

THE RELIABILITY OF PRE- PARTICIPATORY SCREENING TESTS USED ON SPORTS PARTICIPANTS

Nosipho Portia Zumana

Student number: 939345

A research report submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg in partial fulfilment of the requirements for the degree of Master of Science in Physiotherapy

Johannesburg

2017

DECLARATION

I, Nosipho Portia Zumana, hereby declare that this research report is my own work, except to the extent indicated in the reference citations and acknowledgements. It is submitted for the degree of Master of Science in Physiotherapy at the University of Witwatersrand, Johannesburg. It has not been submitted before for any other degree or examination at this or any other university.

Signed By:

Date Signed:

ACKNOWLEDGEMENTS

I would like to firstly thank my God for blessing me with strength, courage and enlightenment to have embarked on this journey.

Secondly, thank my incredible family (Mama, and my children Asiphesona and Avuyile), who supported me unconditionally throughout my learning experience. Your love and support give me strength and courage to always give my best in all aspects of my life. You are appreciated.

Thirdly, I want to express my humble gratitude to my supervisors, Prof. Benita Olivier and Dr. Lonwabo Godlwana. They have shown great leadership, given guidance and advice during this journey. I appreciate your patience, constant encouragement, motivation and positive attitude throughout. I have truly taken pleasure in the opportunity and experience of working with both of you.

I would like to thank the Faculty Research Committee (FRC) Individual Research Grant and the South African Society of Physiotherapy who awarded me with a grant. This financial assistance was truly beneficial.

Finally, I would like to thank the Wits Sports administration (Mr Carter, Coach Neil and Coach Caesar) for allowing me to conduct my study on their players and lastly, my humble appreciation goes to the players who were keen on participating and making my study a success.

ABSTRACT

BACKGROUND

In sports rehabilitation, physiotherapists use physical screening tests at the beginning of the season to ascertain the current musculoskeletal condition of athletes. Early identification of risk of injury through pre-participatory screening is used to minimise injury. The pre-participatory screening tool used should be accurate and practical and must contain tests that are reliable. The objectives of this study were to establish the intra-rater and inter-rater reliability of the one-legged hyperextension test, empty can and full can shoulder impingement test, standing stork test, bridging hold test and the 747 balance test.

METHODS

A reliability study was conducted where data were collected from the University of the Witwatersrand's Cricket and Football Clubs during August 2015. Ethical approval was given by the Human Research Ethics Committee (HREC) of the University of Witwatersrand (Protocol number: M150626). The screening tests were conducted by two qualified physiotherapists, each with at least five years of clinical experience. Thirty five healthy, uninjured, male cricket and football players participated in the study. Players who had undergone surgery to the spine or limbs in the past were excluded. The following tests were included: the one-legged hyperextension test, bridging hold test, the 747 balance test, the empty can and full can shoulder impingement test and the standing stork test. The study took place over a period of two weeks where day 1 was for assessment 1 and day 2 was for assessment 2. These assessments occurred around the same time of day so that the athlete was exposed to the same conditions for both assessments. This was either before practice session, during practice sessions or after practice sessions. Data were analysed to establish intra- and inter-rater reliability. Cohen's kappa was used for the one-legged hyperextension test, empty can and full can impingement test and the standing stork test. The Intraclass correlation coefficient (ICC) was used for the bridging hold test and the 747 balance test. A confidence level of 95% ($p \leq 0.05$) was applied as the criterion for determining statistical significance.

RESULTS

The intra-rater reliability was found to be moderate to substantial in the empty can test ($k=0.6-0.8$; 95%CI: 0.4–1.2; $p<0.001$); no agreement to moderate in the full can test ($k=0.1-0.6$; 95%CI: -0.1–1.1; $p<0.001$); fair to moderate in the one-legged hyperextension test ($k=0.4-0.6$; 95%CI: 0.1–0.9; $p<0.001$); no agreement in the standing stork test ($k=-0.06-0.1$; 95%CI: -0.4–0.7; $p<0.05$); fair to moderate in the bridging hold test (ICC=0.3–0.5; 95%CI: -0.4–0.7; $p<0.05$); and fair to moderate in the 747 balance test (ICC=0.2–0.6; 95%CI: -0.4–0.8; $p<0.05$). The inter-rater reliability was found to be substantial to excellent in the one-legged hyperextension test ($k=0.8-0.9$; 95%CI: 0.7–1.1; $p<0.001$), bridging hold test (ICC=0.8–0.9; 95%CI: 0.6–0.9; $p=0.008$) and substantial in the full can test ($k=0.8$; 95%CI: 0.5–1.1; $p<0.001$); no agreement to substantial in the empty can test ($k=-0.05-0.8$; 95%CI: -0.1–1.1; $p>0.05$); no agreement in the standing stork test ($k=-0.06-0.3$; 95%CI: -0.2–1.3; $p>0.05$) and fair to substantial in the 747 balance test (ICC=0.2–0.7; 95%CI: -0.2–0.9; $p<0.05$).

CONCLUSION

This study shows there is moderate to substantial intra-rater reliability for the empty can test. This study also shows there is substantial to excellent inter-rater reliability for the one-legged hyperextension test, the bridging hold test, and substantial inter-rater reliability for the full can test. The reliability of these tests is acceptable and can therefore be used with confidence as part of the screening tools, on condition that validity is intact. Further in-depth studies still have to be done for the 747 balance test as this test consists of a number of components which need to be assessed individually. It is also suggested that the standing stork test be removed as a field-based screening test as this test demonstrated no agreement within a rater and no agreement among the raters.

CONTENTS

ACKNOWLEDGEMENTS	ii
ABSTRACT	iii
LIST OF TABLES	viii
LIST OF FIGURES	ix
LIST OF ABBREVIATIONS.....	x
APPENDICES	xi
CHAPTER 1	1
1. INTRODUCTION	1
1.1. BACKGROUND	1
1.2. RESEARCH PROBLEM	2
1.3. RESEARCH QUESTION.....	3
1.4. AIM OF STUDY.....	3
1.4.1. RESEARCH OBJECTIVES	3
1.5. SIGNIFICANCE OF THE STUDY	3
CHAPTER 2	5
2. LITERATURE REVIEW	5
2.1 INTRODUCTION	5
2.2. SEARCH STRATEGY.....	6
2.3. WHAT ARE PRE-PARTICIPATORY SCREENING TESTS?.....	6
2.4. THE USE OF PRE-PARTICIPATORY SCREENING TESTS	7
2.5. THE IMPORTANCE OF THE CHOICE OF PRE-PARTICIPATORY SCREENING TESTS USED IN SPORTS.....	8
2.6. PRE-PARTICIPATORYