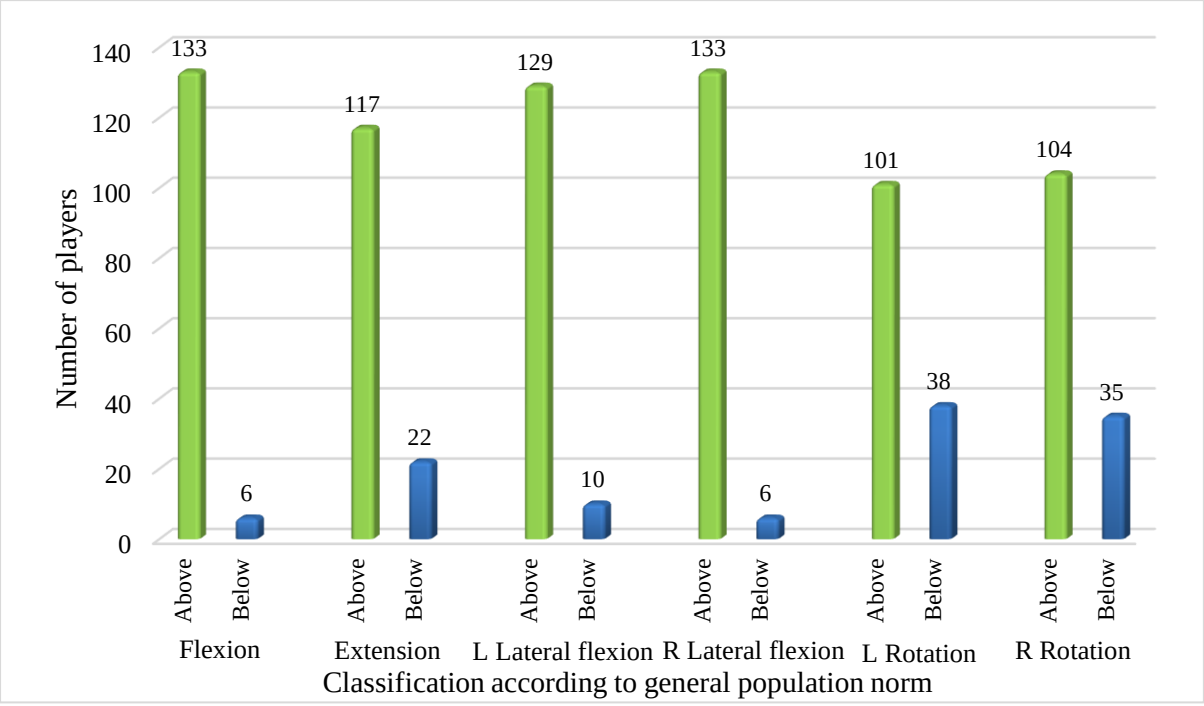


Figure 4.8: Classification of cervical ROM (degrees) for senior male rugby players according to general population norms (n=139)

The results obtained for cervical ROM were divided positionally according to backs and forwards. Table 4.8 below provides the comparisons achieved using the means of each age group.

Table 4.8: Comparison of mean cervical range of motion scores (per movement) between forward and back South African senior rugby players (n = 139)

	Forwards		***Backs***		
Cervical spine ROM	***Mean ± Standard deviation (º)***	***Range(º)***	***Mean ± Standard deviation (º)***	***Range (º)***	***P-value***
Flexion	77.29 ± 9.15	42.50	81.69 ± 9.07	39.20	0.005*
Extension	67.33 ± 9.08	42.90	70.76 ± 8.10	37.70	0.020
Left lateral flexion	57.17 ± 8.10	37.10	59.56 ± 7.95	35.10	0.080*
Right lateral flexion	58.64 ± 7.44	36.74	61.05 ± 7.21	30.90	0.054*
Left rotation	82.41 ± 8.25	42.67	83.23 ± 8.01	44.70	0.550
Right rotation	83.72 ± 9.23	41.00	84.20 ± 9.20	47.23	0.760

**Statistically significant P≤0.05*

4.6 OBJECTIVE 4:

TO DETERMINE ISOMETRIC NECK STRENGTH OF SENIOR RUGBY PLAYERS

The Multi-cervical unit was used to inform this objective.

The players were questioned on whether they had participated in any neck strengthening protocols during their rugby playing career. Figure 4.9 below indicates the number of players who indicated that they either had or had not participated in any type of cervical spine strengthening protocols.

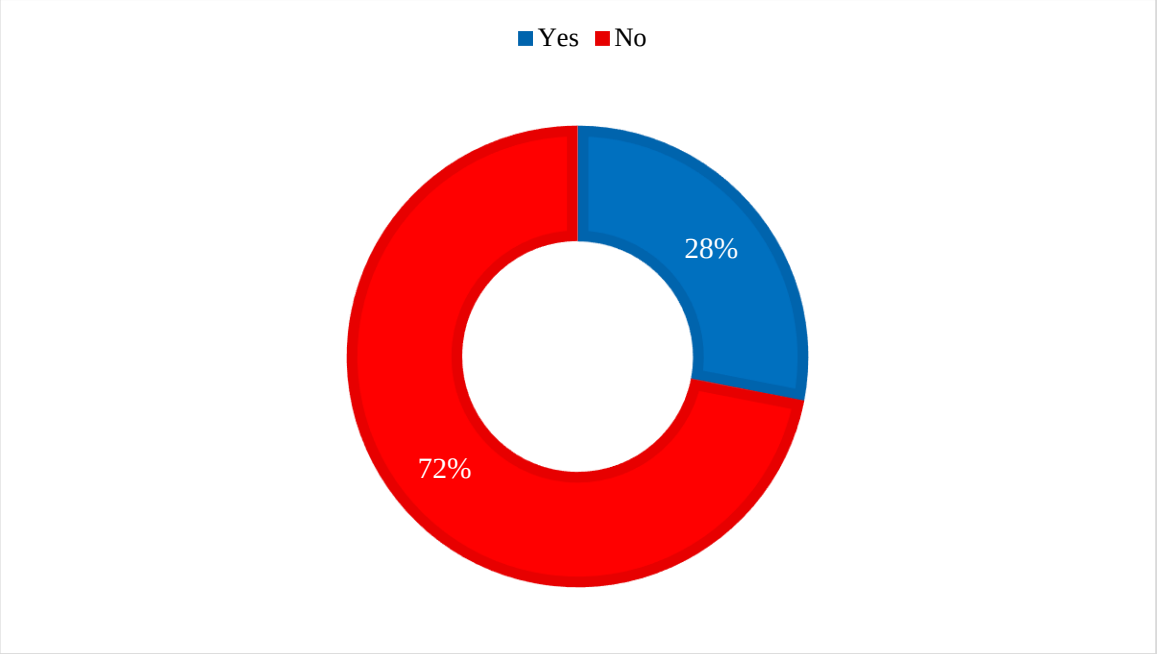


Figure 4.9: Percentage of senior male rugby players who had and had not participated in cervical spine strength protocols prior to this study (n=139)

Neck strength was measured in three different directions namely flexion, extension, and lateral flexion. For analysis purposes these will be discussed under separate headings.

4.6.1 Cervical spine strength in flexion

Neutral flexion for senior rugby players indicated an average of 13.26 ± 5.78 (kg) with 60.43% (n = 84) of the players testing above the general population norm (9.1 – 11.4kg). Strength measured for flexion at 25° for the left and right indicated means of 12.07 ± 4.79 (kg) and 11.80 ± 4.23 (kg) respectively. For both the left and right, most players (left n = 84; right n = 81) tested stronger than the population norm (8.2 – 10.5kg). At 45° of flexion for left and right a mean of 11.28 ± 3.71 (kg) and 11.56 ± 5.41(kg) was measured respectively, with most players (left n = 82; right n = 84) also performing stronger than the general population norm (7.7 – 10kg). Table 4.9 indicates the number of players who tested above, below or within the norms for the general population.

Table 4.9: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for flexion of the cervical spine for senior rugby players in South Africa (n = 139)

Flexion angle	***General population norm (kg)***	***Mean ± Standard deviation (kg)***	***% players testing above the norm***	***% players testing within the norm***	***% players testing below the norm***
Neutral (0°)	9.1 – 11.4	13.26 ± 5.78	60 (n = 84)	24 (n = 33)	16 (n = 22)
25° Left	8.2 – 10.5	12.07 ± 4.79	60 (n = 84)	24 (n = 34)	15 (n = 21)
25° Right	8.2 – 10.5	11.80 ± 4.23	58 (n = 81)	27 (n = 37)	15 (n = 21)
45° Left	7.7 - 10	11.28 ± 3.71	59 (n = 82)	24 (n = 33)	17 (n = 24)
45° Right	7.7 - 10	11.56 ± 5.41	60 (n = 84)	21 (n = 29)	19 (n = 26)

Figure 4.10 illustrates the number of players testing within, above or below the general population norm for various angles of isometric neck strength in flexion.

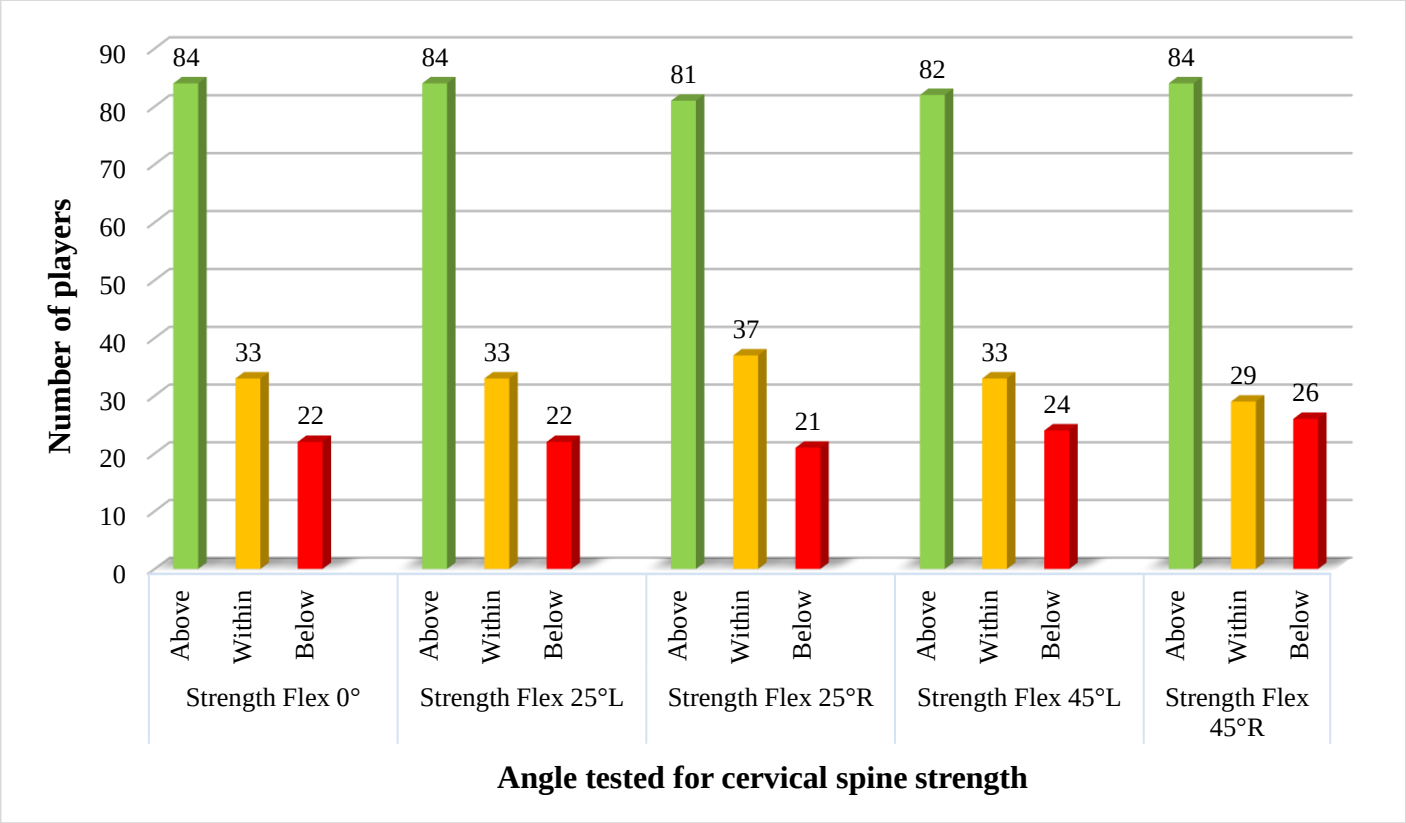


Figure 4.10: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in flexion for senior rugby players in South Africa (n = 139)

4.6.2 Cervical spine strength in extension

A mean of 12.75 ± 3.67 (kg) was measured for the population in neutral extension of the cervical spine. while mean extension at 25º left and right was found to be 12.09 ± 3.70 (kg) and 12.46 ± 6.45 (kg) respectively. The strength measured for extension at 45º averaged 11.81 ± 3.65 (kg) left and 11.83 ± 4.24 (kg) for right. When the results were compared to the general population norm, it was found that 30% (n = 41) players tested weaker for neutral extension (11.4 – 15.9 kg). A total of 37% (n = 36) and 36% (n = 50) tested below the norm for extension at 25º left and right (11.4 – 15.9 kg) while extension at 45º left and right had 27% (n = 37) and 30% (n = 42) players having weaker strength than what was expected for the general population (10.5 – 15 kg).

The results for all extension angles tested indicated that the biggest group of players where classified as testing within the general population norm. Table 4.10 states the means and standard deviations achieved per angle tested as well as the classification of the tests according to the general population norm.

Table 4.10: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for flexion of the cervical spine for senior rugby players in South Africa (n = 139)

Extension angle	***General population norm (kg)***	***Mean ± Standard deviation (kg)***	***% players testing above the norm***	***% players testing within the norm***	***% players testing below the norm***
Neutral (0°)	11.4 – 15.9	12.75 ± 3.67	11 (n = 15)	59 (n = 82)	30 (n = 42)
25° Left	11.4 – 15.9	12.09 ± 3.70	12 (n = 17)	50 (n = 70)	37 (n = 36)
25° Right	11.4 – 15.9	12.46 ± 6.45	14 (n = 19)	50 (n = 70)	36 (n = 50)
45° Left	10.5 - 15	11.81 ± 3.65	15 (n = 21)	58 (n = 81)	27 (n = 37)
45° Right	10.5 - 15	11.83 ± 4.24	17 (n = 23)	53 (n = 74)	30 (n = 42)

Figure 4.11 illustrates the number of players testing within, above or below the general population norm for various angles of isometric neck strength in flexion.

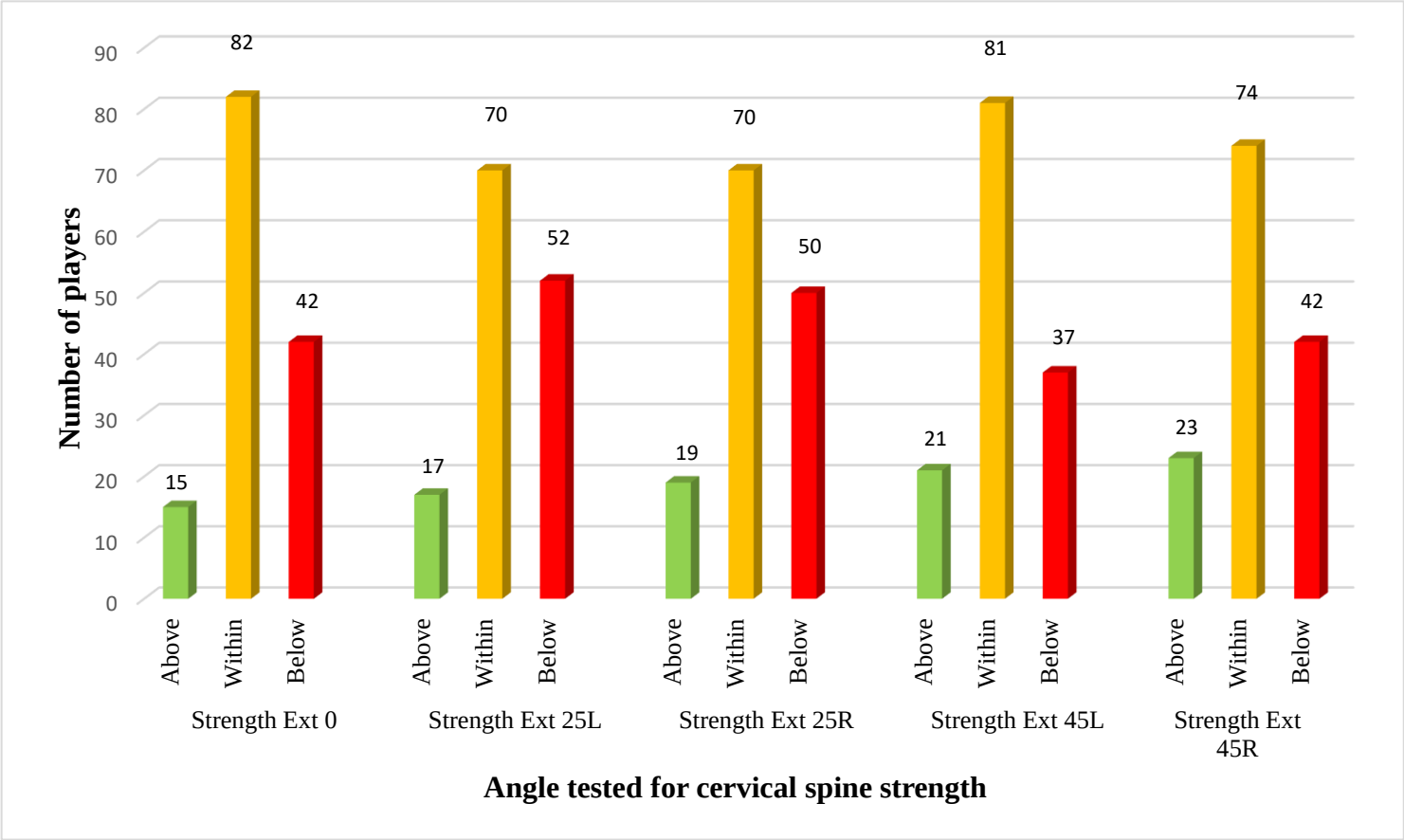


Figure 4.11: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in extension for senior rugby players in South Africa (n = 139)

4.6.3 Cervical spine strength in lateral flexion

A mean of 12.04 ± 6.27 (kg) and 10.93 ± 3.85 (kg) was recorded for the population in lateral flexion for the left and right side, respectively. The 25° angles showed a mean of 11.35 ± 3.58 (kg) and 11.42 ± 3.63 (kg) while 45° was quite similar at 11.53 ± 3.78 (kg) and 11.45 ± 3.70 (kg) for left and right tests, respectively. Classifications according to the general population norms varied between majority testing either above or within the general population norm. Table 4.11 indicates the number of players testing above, below or within the general population norm for various angles of lateral neck flexion.

Table 4.11: Mean cervical muscle strength, and number of players testing above, within or below the general population norms for lateral flexion of the cervical spine for senior rugby players in South Africa (n = 139)

Lateral flexion angle	***General population norm (kg)***	***Mean ± Standard deviation (kg)***	***% players testing above the norm***	***% players testing within the norm***	***% players testing below the norm***
Neutral (0°) flexion Left	9.1 – 11.4	12.04 ± 6.27	49 (n = 68)	32 (n = 44)	19 (n = 27)
Neutral (0°) flexion Right	9.1 – 11.4	10.93 ± 3.85	27 (n = 37)	46 (n = 64)	27 (n = 38)
25° Left	10 – 12.3	11.35 ± 3.58	28 (n = 39)	42 (n = 59)	30 (n = 41)
25° Right	10 – 12.3	11.42 ± 3.63	37 (n = 52)	35 (n = 49)	27 (n = 38)
45° Left	10.5 – 12.7	11.53 ± 3.78	23 (n = 32)	50 (n = 70)	27 (n = 37)
45° Right	10.5 – 12.7	11.45 ± 3.70	30 (n = 41)	40 (n = 56)	30 (n = 42)

Figure 4.12 exemplifies the number of players testing within, above or below the general population norm for various angles of isometric neck strength in lateral flexion.

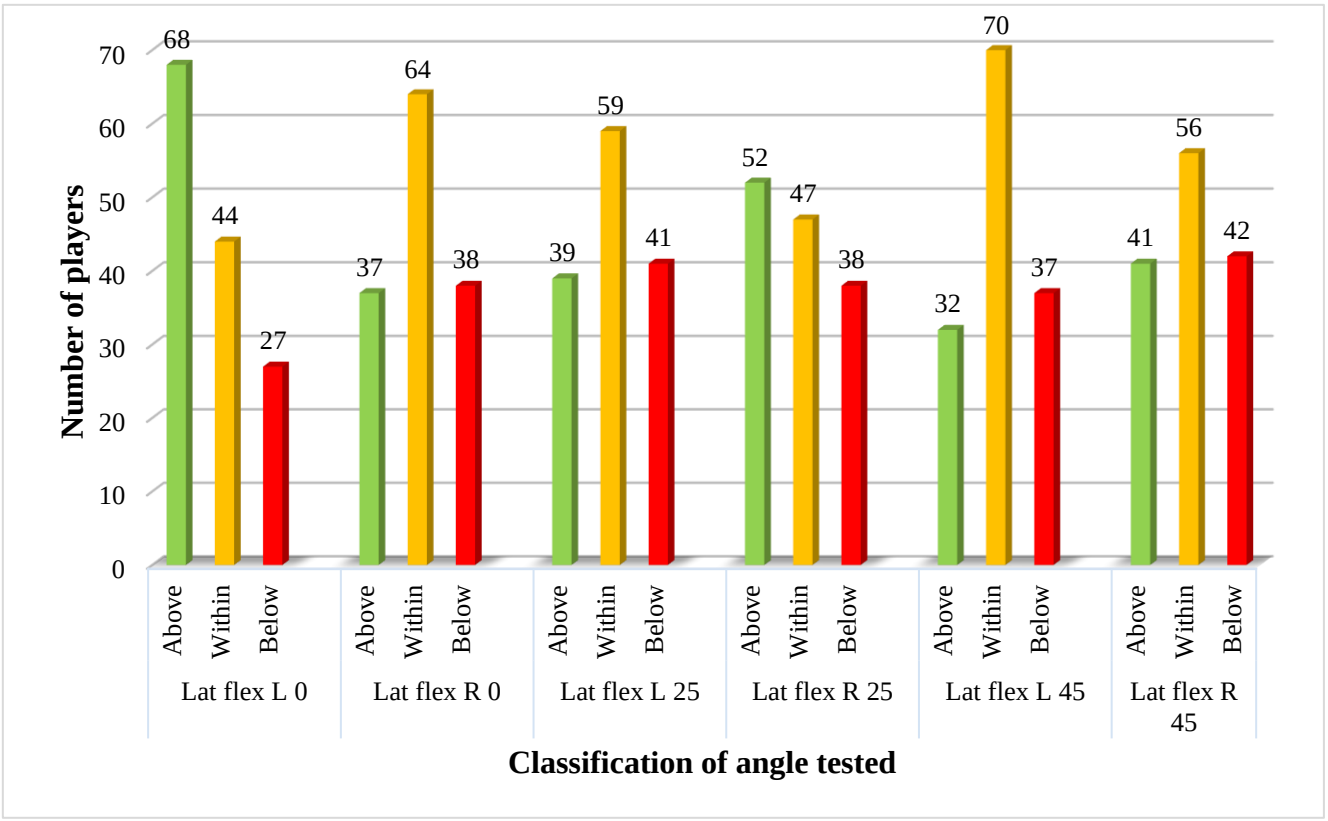


Figure 4.12: Number of players testing within, above or below the general population norm for various angles of isometric neck strength in lateral flexion for senior rugby players in South Africa (n = 139)

The average cervical spine strength for neutral flexion (0º) in forwards (14.55 ± 6.83 kg) compared to backs (11.75 ± 3.75) The same was found to be true at 25 º left and right (p = 0.001 ; p = 0.003), and 45º left (p = 0.013) indicated statistical significant strength differences. Cervical spine extension at neutral (0º) also tested stronger in forwards (13.26 ± 4.01 kg) than backs (12.15 ± 3.16 kg) with a statistically significant result (p = 0.071). Extension at 25º left was also statistically significant (p = 0.032). Comparisons for lateral flexion of the cervical spine at neutral (0º) for both left and right (p = 0.004), 25º left and right (p = 0.002; p = 0.006) and 45º left (p = 0.090) was found to be significant.

Table 4.12 below compares the average strength per age group between forwards and backs.

Table 4.12: Comparison of mean cervical strength per movement between forwards and backs in South African senior rugby players (n=139)

	Forwards		***Backs***		
Cervical spine strength	***Mean ± Standard deviation (kg)***	***Range (kg)***	***Mean ± Standard deviation (kg)***	***Range (kg)***	***P-value***
Flexion neutral (0°)	14.55 ± 6.83	4.27 – 57.40	11.75 ± 3.75	4.83 – 21.27	0.003*
Flexion 25° left	13.23 ± 5.23	3.00 – 38.83	10.70 ± 3.82	4.07 – 20.60	0.001*
Flexion 25° right	12.77 ± 4.28	2.50 – 24.07	10.65 ± 3.91	4.03 – 19.87	0.003*
Flexion 45° left	11.99 ± 3.78	2.60 – 23.07	10.44 ± 3.47	4.40 – 18.23	0.013*
Flexion 45° right	11.91 ± 3.53	2.43 – 20.47	11.14 ± 7.01	3.87 - 54.47	0.427
Extension neutral (0°)	13.26 ± 4.01	4.60 – 25.17	12.15 ± 3.16	4.40 – 21.93	0.071*
Extension 25° left	12.69 ± 4.07	5.33 – 24.23	11.38 ± 3.09	4.70 – 18.63	0.032*
Extension 25° right	12.87 ± 3.75	5.57 – 22.20	11.96 ± 8.62	4.23 – 75.27	0.435
Extension 45° left	12.40 ± 4.06	4.30 – 22.83	11.11 ± 2.99	4.20 – 19.20	0.032
Extension 45° right	12.36 ± 4.41	3.83 – 24.73	11.22 ± 3.98	3.07 – 30.13	0.111
Lateral flexion neutral left (0°)	13.39 ± 7.71	2.97 – 68.03	10.45 ± 3.38	2.57 – 18.47	0.004*
Lateral flexion neutral right	11.78 ± 4.07	2.97 – 23.03	9.92 ± 3.34	2.97 – 18.87	0.004*

(0°)					
Lateral flexion 25° left	12.19 ± 3.74	3.07 - 21.27	10.38 ± 3.14	3.17 – 18.00	0.002*
Lateral flexion 25° right	12.18 ± 3.85	3.97 – 23.13	10.54 ± 3.15	2.53 – 18.47	0.006*
Lateral flexion 45° left	12.02 ± 4.05	4.00 – 25.07	10.95 ± 3.38	3.63 – 22.13	0.090*
Lateral flexion 45° right	12.02 ± 3.99	4.33 – 26.63	10.79 ± 3.23	3.17 – 19.33	0.047

** Statistically significant P-value ≤0.05%*

4.7 OBJECTIVE 5:

TO DETERMINE IF THERE IS A RELATIONSHIP BETWEEN CERVICAL MUSCLE WEAKNESS AND POOR POSTURE

An analysis between the results obtained from Multi-cervical unit and the New York posture rating scale.

A Pearson's correlation test was performed to determine if there is a relationship between posture, obtained from the NYP rating scale, and cervical spine strength in all angles tested for flexion, extension, and lateral flexion.

Significant relationships were found for mean neck posture scores (p = 0.014) and cervical spine flexion 25º for the left side. Mean scores for posture were significant for hip (p = 0.05) and neck (p= 0.030) in flexion at 25º for the right. The same was found to be true for mean left the hip (p = 0.05) strength in flexion at 45º. Furthermore, Posture significant mean scores for the hips (p = 0.005) and neck (p = 0.022) were found in flexion at 45º for the right.

Table 4.13 below illustrates the correlation of isometric neck strength per angle in flexion with overall and body site posture score(s) in male South African senior rugby players (n = 139).

Table 4.13: Correlation between isometric neck strength for flexion with the overall and score(s) per body region in senior rugby players (n = 139)

Cervical spine strength (per angle)	***Overall posture score***	***Head***	***Shoulders***	***Spine***	***Hips***	***Ankles***	***Neck***	***Upper back***	***Trunk***	***Abdomen***	***Lower back***
Flexion neutral (0°)	0.11 (0.204)	-0.12 (0.153)	-0.01 (0.937)	0.13 (0.134)	-0.13 (0.124)	-0.0038 (0.965)	0.14 (0.091)	0.07 (0.430)	0.03 (0.748)	0.04 (0.666)	0.15 (0.075)
Flexion 25° left	0.095 (0.268)	-0.06 (0.455)	-0.003 (0.970)	0.045 (0.602)	-0.13 (0.251)	0.10 (0.251)	0.21 (0.014)*	0.094 (0.273)	0.13 (0.140)	0.02 (0.805)	0.05 (0.534)
Flexion 25° right	0.050 (0.934)	-0.10 (0.248)	-0.01 (0.929)	0.13 (0.139)	-0.17 (0.05)*	-0.23 (0.792)	0.18 (0.030)*	0.05 (0.572)	0.05 (0.587)	0.05 (0.566)	0.11 (0.210)
Flexion 45° left	-0.01 (0.9340	-0.01 (0.934)	-0.16 (0.053)	-0.05 (0.572)	-0.17 (0.05)*	-0.02 (0.773)	0.13 (0.124)	0.01 (0.912)	0.05 (0.554)	0.004 (0.967)	0.05 (0.548)
Flexion 45° right	-0.67 (0.436)	-0.13 (0.127)	-0.13 (0.130)	0.10 (0.236)	-0.23 (0.005)*	-0.14 (0.098)	0.19 (0.022)*	0.003 (0.973)	-0.04 (0.682)	0.007 (0.936)	0.06 (0.501)

*Data presented as r (p-value); *p≤0.05*

Significant relationships were found for mean hip (p = 0.005) and neck (p = 0.022) posture scores in neutral extension (0°). Extension at 25° left and right indicated a significant relationship with the overall posture score (p = 0.002), spine (p = 0.044), neck (p = 0.003) and lower back (p = 0.001) scores. Extension at 45° for the left saw a significant relationship with the overall posture score (p = 0.027), spine (p = 0.033), hips (p = 0.012) and the neck (p = 0.003) posture scores. Posture scores for neck (p = 0.047) and lower back (p = 0.004) indicated a significance with extension at 45º for the right side.

Table 4.14 illustrates the correlation of isometric neck strength per angle in extension with overall and body site posture score(s) in senior rugby players (n = 139).

Table 4.14: Correlation of isometric neck strength per angle in extension with overall and individual posture body site score(s) in senior rugby players (n = 139)

Cervical spine strength (per angle)	***Overall posture score***	***Head***	***Shoulders***	***Spine***	***Hips***	***Ankles***	***Neck***	***Upper back***	***Trunk***	***Abdomen***	***Lower back***
Extension neutral (0°)	-0.07 (0.436)	-0.13 (0.127)	-0.13 (0.130)	0.10 (0.236)	-0.23 (0.005)*	-0.14 (0.098)	0.19 (0.022)*	0.003 (0.973)	-0.04 (0.682)	0.007 (0.936)	0.06 (0.501)
Extension 25° left	0.26 (0.002)*	0.04 (0.679)	0.08 (0.333)	0.17 (0.044)*	-0.08 (0.326)	0.08 (0.327)	0.25 (0.003)*	0.13 (0.126)	0.14 (0.092)	0.06 (0.502)	0.27 (0.001)*
Extension 25° right	0.26 (0.002)*	0.04 (0.679)	0.08 (0.333)	0.17 (0.044)*	-0.08 (0.0326)	0.08 (0.327)	0.25 (0.003)*	0.13 (0.126)	0.14 (0.092)	0.06 (0.502)	0.27 (0.001)*
Extension 45° left	0.19 (0.027)*	0.003 (0.973)	0.08 (0.358)	0.18 (0.033)*	-0.21 (0.012)*	0.04 (0.652)	0.246 (0.003)*	0.16 (0.064)	0.14 (0.097)	0.54 (0.525)	0.16 (0.066)
Extension 45° right	0.10 (0.241)	-0.10 (0.225)	0.12 (0.168)	0.01 (0.894)	-0.15 (0.078)	0.003 (0.971)	0.17 (0.047)*	0.09 (0.275)	0.08 (0.323)	-0.02 (0.84)	0.25 (0.004)*

*Data presented as r (p-value); *p≤0.05*

Significant relationships were found for the mean hip posture score (p = 0.015) and left lateral flexion at neutral (0°), while the mean hips (p = 0.015) and neck (p = 0.011) posture score were significant for right lateral flexion at neutral (0º). Mean postures scores of the hips (p = 0.015), neck (p = 0.035) and the lower back (p = 0.015) were significant in relation to left lateral neck flexion at 25º, while the hips (p = 0.026) and neck (p = 0.022) regions had statistically significant relationships in right lateral neck flexion at 25º. The overall mean posture score (p = 0.013), spine (p = 0.019) and neck (p = 0.001) scores had statistical significant correlations in lateral neck flexion at 45º left, while overall posture score (p = 0.047), neck (p = 0.029) and the lower back (p = 0.037) regions showed significant results with lateral neck flexion at 45º right.

Table 4.15 illustrates the correlation of isometric neck strength per angle in lateral flexion with overall and body site posture score(s) in senior rugby players (n = 139).

Table 4.15: Correlation of isometric neck strength per angle in lateral flexion with overall and individual posture body site score(s) in senior rugby players (n = 139)

Cervical spine strength (per angle)	***Overall posture score***	***Head***	***Shoulders***	***Spine***	***Hips***	***Ankles***	***Neck***	***Upper back***	***Trunk***	***Abdomen***	***Lower back***
Lateral flexion left at neutral (0°)	0.06 (0.479)	-0.003 (0.969)	-0.06 (0.478)	0.07 (0.381)	-0.21 (0.015)*	0.0002 (0.998)	0.11 (0.185)	0.11 (0.189)	0.13 (0.115)	0.03 (0.722)	0.06 (0.473)
Lateral flexion right at neutral (0°)	0.05 (0.530)	-0.1 (0.886)	-0.11 (0.188)	-0.01 (0.876)	-0.21 (0.015)*	0.05 (0.580)	0.22 (0.011)*	0.06 (0.465)	0.06 (0.505)	-0.04 (0.631)	0.13 (0.126)
Lateral flexion 25° left	0.09 (0.287)	-0.06 (0.943)	-0.03 (0.727)	0.07 (0.369)	-0.21 (0.015)*	-0.02 (0.786)	0.18 (0.035)*	0.08 (0.325)	0.10 (0.230)	0.0001 (0.999)	0.21 (0.015)*
Lateral flexion 25° right	0.10 (0.219)	-0.02 (0.791)	-0.02 (0.776)	0.06 (0.491)	-0.19 (0.026)*	0.03 (0.718)	0.19 (0.022)*	0.14 (0.100)	0.13 (0.115)	0.038 (0.661)	0.13 (0.123)
Lateral flexion 45° left	0.21 (0.013)*	0.02 (0.811)	0.07 (0.404)	0.20 (0.019)*	-0.13 (0.118)	0.10 (0.262)	0.27 (0.001)*	0.14 (0.089)	0.08 (0.338)	0.02 (0.853)	0.16 (0.061)
Lateral flexion 45° right	0.17 (0.047)*	-0.05 (0.573)	0.10 (0.253)	0.13 (0.129)	-0.16 (0.059)	0.11 (0.216)	0.19 (0.029)*	0.07 (0.409)	0.16 (0.056)	0.04 (0.654)	0.18 (0.037)*

*Data presented as r (p-value); *p≤0.05*

4.8 OBJECTIVE 6:

SPORT SPECIFIC CERVICAL SPINE STRENGTH NORMS FOR SENIOR RUGBY PLAYERS

An analysis between the results obtained from Multi-cervical unit.

The cervical spine strength results generated from the MCU test were analysed and split into age groups u/19, u/21, and senior players (22 years to 33 years of age). Norms for this study were calculated around the median, using the average as the bottom end of the range, and adding the standard deviation to obtain the top range value. These norms were specially created for senior (u/19 and older) professional rugby players. It was further divided into positions with the forwards and backs. The forwards are made up out of the following positions: prop; hooker; lock; flank and eighth man, while the backs are: scrumhalf; flyhalf; wing; centre; fullback and utility back.

Table 4.16 identifies the total number of players after categorization in which the cervical spine strength norms were developed.

Table 4.16: Number of players per age category for the development of cervical spine strength norms (n = 139)

Age group	***Number of forwards***	***Number of backs***
u/19	37	32
u/21	14	11
Seniors	23	22

4.8.1 u/19 rugby players – Forwards

Table 4.17: Cervical spine strength norms for u/19 male rugby players - forwards (n = 37)

	Mean ± Standard deviation (kg)	***Range (kg)***
Flexion Neutral (0°)	12.60 ± 4.87	12.60 – 17.46

Flexion 25° Left	12.75 ± 6.34	12.75 – 19.09
Flexion 25° Right	11.55 ± 4.6	11.55 – 16.22
Flexion 45° Left	11.07 ± 4.12	11.07 – 15.20
Flexion 45° Right	11.06 ± 3.93	11.06 – 14.99
Extension Neutral (0°)	12.50 ± 4.41	12.50 – 16.91
Extension 25° Left	12.16 ± 4.62	12.16 – 16.78
Extension 25° Right	12.27 ± 4.09	12.27 – 16.36
Extension 45° Left	11.76 ± 4.58	11.76 – 16.34
Extension 45° Right	11.06 ± 4.85	11.06 – 15.91
Lateral flexion neutral Left (0°)	12.14 ± 4.75	12.14 – 16.89
Lateral flexion neutral Right (0°)	11.07 ± 4.30	11.07 – 15.37
Lateral flexion 25° Left	11.08 ± 4.21	11.08 – 15.29
Lateral flexion 25° Right	10.91 ± 3.87	10.91 – 14.78
Lateral flexion 45° Left	11.85 ± 4.79	11.85 – 16.64
Lateral flexion 45° Right	11.14 ± 4.35	11.14 – 15.50

4.8.2 u/19 rugby players - Backs

Table 4.18: Cervical spine strength norms for u/19 male rugby players - backs (n = 32)

	Mean ± Standard deviation (kg)	***Range (kg)***
Flexion Neutral (0°)	10 ± 13.17	10.00 – 3.17
Flexion 25° Left	9.1 ± 3.08	9.11 – 12.19
Flexion 25° Right	9.02 ± 3.37	9.02 – 12.39
Flexion 45° Left	9.03 ± 3.15	9.03 – 12.18
Flexion 45° Right	9.24 ± 4.97	9.24 – 14.21
Extension Neutral (0°)	10.54 ± 2.18	10.54 – 12.73
Extension 25° Left	10.11 ± 2.55	10.11 – 12.66
Extension 25° Right	9.93 ± 2.58	9.93 – 12.50
Extension 45° Left	9.79 ± 2.65	9.79 – 12.44

Extension 45° Right	10.24 ± 4.47	10.24 – 14.71
Lateral flexion neutral Left (0°)	8.94 ± 8.94	8.94 – 11.85
Lateral flexion neutral Right (0°)	9.31 ± 2.98	8.95 – 11.93
Lateral flexion 25° Left	9.65 ± 2.91	9.31 – 12.22
Lateral flexion 25° Right	9.76 ± 2.70	9.65 – 12.34
Lateral flexion 45° Left	9.76 ± 2.63	9.76 – 12.39
Lateral flexion 45° Right	9.90 ± 2.80	9.90 – 12.69

4.8.3 u/21 rugby players - Forwards

Table 4.19: Cervical spine strength norms for u/21 male rugby players - forwards (n =14)

	Mean ± Standard deviation (kg)	***Range (kg)***
Flexion Neutral (0°)	18.24 ± 12.07	18.24 – 30.32
Flexion 25° Left	14.52 ± 4.46	14.52 – 18.98
Flexion 25° Right	14.37 ± 3.83	14.37 – 18.22
Flexion 45° Left	12.89 ± 3.70	12.89 – 16.59
Flexion 45° Right	13.16 ± 3.28	13.16 – 16.44
Extension Neutral (0°)	15.23 ± 4.15	15.23 – 19.37
Extension 25° Left	14.3 ± 3.88	14.3 – 18.18
Extension 25° Right	14.01 ± 3.21	14.01 – 17.22
Extension 45° Left	13.22 ± 3.43	13.22 – 16.64
Extension 45° Right	13.61 ± 3.36	13.61 – 16.98
Lateral flexion neutral Left (0°)	12.48 ± 3.46	12.48 – 15.94
Lateral flexion neutral Right (0°)	12.45 ± 3.76	12.45 – 16.21
Lateral flexion 25° Left	13.00 ± 3.09	13.00 – 16.09
Lateral flexion 25° Right	13.06 ± 3.26	13.06 – 16.32
Lateral flexion 45° Left	13.57 ± 3.25	13.57 – 16.82
Lateral flexion 45° Right	13.83 ± 3.23	13.83 – 17.06

4.8.4 u/21 rugby players - Backs

Table 4.20: Cervical spine strength norms for u/21 male rugby players - backs (n =11)

	Mean ± Standard deviation (kg)	***Range (kgs)***
Flexion Neutral (0°)	13.51 ± 3.61	13.51 – 17.12
Flexion 25° Left	12.50 ± 3.81	12.50 – 16.31
Flexion 25° Right	12.29 ± 3.89	12.29 – 16.18
Flexion 45° Left	11.56 ± 3.14	11.56 – 14.70
Flexion 45° Right	15.4 ± 13.38	15.4 – 28.78
Extension Neutral (0°)	15.1 ± 3.41	15.1 – 18.51
Extension 25° Left	14.61 ± 2.73	14.61 – 17.34
Extension 25° Right	17.58 ± 19.64	17.58 – 37.21
Extension 45° Left	13.46 ± 3.57	13.46 – 17.04
Extension 45° Right	12.84 ± 3.61	12.87 – 16.48
Lateral flexion neutral Left (0°)	12.79 ± 3.50	12.79 – 16.29
Lateral flexion neutral Right (0°)	12.55 ± 3.93	12.55 – 16.49
Lateral flexion 25° Left	12.98 ± 3.60	12.98 – 16.59
Lateral flexion 25° Right	12.08 ± 3.44	12.08 – 15.51
Lateral flexion 45° Left	14.16 ± 4.04	14.16 – 18.20
Lateral flexion 45° Right	12.61 ± 3.60	12.61 – 16.21

4.8.5 Senior rugby players - Forwards

Table 4.21: Cervical spine strength norms for senior male rugby players - forwards (n = 23)

	Mean ± Standard deviation (kg)	***Range (kg)***
Flexion Neutral (0°)	15.27 ± 3.95	15.27 – 19.22
Flexion 25° Left	13.12 ± 3.55	13.12 – 16.67
Flexion 25° Right	13.49 ± 3.49	13.49 – 16.99
Flexion 45° Left	12.66 ± 2.99	12.66 – 15.65

Flexion 45° Right	12.34 ± 2.76	12.34 – 15.11
Extension Neutral (0°)	12.94 ± 2.74	12.94 – 15.69
Extension 25° Left	12.44 ± 3.21	12.44 - 15.65
Extension 25° Right	13.11 ± 3.41	13.11 – 16.52
Extension 45° Left	12.61 ± 3.31	12.61 – 15.92
Extension 45° Right	13.45 ± 3.78	13.45 – 17.23
Lateral flexion neutral Left (0°)	15.62 ± 11.97	15.27 – 27.59
Lateral flexion neutral Right (0°)	12.18 ± 3.51	12.18 - 15.69
Lateral flexion 25° Left	13.43 ± 2.96	13.43 – 16.40
Lateral flexion 25° Right	13.36 ± 3.51	13.56 – 16.87
Lateral flexion 45° Left	11.38 ± 3.22	11.38 – 14.61
Lateral flexion 45° Right	12.23 ± 3.71	12.23 – 15.94

4.8.6 Senior rugby players - Backs

Table 4.22: Cervical spine strength norms for senior male rugby players - forwards (n = 22)

	Mean ± Standard deviation (kg)	***Range (kg)***
Flexion Neutral (0°)	13.65 ± 3.66	13.65 – 17.32
Flexion 25° Left	12.37 ± 4.09	12.54 – 16.46
Flexion 25° Right	12.54 ± 3.82	12.54 – 16.36
Flexion 45° Left	12.22 ± 3.42	12.22 – 15.64
Flexion 45° Right	11.96 ± 13.31	11.96 – 15.27
Extension Neutral (0°)	13.26 ± 2.94	13.26 – 16.20
Extension 25° Left	11.80 ± 2.83	11.80 – 14.64
Extension 25° Right	12.22 ± 2.75	12.22 – 14.96
Extension 45° Left	12.21 ± 2.72	12.21 – 14.94
Extension 45° Right	12.04 ± 3.22	12.04 – 15.26
Lateral flexion neutral Left (0°)	12.00 ± 3.83	12.00 – 15.83

Lateral flexion neutral Right (0°)	10.50 ± 3.62	10.50 – 14.12
Lateral flexion 25° Left	10.75 ± 2.44	10.75 – 13.19
Lateral flexion 25° Right	11.45 ± 3.69	11.45 – 15.14
Lateral flexion 45° Left	11.13 ± 2.87	11.13 – 14.01
Lateral flexion 45° Right	11.33 ± 3.20	11.33 – 14.53

CHAPTER 5: DISCUSSION

5.1 INTRODUCTION

This chapter will discuss the results presented in chapter 4. To the researcher's knowledge, this study is the first of its kind assessing neck strength and ROM using the MCU and performing a comparison to the injury history and posture assessment of the players.

5.1.1 Demographic information

A total of 139 senior rugby players participated in this research study and had an average age of 20.42 ± 3.29 years. Considering standard team composition in rugby (4), it is expected that a team of 23 players, which includes the reserves, will consist of more forwards than backs. This study is reflective of this composition whereby more forwards were included in this study than backs.

A) *The use of protective gear*

In this study, it was found that the bulk of players played with some type of protective gear. The most common of which, was the use of the mouthguard (used by 119 players out of 139 (76%), while concussion headbands seemed to not be used as readily. It was however not established whether headbands were not worn due to lack of awareness of the gear or the preference to play without it. These findings were similar to the findings of Marshall et al. (2001) who found that mouthguards were the most popular protective gear used while training or participating in a match format [(90)]. Furthermore, Marshall et al. (2001) also established that players who were at a higher risk of obtaining an injury, (forwards, seniors and male players), were more likely to use some form of protective equipment [(90)].

This study did not collect any information on whether the players believed that the use of protective gear would prevent the occurrence of injuries, yet Menger et al. (2016) stated that 38.1% of their study population consisting of male rugby players believed that headgear would prevent concussions [(91)]. Studies investigating whether mouthguards had an effect on reducing head- and spinal cord injuries have mainly been based on case studies and retrospective surveys related to injuries [(91, 92, 93)]. According to Dr. Paul McCrory, no persuasive evidence exists that mouthguards have a protective function. Thus, further research would be beneficial in understanding why players opt for mouth guards as a form of player protection [(92)]. Interestingly, Menger et al. (2016) found that

42.2% of players in his study played more aggressively since they were wearing headgear [91]. This study found that even though a high percentage of players used protective headgear (18.9%; n = 23), concussions and cervical spine injuries still had a high incidence rate, yet a relationship between these variables was not established.

B) Neck Disability Index (NDI) results in senior rugby players

An ideal score for the NDI is 0%, which indicates that the participant does not experience any neck pain during participation in everyday activities or sports participation. For this sample, the average NDI score was 3% ± 0.04% indicating that the discomfort experienced per scenario was minimal. Only one participant had a calculated NDI score of 18%, however, this is still below 20% and was therefore cleared for further participation in the study. Nevertheless, considering that the NDI includes scenarios related to headaches, concentration problems and issues with sleeping patterns, a score of below 20% is accepted as ideal. Since that the participants in this study population are physically active and participate in strength training daily, it was expected that the scores would be quite low. When considering the overall study population, the majority indicated that they were either struggling with slight infrequent headaches of mild intensity or headaches of moderate intensity. The second highest NDI score was found for concentration problems. Twenty-two players indicated that they were able to concentrate when they need to, however with some difficulty. Seven participants indicated that they had a fair amount of difficulty in concentrating and 1 indicated that they experienced a lot of difficulty with concentration. The highest score recorded was for a greatly disturbed sleeping pattern with the participant indicating being sleepless for 3 – 5 hours. This corresponds with a study performed by Watson et al. (2014) who also found that headaches were the most commonly reported comorbidity amongst rugby players, along with sleeping [94].

5.1.2 Occurrence of cervical spine injuries in senior rugby players

Concussions were the most common head and neck injury that occurred within this study population. Data collected regarding the occurrence of a concussion indicated that 50 players, from a total of 83 who had sustained concussions, had between 1 and 5 in the last 2 years. A study conducted amongst professional Irish rugby clubs involved 172 players with an average age of 24.97 ± 4.11 years [49], and found that 45% of the players had sustained a concussion between 2010 – 2011. This study found that backs were more prone to suffer concussions than forwards. Harmon et al. (2013) estimated that about 3.8 million concussions occurred in

the United States of America (USA) per competitive sports year. He also stated that about 50% of all concussions generally go unreported [95].

Of all cervical injuries, whiplash (42%; n =8) was indicated as the most common injury amongst the players, with muscle sprains (26.3%; n = 5) coming in as the second most common. Tee et al. (2017) investigated a case study on the injury occurrence rates and characteristics in South African school first rugby teams [96]. They found that concussions had the highest incidence rates, while haematomas to the head/face were the second highest. This was followed by contusions to the neck and cervical muscle strains. Their focus was however, only on injuries that could occur on the field during rugby [96]. The conclusion of the study done by Tee et al. (2017) corresponds to the findings of this study with concussion being the most frequent injury occurring amongst rugby players [96].

A) *Concussions and other musculoskeletal injuries*

Few studies have investigated the relationships between concussions and the occurrence of musculoskeletal injuries in the same year. Current literature suggests that a player might be more prone to occurring another injury in the same year as obtaining a concussion [97, 98]. In this study however just more than a quarter of the players who did obtain a concussion sustained another injury during the same year. The larger part of the injuries sustained occurred at the knee joint (26%; n = 7). This was followed by injuries at the shoulder (19.23%; n = 5) and ankle (15.38%; n = 4) level. Further research will be needed to identify whether a player would be at a definite risk of obtaining other musculoskeletal injuries in the same year as a concussion.

A study by Herman et al. (2017) found that a direct relationship between concussions and an increased risk of lower extremity injuries after returning to play existed. Even though information is lacking with regards to relationships between cervical musculature and injuries [97]. This study aimed to bridge the current gap in research by assessing the cervical spine musculature and injuries. The biggest concern with the comparison of cervical spine strength results to the general population norms is that from the 16 different angles tested for extension, 9 areas involved the greater part of the study population. The results found by Kardouni et al. (2018) correlates with Herman et al. (2017) and further identifies that the risk remains elevated up to one year after sustaining

a concussion [97, 98]. The difference in the findings between these studies and the results obtained might be due to age-related and amount of playing years.

B) Baseline concussion testing in rugby players

This study revealed that 74% of the participants had had a baseline concussion test. Some players had more than one test, as a total of 144 tests were recorded for the 103 players that underwent testing. Furthermore, this was an indication that there were some players (26%) that had not undergone baseline concussion testing which may have increased the risk for them returning to play before they had completely recovered from the concussion. According to literature a remiss of baseline testing has a direct increase in the risk of developing secondary concussion syndrome. The aim of BokSmart, in training referees and coaches and the recent rule changes in rugby, was to improve the safety of rugby players and to decrease the occurrence of concussions and cervical spine injuries [53]. It was however still found in this study that the incidence rates of concussions are quite high, particularly when looking of the concussion stats for the last two years. Even though BokSmart does exist with the main aim to protect players against injuries, an uncertainty still exists as to whether a player will be at an increased risk for sustaining a concussion or cervical spine injury.

From school level rugby it is advised that rugby players undergo a baseline concussion test to safely return the player to sport participation. In this study it was found that the majority players had undergone this testing, however, it was noted that some players were uncertain as to which programme, they used and there were still some players who have not undergone these baseline tests. Baseline concussion test should not be seen as an indication for the risk to obtain a future sports-related concussion [57]. It should rather be used for comparison purposes with post-injury tests to ensure that the player is back to pre-injury standard before returning to play. This will then decrease the risk for post-concussion syndrome. These tests should be made more widely available and should be compulsory for athletes of all ages.

5.1.3 Posture of senior rugby players

In this study, a posture rating score was used to classify players for specific body areas, ratings of poor (0), average (5) or good (10) were described. Therefore, the higher the score obtained, the better the overall posture of a player. The highest recorded posture rating using

the New York Posture (NYP) rating chart was 95% and the lowest 45%. The overall average of the study population had a NYP rating of 7.14 ± 0.93. The body area that which had the lowest mean posture score was the neck region (4.89 ± 2.47), while the abdomen region (10 ± 0) scored the best amongst this study population.

Lopezosa-Reca et al. (2020) studied the association between foot posture and injuries associated with the lower limbs in male basketball players [(99)]. It was concluded that patellar tendinopathy was associated with supinated feet [(99)]. Leppänen et al. (2020) found that an increase contralateral pelvic hike is associated with non-contact knee injuries amongst young basketball enthusiasts. While it increased the risk of non-contact ACL injuries in young female athletes [(100)]. Watson (2001) investigated sports injuries over a two-year period that occurred amongst 102 high-level soccer players [(101)]. He recommended that improving posture during rehabilitation after obtaining an injury should be a focus rather than increasing flexibility. This is possibly because injuries are often associated with muscle atrophy. He also advised that additional research was needed to confirm this statement. He also identified that posture evaluation should be quantitative in nature and should be accurately performed [(101)]. In 1995 he also performed a study related to posture abnormalities and body mechanics in relation to sports injuries [(101)]. Watson concluded that the occurrence of injuries to the ankles, back, knees and general muscle injuries was influenced by flaws in body mechanics and postural abnormalities [(102)]. This relates to the correlation found in this study between the cervical spine strength and the posture rating scores, which will be discussed later in this section. Langdon et al. (2019) found that when rugby players retire as well as for long term health benefits, postural correction can be beneficial [(15)]. An increased lumbar lordosis and forward head position have the potential to increase lower back pain and neck pain, respectively. They also found that older players and those with larger body weight were more likely to obtain an injury [(15)]. This study did not record or obtain information on the weight or height of the participants. It was however found that the seniors had a higher percentage (82% ; n = 23) of players who have sustained concussions as well as other cervical spine injuries (21% ; n = 6) when compared to the u/19 [47% (n = 39 ; 12% (n = 10)] and u/21 [75% (n = 21) ; 10% (n = 3) players. It should also be taken into consideration that the group of u/19 players (n = 83) were much bigger than the senior group (n = 28). The senior rugby players also have been participating for a much longer period compared to the other players and are therefore more likely to have had more injuries. Langdon et al. (2019) also found that rugby players in the uninjured group had moderate deviations of Cervical spine scoliosis

compared to those in the uninjured group [15]. They concluded that posture might not have a direct influence in obtaining a lower limb injury, however, they were uncertain as to the influence it may have on upper limb, or spinal injuries [15]. To the researcher's knowledge, no other studies investigated the influence of posture on the risk of obtaining cervical spine injuries and concussions. Hennessy and Watson (1993) stated that anatomical abnormalities including muscle imbalances, limited strength and ROM and are important risk factors to consider [103].

5.1.4 Cervical ROM of senior rugby players

Within this study population, the majority of the participants were categorised as having higher than normal cervical ROM. Storm et al. (2018) summarized that there a relationship exists between the range of motion (ROM) and injury incidence rates [104]. This study did not measure the correlation between cervical ROM and the injury incidence rates. The test results for cervical spine ROM were compared according to general population norms. The average norms are: Flexion 60°; Extension 60°; Lateral flexion 45°, and Rotation 80°. It was however found that cervical rotation to the left (27%; n = 38) and right (25%; n = 35) involved the biggest group of players who tested below the norms. Considering these two specific ROM tests, the larger part of the players still tested above the norm (left = 73%; right = 75%). Hemelryck et al. (2018) performed an ultrasonographic assessment on the neck muscular size and ROM of rugby players and found that cervical ROM was decreased in front row players when comparing them to the backs [105]. This is however in contrast to the findings of this study where forwards had stronger neck musculature which will relate to larger muscle size. Davis et al. (2015) found no significant difference between Cervical ROM when comparing age groups or playing positions [106]. It was however noticed that the tighthead props had a reduced ROM [106]. Forming a direct comparison to this last-mentioned statement was difficult as not all the props indicated whether they were in the loose- or tighthead position. The means in this study did, however, identify that the backs had a greater cervical ROM than the forwards for all angles that were tested. Statistically significant results were found for Flexion 0º ($p = 0.005$), left lateral flexion ($p = 0.08$), and right lateral flexion ($p = 0.054$) when drawing comparisons between the forwards and backs.

Majority of the players also tested above the general population norm over the entire range tested which had been identified by other studies to have the ability to increase the risk of obtaining injuries [104]. Only rotation to both left and right was seen to be limited in a bigger

group of players. However, this is still only 28.34% and 25.18% of the total study population. Limited research is however available on the evaluation of cervical ROM of senior rugby players.

5.1.5 Isometric neck strength of senior rugby players

The general consensus on the prevention of injuries that occur during sports participation is that strength training is of great importance. Due to the constant increase in the total number of participants in rugby, a prevention programme is required to aid in decreasing the occurrence of sports-related concussions and cervical spine injuries. In this study, it was found that only 28% of the study population had participated in some form of neck strengthening. This study found that the forwards tested stronger in all cervical spine angles when compared to the backs. It was however found that statistically significant differences existed between the strength of cervical spine flexion of forwards to that of backs ($P = 0.005$). The same was found for left lateral flexion ($P = 0.08$) and right lateral flexion ($P = 0.054$).

Hamilton and Gatherer (2014) found that neck extension produced the greatest amount of force with the lateral flexion values only producing about 90% of the total extension values [(107)]. The players in the forwards position also produced more force when compared to the backs [(107)]. This is similar to the results found where the forwards produced more strength for cervical spine flexion and lateral flexion in all angles. When analysing extension, the forwards tested stronger for neutral, 25° left and 45° while the backs produced a greater force at extension 25° right and 45° left.

Collins et al. (2014) investigated whether neck strength was a protective factor against concussions [(108)]. They concluded that neck strength is a significant predictor of concussion amongst high school athletes. This study was however performed on basketball, soccer and lacrosse athletes and they have recommended that studies should be performed on other sporting codes to draw a comparison [(108)]. In this study it was found even though the bulk of the rugby players tested within the general population norms, the occurrence of concussions were still high. Taking into consideration the amount of training and high-impact events that occur during rugby, it would have been expected that they would test much stronger in strength when compared to the general population norms.

Hrysomallis (2016) found, in a retrospective analysis, that isometric training in senior rugby players reduced cervical spine injuries and sports-related concussion risk [109]. Considering the comparison of the results found in this study it is expected for professional rugby players to be stronger than their aged-matched general population group. An intervention done by Geary et al. (2014) found that a 5-week neck strengthening programme improves isometric neck strength which has the potential to reduce injury risk [110]. Naish et al. (2013) agreed with Geary that a neck strengthening protocol has the potential to decrease the risk of obtaining injuries, however, stated that 5-weeks might be too short to achieve significant increases [111].

5.1.6 Relationship between cervical muscle weakness and posture

A statistical significance was present between cervical spine strength and the NYP rating scores for some body region of the players. No correlations were found when comparisons were drawn between neutral cervical spine flexion, however, the neck and hip regions were found to be significant in the flexion at 25º left and right, as well at flexion at 45º left and right. When considering the overall results, cervical spine flexion at the specified angles could be influenced by the poor hip and neck posture rating scores. This could be explained by the fact that when analysing individuals with forward head postures, they have a higher probability of having a pelvic misalignment or an increased pelvic tilt. Lee et al. (2015) concluded that pelvic posture should be analysed when dealing for forward head postures due to the fascia [112].

Cervical spine extension at neutral (0º) indicated significance with the hip and neck regions, while extension at 25º left found correlations between the overall posture rating, spine, neck, and lower back regions. Extension at 45º left identified results that were significant when compared to the overall posture score, spine, hip, and neck regions while extension at 45º right only identified a correlation between the neck and the lower back region. Various body regions were identified to have an influence on cervical spine extension however, it was noted that a poor neck rating was most likely to be involved. This identifies that postural correction with deep neck flexor activation is still deemed an important aspect of training, even in a specialised population such as rugby players.

Lateral neck flexion at neutral (0º) to the left identified a significance with a poor hip region rating, while lateral neck flexion at neutral (0º) to the right had a significance with both the

hips and neck regions. Lateral neck flexion at 25º left had a significant correlation with the hip, neck, and lower back region while lateral neck flexion at 25º right indicated a significance with the hip and neck region. The overall posture score, spine and neck regions showed a positive correlation with lateral neck flexion at 45º left. Lateral neck flexion at 45º right indicated significance with the overall posture score, neck, and lower back regions. The score of the neck region was again identified as the region that was most likely to influence cervical spine strength for lateral flexion. This confirms that the postural alignment of the neck has a noteworthy influence on the overall strength production of the neck musculature.

The New York Posture (NYP) score for the neck and hips have shown to have a significant correlation when tested against the cervical spine strength. The neck region was identified to influence twelve body regions while the hips were associated with nine regions.

Analysis of the overall posture ratings Poor posture can lead to back pain, rounded shoulders, spinal abnormalities, and degeneration of joints [32, 89]. It is known that with postural abnormalities there are other body mechanics that perform uncharacteristically. Limited research exists on this finding and should be further investigated.

5.1.7 Sport-specific strength norms

No current cervical spine strength norms exist for senior rugby players in South Africa. Due to the forever increase in popularity and the growing interest to participate in rugby, it is deemed important that there are norms to compare players to. The establishment of strength norms for this specific population has the potential to decrease cervical spine injuries, improve return-to-play protocols after injuries, and improving general health and wellbeing. Performance of a baseline test in pre-season will give the team sport scientist and Biokineticist the accurate results whether a player has a weakness which has the potential to increase his cervical spine injury – and concussion risk. It is suggested that additional studies be conducted to achieve a larger collection of data for comparison purposes to establish whether the results found in this study is reliable for the use of norms.

The norms will be useful in determining whether a player might be at an increased risk for injury and whether they can be cleared for play from school – to senior – level of play. These norms are also specific to the senior population as well as divided between forwards and

backs, which makes it possible for more specific comparisons and analysis of players to occur.

CHAPTER 6: CONCLUSION, STRENGTHS & LIMITATIONS OF STUDY AND RECOMMENDATIONS

6.1 CONCLUSIONS

This study confirmed that neck and head injuries are deemed to be a major concern within the rugby population. Not only do they occur in the younger and more inexperienced players, but also in the older players, who have had more experience. The amount of playing time also leads to higher incidence rates of concussions and cervical spine injuries. Players are often forced to retire from rugby at a much younger age than previously reported due to the high occurrence rates of these often-life-threatening injuries. Even though a lot of preventative techniques and specific training through BokSmart are being incorporated, concussions and cervical spine injuries still have a high occurrence rate in this study population.

The posture assessment of these players highlighted that even though they are professional sportsman who participates in strength training daily, they still have postural abnormalities. Particularly related to the shoulder, neck, and ankle regions. It is a possible indication that their posture is position-specific, due to the different requirements and demands of that position. Additional research should be performed to further assess this statement. To the researcher's current knowledge, no other studies have investigated how posture can influence cervical spine strength and range of motion of senior rugby players, therefore comparative results could not be made. It was however stated by Watson (2001), Lopezosa-Reca et al. (2020) and Leppänen et al. (2020) that postural abnormalities have an influence on the occurrence rates of injuries [99,100,101]. Langdon et al. (2019) also stated that postural correction in professional sports players can be beneficial even after retirement [15].

Cervical ROM indicated some significant differences when compared to a low NYP rating scale. The best part of the players did not indicate any limitations in any of the ROM angles tested when compared to the general population norm. In general, it is agreed to prevent cervical spine strength deficits, neck muscle strengthening is required. This study found that even though a big portion of the players may have tested stronger than the population norms, the majority of them had at least one angle in which cervical neck strength was weaker than the expected norm. Isometric neck strength in Extension was indicated as the biggest concern for the players, which was correlated to the poor head postures found in the posture analysis. Interestingly, the forwards tested stronger in all flexion, extension, and lateral flexion in

neutral positions (u/19 and u/21 age groups), yet the senior groups, tested stronger in back extension in neutral compared to the forwards. This can be explained since the forwards are involved in the scrum movement which requires more neck flexion than extension. This statement should, however, be further investigated.

It was noted that not all the rugby players participated in cervical spine strengthening protocols. Current literature does, however, state that general strengthening of a specific musculature group can decrease the risk of obtaining an injury. Cervical spine strengthening should form part of the overall training sessions of all the rugby players and should not just be position or age-specific. The forward players would need more training as well as movement specific strengthening and technique training to reduce the potential risk of injuries, however, it is deemed just as important for the backs to strengthen the cervical spine musculature as it is for the forwards.

Multiple correlations were found between the cervical spine strength and posture rating scores. This was an indication that posture correction interventions could potentially play a big role in injury prevention strategies for rugby players. This is true for of flexion at 25º left and right, and 45º left and right; extension (neutral (0º); 25 º left and right, and 45º left and right) and lateral flexion ((neutral left and right (0º); 25 º left and right, and 45º left and right). The neck, hips, lower back, and spine were the four specific body regions that were found to have the greatest potential to affect the cervical spine strength (for different angles). Overall mean posture rating scores were also seen to have an influence, however only at four angles (extension 25° left and right; and lateral flexion at 45° left and right). The neck (angles = 12) and the hips (angles = 9) being the two most regions affecting the most angles.

Strength norms were established in this study and thus, may assist in the future in identifying whether a player is at a higher risk for obtaining cervical spine- and head injuries. These norms may when used correctly could potentially influence the results found in pre-season testing (flag weaknesses and indicate players for intervention) and the occurrence of cervical spine injuries. Each position in rugby requires a distinctive set of skills and physical requirements and therefore these norms have been categorized.

Due to the study population being professional sportsman, the Neck Disability Index found were expected to be quite low. This was true with the highest score achieved being 18%

which is deemed as normal as it is below 20%. Even though a lot of studies had emphasised the focus on performing baseline concussion testing and the importance thereof, it was still found that some players had not undergone these pre-season screenings. This, however, does arise some concern as they form part of the professional rugby playing population.

Overall, this study was able to identify the risk South African Rugby Union players are at and what variables should be considered in a pre-season screening to lower the risk for obtaining these life-threatening and possibly life changing incidences.

6.2 STRENGTHS OF STUDY

This study allowed for the establishment of sport-specific cervical spine strength norms for senior male rugby players. No such norms currently exist in any databases and have the potential, with additional research, to reduce cervical spine injuries and sports-related concussion risk. This study involved a large study population and a comprehensive profile for posture and cervical isometric neck strength in various angles was established. It is the first study in South Africa that made use of the MCU machine which is deemed to be the golden standard for cervical spine assessments of ROM and strength.

6.3 LIMITATIONS OF STUDY

Training schedules and transport provided problems in having the tests conducted. Even though transport for the players was arranged, busy player schedules did not allow for availability. The inability of the MCU to be transported was the main reason as to why the study was completed with a smaller sample size. The norms created are specific for professional senior rugby players and age groups younger than 19 will not be able to benefit from these norms.

6.4 RECOMMENDATIONS FOR FUTURE STUDIES

Although the knowledge gained from this research study has the potential to be useful in its own manner, it also can be used in a contributing manner for other research studies in a similar field. Areas of concern that were noted during this study and has the potential to influence the outcome is the following:

- **The activation of the upper trapezius muscles during neck muscle activation or testing of neck strength.**

  Shoulder elevation was noted with some players as they were performing their neck strength tests. Performing a muscle activation test of the upper traps using an EMG while performing neck strength tests on the MCU.

- **Neck strength intervention programme on baseline values using the MCU**

  A recommended baseline neck strength and cervical ROM should be performed pre-season after which an intervention for neck strengthening can be followed, should it be identified as testing below the norm strength values.

- **Neck strength intervention programmes post-injury using the MCU**

  After injuries and concussions intervention programmes focussing on neck strengthening protocols on the MCU and identifying whether participation in these intervention programmes returns the player to participation sooner compared to other intervention strategies.

- **Injury prevention by using protective gear**

  Randomised controlled trial studies should be performed to determine whether protective gear like mouthguards, headgear and concussion headbands have a noteworthy influence in the prevention of concussions and cervical spine injuries.

- **Effect of posture on cervical spine weakness**

  It is well known in literature that muscle weakness leads to poor posture and that it can cause pain and discomfort. Research should focus on the effect of posture and cervical spine weakness in a sport-specific population.

- **Investigate the positional specific differences in cervical spine strength and ROM**

  Different rugby positions place different types of strain on the human body. This should be investigated to ensure that each player is conditioned to handle the strain of that position.

- **Information keeping on injury history**

  It is important for the specific rugby unions to keep a record of the injuries sustained by the player as well as a timeframe for better management of players. The use of protective gear appears to still be a very controversial matter and even though the use of mouthguards was found to be used by the largest proportion of rugby players in this study, the effectiveness of the use of it to protect against cervical spine and head injuries should be further investigated.

- **Concussion effects on sleep and concentration of individual**

  A thought-provoking finding in this study was that the majority of participants indicated that they had some form of sleep disturbances as well as concentration difficulties. It might be an interesting factor to compare the number of concussions to what effect or influence it may have on the sleep and concentration of players.

~ If you knew you couldn't play tomorrow, how hard would you play today? ~

Geoff Watts

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APPENDICES

APPENDIX A

Letter requesting permission to use facility for research purposes

REQUEST FOR PERMISSION TO USE FACILITY FOR DATA COLLECTION FOR RESEARCH FOR THE DEGREE OF MSC(MED) IN BIOKINETICS

Dear Adriaan van der Merwe,

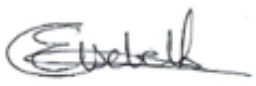
I am currently busy with my MSc(Med) by dissertation in Biokinetics through the University of the Witwatersrand in Johannesburg. The research I wish to conduct for my Masters thesis involve: A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng". This research project will be conducted under the supervision of Miss Natalia Neophytou.

I am hereby seeking your consent to use your Biokinetics practice located in the Sport Centre in the Morningside Mediclinic to conduct my research and collect data. My research assistant will be trained in conducting the testing on the Multi-Cervical Unit (MCU).

Upon the conclusion of my study, I undertake to provide the Biokinetic practice with a bound copy of my full research report. If you require any further information, please do not hesitate to contact me on 072 424 8299 or by email cetsebeth.bio@gmail.com.

I thank you for your time and consideration in this matter.

Yours sincerely,



Chantelle Etsebeth
Biokineticist

APPENDIX B

Permission to use facility for data collection

biorehab.co.za
Adriaan van der Merwe and Associates

biorehab.co.za
Morningside Sports Medicine
Morningside Medi-Clinic, Cnr Rivonia & Hill Roads, Morningside
Tel 011 883 9000 Fax 011 282 5165
Adriaan van der Merwe and Associates Practice No. 0910000553301
Adriaan van der Merwe Incorporated Registration No. 2007/003044/21

29 January 2018

To Human Research Ethics Committee (Medical)
Faculty of Health Sciences

PERMISSION TO USE FACILITY FOR DATA COLLECTION

Student Chantelle Etsebeth (student number 604323), doing her MSc (Med) in Biokinetics has requested permission to use my biokinetics practice, Adriaan van der Merwe and Associates, to conduct her research project.

This letter serves to confirm that permission is granted for her to use the facility to present the exercise intervention and use the data collected for the research project titled: "A descriptive study investigating cervical spine injuries and cervical muscle weakness and establish norms for senior rugby players in Gauteng".

Yours sincerely,

Adriaan van der Merwe
Biokineticist and practice owner
Adriaan van der Merwe and Associates

APPENDIX C

Invitation to participate in study

Centre for Exercise Science and Sports Medicine
and
FIFA Medical Centre of Excellence
and
FIMS Collaborating Centre of Sports Medicine
School of Therapeutic Sciences, Faculty of Health Sciences University of the Witwatersrand, Johannesburg
Director: Professor D Constantinou

Study title: A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng

Attention: Rugby Player, Team coach, Team management

Good day,

Introduction:
I, Chantelle Etsebeth, am currently doing my MSc(Med) in Biokinetics with research focused on senior rugby players through the University of the Witwatersrand. Research is the process to learn the answer to a question that is deemed necessary in our environment. This study will be performed under the supervision of Miss Natalia Neophytou, through the University of the Witwatersrand. In this study we want to establish sport specific neck strength norms for senior rugby players, which in turn will assist in clearance to return to sport after injury. We also want to identify whether the weaker neck strength and poor posture correlates with a higher risk for cervical spine injuries.

Invitation to participate: We are asking / inviting your senior teams (turning 19 years of age in 2018 or older) to take part in a research study.

What is involved in the study: The player will be asked to fill in a personal details and injury screening questionnaire with a neck disability index. To be included in the study the player will have to sign a consent form giving the researcher permission to add his results to the study. This study will be fully confidential, and no identifying information will be included in the final write up of the study. Only the main researcher, the research assistant and the research supervisor will have access to the raw data. Four photos will be taken of the player for analysis of the posture. This will be followed by two tests: Isometric strength test and cervical range of motion test which will both be conducted on the Multi Cervical Unit (MCU). He will do 3 repetitions of each test after which an average is calculated to find a result. This test takes up to 30min to complete.

Risks: No risks are involved in this study.

Benefits: I will be able to identify if the player has any increased risks of cervical spine injuries when combining the results of both the strength and range of motion tests. It will provide us with the ability to have a baseline result for the player should he succumb to an injury during the season. This will then aid in the clearance test for return to sport post injury.

Alternative: On completion of my study I will be able to provide you with the results after analysis have been completed. The study will take place at Adriaan van der Merwe & Associates located Imude Sport & Wellness. Correspondence with the players, coaches and team management will be done to find a convenient time for each player to have his test conducted.

The participant will be given pertinent information on the study while involved in the project.

Participation is voluntary, and refusal to participate will involve no penalty or loss of benefits to which the participant is otherwise entitled. The participant may also discontinue participation at any time without penalty or loss of benefits to which the participant is otherwise entitled.

Exclusion criteria:

- Current cervical- or head injury, by using the Neck Disability Index (NDI) and medical clearance from team physician.
- Any player that presents with a medical condition, that has the potential to be aggravated by the testing performed on the Multi Cervical Unit.

Contact details of researcher: If you do require any additional information please do not hesitate to contact me on 072 424 8299 or by email cetsebeth.bio@gmail.com.

Contact details of supervisor: Miss Natalia Neophytou
Centre for Exercise Science and Sports Medicine
University of the Witwatersrand
011 717 3368
Natalia.Neophytou@wits.ac.za

Contact details of the HREC (Medical):
HREC(Med) Chairperson:
Prof Clement Penny
011 717 2301

Administrators:
Ms Zanele Ndlovu
Mr Rhulani Mkansi
Ms Mapula Ramaila
011 717 2700 / 2656 / 1234 / 1252
HREC-Medical.ResearchOffice@wits.ac.za

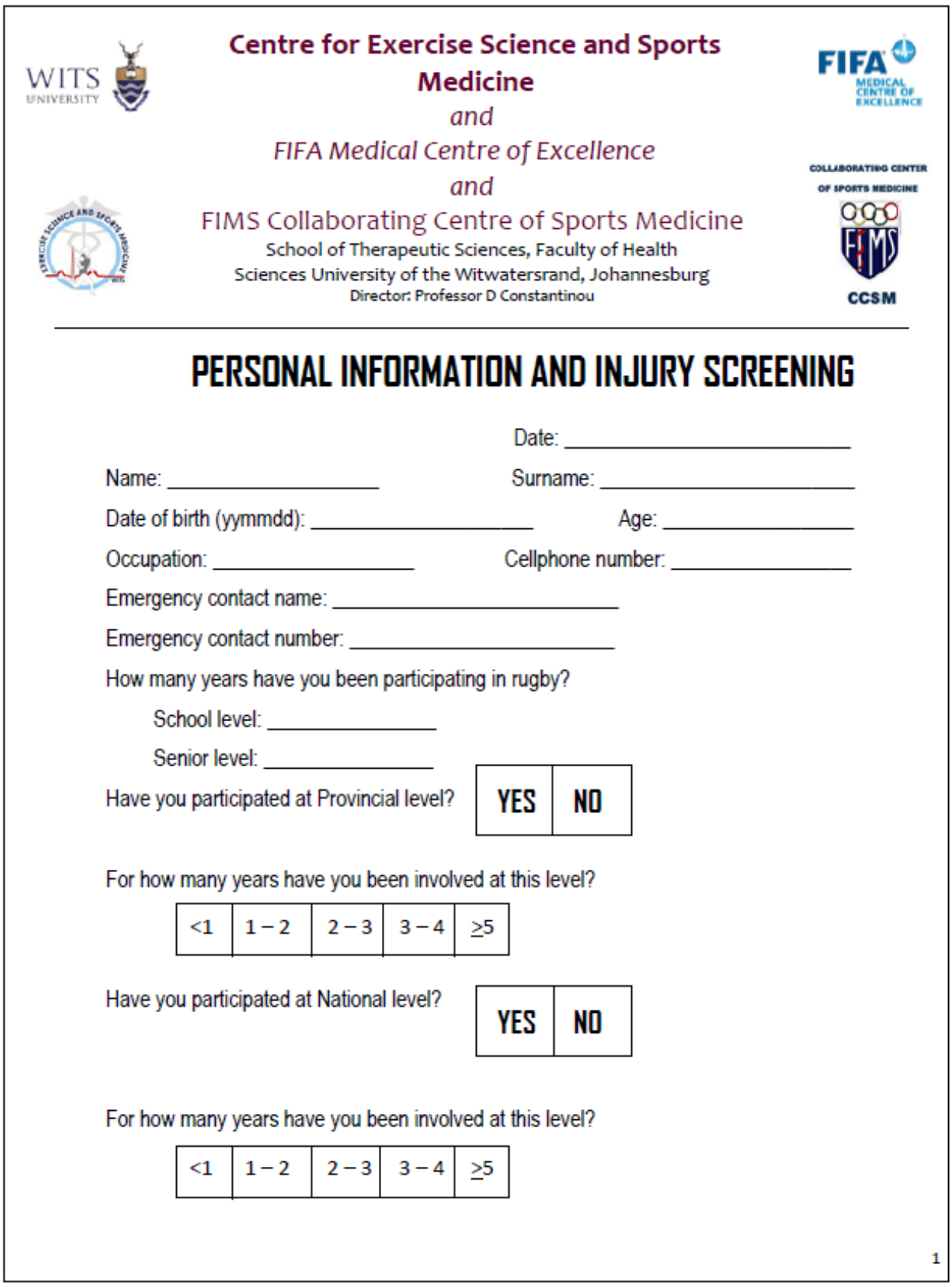
We thank you for your consideration and assistance with this study.
Without your participation it would not be possible.

Kindest regards,

Chantelle Etsebeth
Biokineticist
Imude Sport & Wellness

APPENDIX D

Personal information and injury screening questionnaire



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School of Therapeutic Sciences, Faculty of Health Sciences University of the Witwatersrand, Johannesburg
Director: Professor D Constantinou

PERSONAL INFORMATION AND INJURY SCREENING

Date: _____

Name: _____ Surname: _____

Date of birth (yymmdd): _____ Age: _____

Occupation: _____ Cellphone number: _____

Emergency contact name: _____

Emergency contact number: _____

How many years have you been participating in rugby?

School level: _____

Senior level: _____

Have you participated at Provincial level? YES | NO

For how many years have you been involved at this level?

<1	1 – 2	2 – 3	3 – 4	≥5

Have you participated at National level? YES | NO

For how many years have you been involved at this level?

<1	1 – 2	2 – 3	3 – 4	≥5

1

For which club are you currently playing? _____

What team are you playing for?	u/19	u/21	Senior	Other:

Please state your most frequent/current playing position. _____

For how long have you been playing this position? _____

Do you have an alternative playing position to the one mentioned above? If yes, please state the position.

_____

Has your current position changed from what you played at school level? If yes, please state the position you played at school.

_____

What other sports did you participate in at school level? Please indicate with a ✓. If other, please indicate.

Cricket		Athletic: Field events	
Soccer		Athletic: Track event	
Hockey		Boxing	
Artistic gymnastics		Baseball	
Other:			

What other sports did you participate in at senior level? Please indicate with a ✓. If other, please indicate.

Cricket		Athletic: Field events	
Soccer		Athletic: Track event	
Hockey		Boxing	
Artistic gymnastics		Baseball	
Other:			

2

Has your doctor ever informed you that you have a heart condition or that you should only do physical activity recommended by your doctor? YES | NO

Do you have any bone or joint problems that could be worsened by physical activity? YES | NO

Have you ever suffered a neck injury? (excluding concussions) YES | NO

If yes, please mark the injury obtained with a ✓. If other, please state. Please also indicate the number of times you have obtained the particular injury.

Injury type	✓	No.	Injury type	✓	No.
Unilateral facet dislocation (one side)			Fracture		
Bilateral facet dislocation (both sides)			Disc prolapse / Slipped disc		
Whiplash			Muscle sprain		
Facet joint fracture			Ligament strain		
Other:					

Are you fully recovered from these injuries mentioned above? YES | NO

Have you ever suffered a concussion? YES | NO

If YES, how many have you suffered? _____

How many concussions have you suffered in the last 2 years? _____

Did any other injury occur in the same year as when you obtained a concussion? If yes, please state which injury. YES | NO _____

3

What symptoms did you experience with your concussion/s? Please indicate with a ✓. Please also state the severity of that particular symptom from 1 to 5 (not bad to debilitating)

Symptom	✓	Rate		✓	Rate
Headache			Nausea		
Dizziness			Vomiting		
Confusion			Sensitivity to light		
Memory loss			Sleep disturbances		
Other:					

By whom was your concussion/concussions diagnosed, please indicate with a ✓. If other, please specify:

Team doctor		Sports physician	
General Practitioner (GP)		Emergency room doctor	
Paramedic		Other:	

When did you have your last concussion? _____

Are you fully recovered from this concussion mentioned above?

YES	NO

What was the severity of this last concussion?

Mild (grade 1)	
Moderate (grade 2)	
Severe (grade 3)	

Did you undergo baseline concussion testing?

YES	NO

Please indicate the programme with a ✓. If other, please specify:

BOKSmart		ImPACT	
CogState Sport		Balance testing	
Other:			

Do you play with any of the following gear? Please indicate with a ✓. Please also state for how long you have been playing using that specific gear.

Gear type	✓	No.	Gear type	✓	No.
Mouthguard			Headgear		
Concussion headband			None		
Other:					

Have you participated in any neck specific strengthening protocols?

YES	NO

APPENDIX E

Neck disability index

Centre for Exercise Science and Sports Medicine
and
FIFA Medical Centre of Excellence
and
FIMS Collaborating Centre of Sports Medicine
School of Therapeutic Sciences, Faculty of Health Sciences University of the Witwatersrand, Johannesburg
Director: Professor D Constantinou

Neck Disability Index

Participant's full names: _____

This questionnaire has been designed to give us information as to how your neck pain has affected your ability to manage in everyday life. Please answer every section and mark in each section only the one box that applies to you. We realise you may consider that two or more statements in any one section relate to you, but please just mark the box that most closely describes your problem.

Section 1: Pain intensity

- ☐ I have no pain at the moment.
- ☐ The pain is very mild at the moment.
- ☐ The pain is moderate at the moment.
- ☐ The pain is fairly severe at the moment.
- ☐ The pain is very severe at the moment.
- ☐ The pain is the worst imaginable at the moment.

Section 2: Personal Care (Washing, Dressing, etc.)

- ☐ I can look after myself normally without causing extra pain.
- ☐ I can look after myself normally but it causes extra pain.
- ☐ It is painful to look after myself and I am slow and careful.
- ☐ I need some help but can manage most of my personal care.
- ☐ I need help every day in most aspects of self care.
- ☐ I do not get dressed, I wash with difficulty and stay in bed.

Please see next page

Section 3: Lifting

- ☐ I can lift heavy weights without extra pain.
- ☐ I can lift heavy weights, but it gives extra pain.
- ☐ Pain prevents me lifting heavy weights off the floor, but I can manage if they are conveniently placed, for example on a table.
- ☐ Pain prevents me from lifting heavy weights, but I can manage light to medium weights if they are conveniently positioned.
- ☐ I can only lift very light weights
- ☐ I cannot lift or carry anything

Section 4: Reading

- ☐ I can read as much as I want to with no pain in my neck.
- ☐ I can read as much as I want to with slight pain in my neck.
- ☐ I can read as much as I want with moderate pain in my neck.
- ☐ I can't read as much as I want because of moderate pain in my neck.
- ☐ I can hardly read at all because of severe pain in my neck.
- ☐ I cannot read at all.

Section 5: Headaches

- ☐ I have no headaches at all.
- ☐ I have slight headaches, which come infrequently.
- ☐ I have moderate headaches, which come infrequently.
- ☐ I have moderate headaches, which come frequently.
- ☐ I have severe headaches, which come frequently.
- ☐ I have headaches almost all the time.

Please see next page

Section 6: Concentration

- ☐ I can concentrate fully when I want to with no difficulty.
- ☐ I can concentrate fully when I want to with slight difficulty.
- ☐ I have a fair degree of difficulty in concentrating when I want to.
- ☐ I have a lot of difficulty in concentrating when I want to.
- ☐ I have a great deal of difficulty in concentrating when I want to.
- ☐ I cannot concentrate at all.

Section 7: Work

- ☐ I can do as much work as I want to.
- ☐ I can only do my usual work, but no more.
- ☐ I can do most of my usual work, but no more.
- ☐ I cannot do my usual work.
- ☐ I can hardly do any work at all.
- ☐ I can't do any work at all.

Section 8: Driving

- ☐ I can drive my car without any neck pain.
- ☐ I can drive my car as long as I want with slight pain in my neck.
- ☐ I can drive my car as long as I want with moderate pain in my neck.
- ☐ I can't drive my car as long as I want because of moderate pain in my neck.
- ☐ I can hardly drive at all because of severe pain in my neck.
- ☐ I can't drive my car at all.

Please see next page

Section 9: Sleeping

- ☐ I have no trouble sleeping.
- ☐ My sleep is slightly disturbed (less than 1hr sleepless).
- ☐ My sleep is mildly disturbed (1-2 hrs sleepless).
- ☐ My sleep is moderately disturbed (2-3 hrs sleepless).
- ☐ My sleep is greatly disturbed (3-5 hrs sleepless).
- ☐ My sleep is completely disturbed (5-7hrs sleepless).

Section 10: Recreation

- ☐ I am able to engage in all my recreation activities with no neck pain at all.
- ☐ I am able to engage in all my recreation activities, with some pain in my neck.
- ☐ I am able to engage in most, but not all of my usual recreation activities because of pain in my neck.
- ☐ I can hardly do any recreation activities because of pain in my neck.
- ☐ I can't do any recreation activities at all.

For the use of the researcher:

TOTAL : _____/50

Percentage: _____%

Included in the study:

YES	NO

_____

_____

_____

APPENDIX F

Consent form

Centre for Exercise Science and Sports Medicine

and

FIFA Medical Centre of Excellence

and

FIMS Collaborating Centre of Sports Medicine

School of Therapeutic Sciences, Faculty of Health Sciences University of the Witwatersrand, Johannesburg

Director: Professor D Constantinou

CONSENT FORM

Study title: A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng

Name of researcher: Chantelle Etsebeth

I, _____ agree to participate in this research project. I know what is expected of me and the research has been explained to me therefore I understand what my participation will involve.

	Please circle	
I agree that my participation will remain anonymous	YES	NO
I agree that the researcher may use anonymous quotes in her research report	YES	NO
I understand that my participation is completely voluntary and that I can withdraw at any moment with no disadvantages	YES	NO
I agree that the information I provide may be used anonymously by other researchers following this study	YES	NO
I agree that photographs may be taken for the analysis of my posture.	YES	NO

Any further studies that will be done using this data will require approval from the HREC (Medical).

Participant name: _____

Participant: signature _____ Date:_____

APPENDIX G

Invitation to participate in questionnaire validation

Centre for Exercise Science and Sports Medicine
and
FIFA Medical Centre of Excellence
and
FIMS Collaborating Centre of Sports Medicine
School of Therapeutic Sciences, Faculty of Health Sciences University of the Witwatersrand, Johannesburg
Director: Professor D Constantinou

CCSM

Dear Healthcare Professional,

I would hereby like to invite you to complete a survey for validation of a questionnaire that will be used for a Masters study. As an expert in your respective field, I would appreciate your assistance in completing the following form for me to obtain feedback and guidance on a proposed questionnaire. This questionnaire will be used as an Injury screening questionnaire in a study titled: A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng.

This study will aim to identify the prevalence and frequency at which cervical spine injuries occur within the rugby population as well as to identify that weak neck musculature, limitation in cervical range of motion and poor posture increases the risk for cervical spine injuries. It will also aspire to establish sport specific norms for neck strength which in turn will assist in return to sport clearance which in turn has the potential to decrease the re-injury risk for senior rugby players.

Please note that your participation is entirely voluntary, and you are free to decline to participate in this survey. This study has been approved by the Medical Ethics committee of the University of the Witwatersrand and will be conducted under the supervision of Miss Natalia Neophytou, lecturer and Biokineticist at the Centre for Exercise and Sports Medicine at WITS. The survey is anonymous and response data will only be analysed at aggregate level.

If you are willing to participate and complete the electronic survey, please click on the link below.
https://docs.google.com/forms/d/e/1FAIpQLSeP3r_FB3DdAN_ojhPw-UfUax45Jc10SdSaD8BrTbHjXf1njg/viewform?usp=sf_link

Kindly note the closing date of the survey is Sunday, 19 August 2018. It will not take you more than 15 minutes to complete the questionnaire.

If you have any questions or concerns about this study, please feel free to contact me on cetsebeth.bio@gmail.com or supervisor Miss Neophytou at Natalia.neophytou@wits.ac.za.

Your participation in the validation of this questionnaire is highly appreciated.

Yours sincerely,
Chantelle Etsebeth
BHSc(Biokinetics)

APPENDIX H

Invitation to participate in Pilot study

Centre for Exercise Science and Sports Medicine
and
FIFA Medical Centre of Excellence
and
FIMS Collaborating Centre of Sports Medicine
School of Therapeutic Sciences, Faculty of Health
Sciences University of the Witwatersrand, Johannesburg
Director: Professor D Constantinou

Dear Rugby Participator,

I would hereby like to invite you to participate in the pilot study for the validation of a questionnaire that will be used for a Masters study in Biokinetics. As a player, I would appreciate your assistance in completing the following form for me to obtain feedback. This questionnaire will be used as an Injury screening questionnaire in a study titled: A descriptive study investigating cervical spine injuries, cervical muscle weakness, posture and establishing norms for senior rugby players in Gauteng.

This study will aim to identify the prevalence and frequency at which cervical spine injuries occur within the rugby population as well as to identify that weak neck musculature, limitation in cervical range of motion and poor posture increases the risk for cervical spine injuries. It will also aspire to establish sport specific norms for neck strength which in turn will assist in return to sport clearance which in turn has the potential to decrease the re-injury risk for senior rugby players.

Please note that your participation is entirely voluntary, and you are free to decline to participate in this study. This study has been approved by the Medical Ethics committee of the University of the Witwatersrand and will be conducted under the supervision of Miss Natalia Neophytou, lecturer and Biokineticist at the Centre for Exercise and Sports Medicine at WITS. The survey is anonymous and response data will only be analysed at aggregate level.

If you are willing to participate and complete the electronic study, please click on the link below.
https://docs.google.com/forms/d/e/1FAIpQLSfaaPby5nOLxVZ4cLhSO0Bvz2T3K9d7rqxvuR5Eu5yxdDCZ1g/viewform?usp=sf_link

Kindly note the closing date of the pilot study is Sunday, 2 September 2018. It will not take you more than 15 minutes to complete the questionnaire.

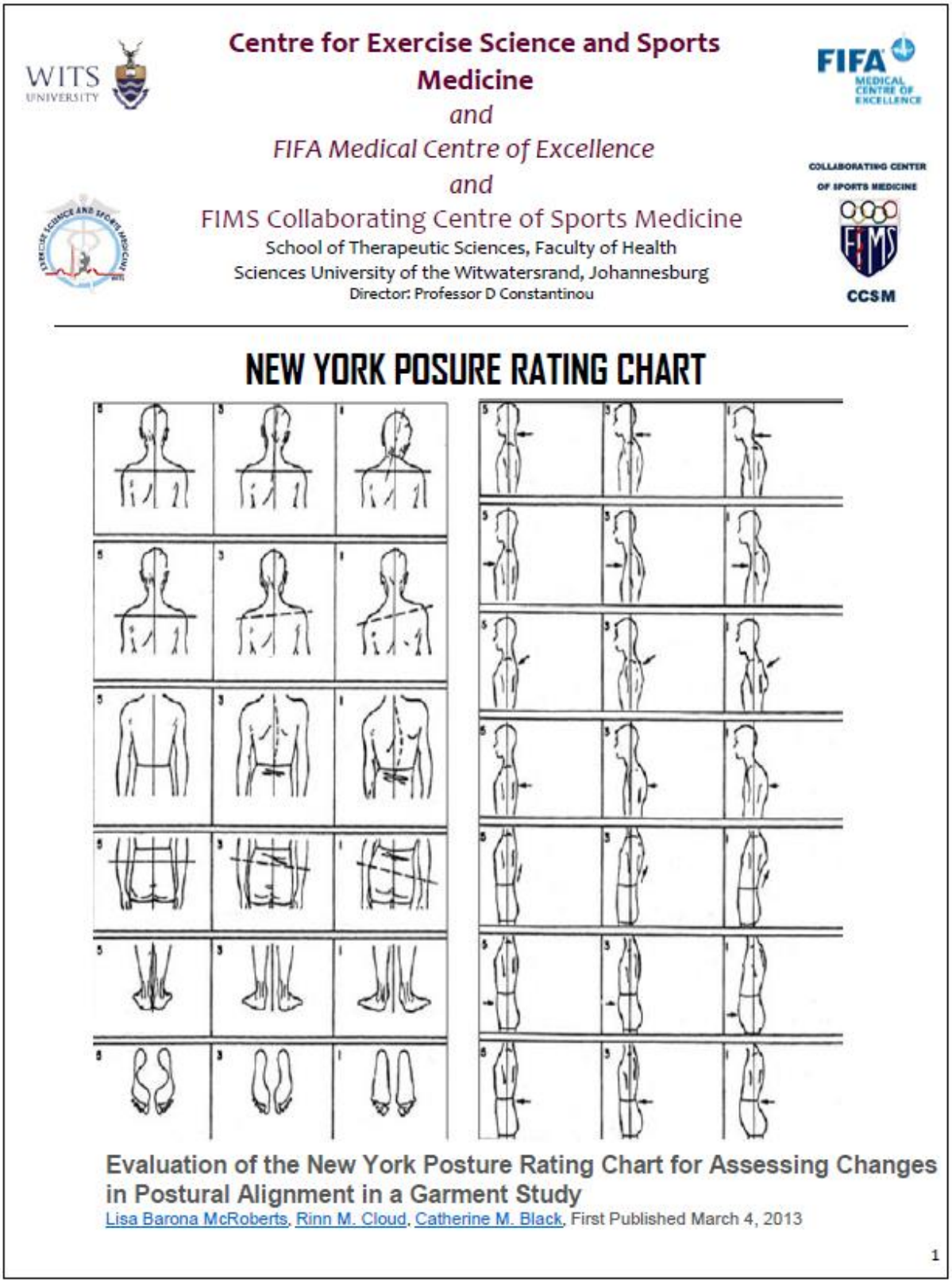
If you have any questions or concerns about this study, please feel free to contact me on cetsebeth.bio@gmail.com or supervisor Miss Neophytou at Natalia.neophytou@wits.ac.za.

Your participation in the pilot study for the validation of this questionnaire is highly appreciated.

Yours sincerely,
Chantelle Etsebeth
BHSc(Biokinetics)

APPENDIX I

New York posture rating scale



APPENDIX J

Example of result sheet

MCU - Cervical Radar Graph

Patient Information

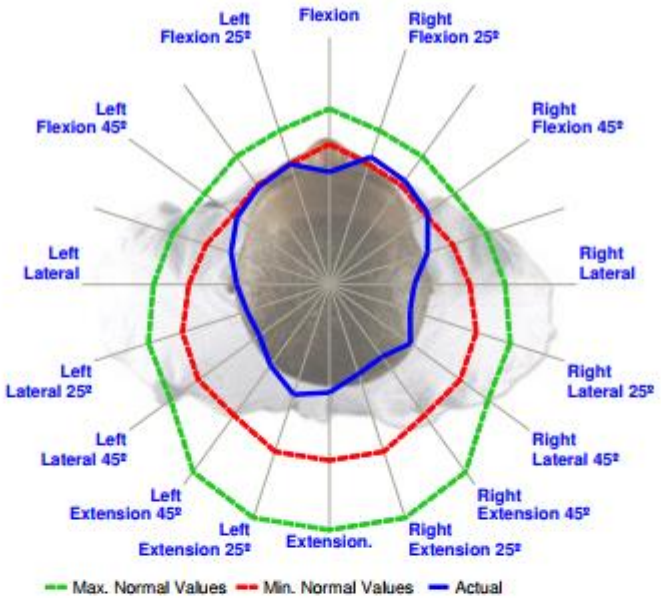
Patient Name:

Start & Finish Date:
Report Print Date:
Injury Date:
Injury Location(s):

Height:
Weight:

Health Card #: Not Applicable
Date of Birth:
Sex: Male

Strength Testing Data - Superior Axial View



	Target Strength Range								
	Flexion			Extension			Lateral Flexion		
Male	Target	Left	Right	Target	Left	Right	Target	Left	Right
Neutral	9.1 - 11.4 kg			11.4 - 15.9 kg			9.1 - 11.4 kg		
25°	8.2 - 10.5 kg			11.4 - 15.9 kg			10 - 12.3 kg		
45°	7.7 - 10 kg			10.5 - 15 kg			10.5 - 12.7 kg		

Green = Within Target Strength Range Red = Below Target Strength Range Blue = Above Target Strength Range

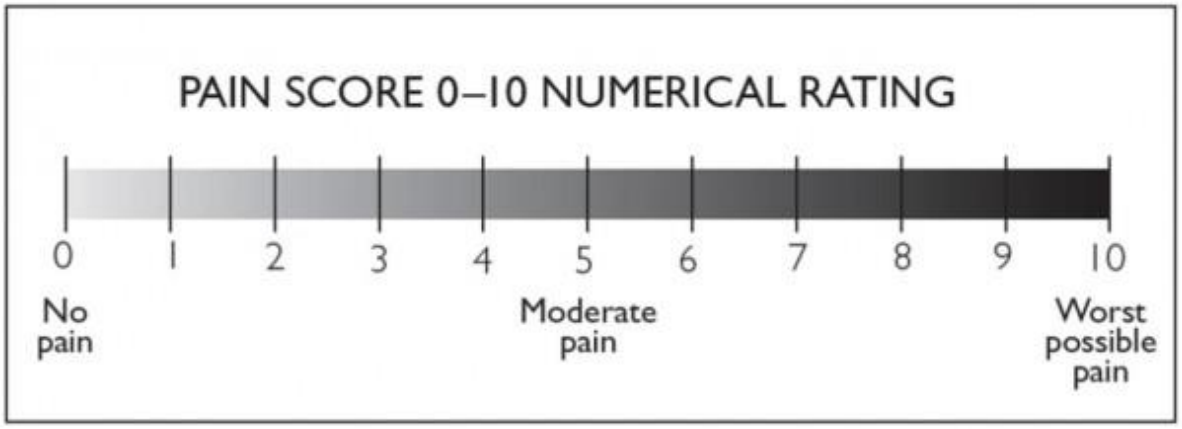
ADRIAAN VAN DER MERWE BIOKINETICISTS
MORNINGSIDE SPORTS MEDICINE CLINIC JOHANNESBURG GAUTENG 2128

All testing was completed using MCRP-Multi Cervical Rehabilitation Program, Data Management was compiled through MCU

p. 1

APPENDIX K

Numeric Pain Rating Scale (NPRS)



APPENDIX L

HREC clearance certificate

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

R14/49 Miss Chantelle Etsebeth

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M180381

NAME: (Principal Investigator)	Miss Chantelle Etsebeth
DEPARTMENT:	Centre for Exercise Science and Sports Medicine Adriaan van der Merwe and Associates in the Sport Centre The Morningside Mediclinic
PROJECT TITLE:	A Descriptive Study Investigating Cervical Spine Injuries, Cervical Muscle Weakness, Posture and Establishing Norms for Senior Rugby Players in Gauteng
DATE CONSIDERED:	06/04/2018
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Miss Natalia Neophytou
APPROVED BY:	Professor CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	11/07/2018

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary on the Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in **March** and will therefore be due in the month of **March** each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

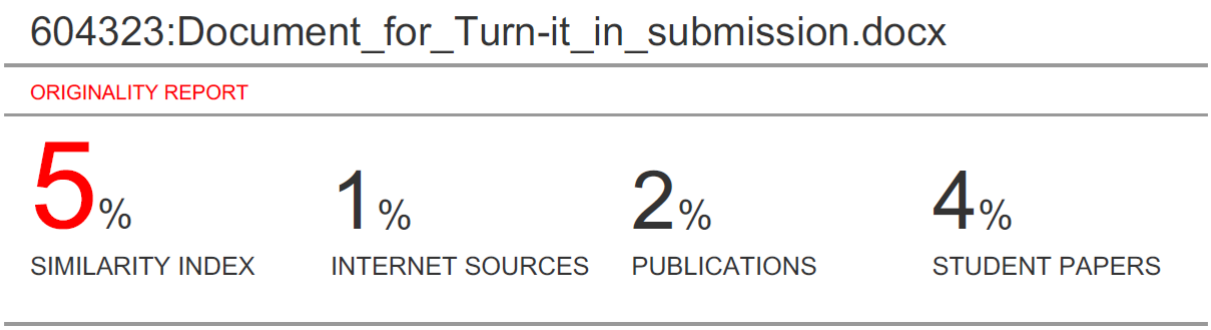
C. Etsebeth — Principal Investigator Signature

13 July 2018 — Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX M

Turn-it in report



APPENDIX N

Data disc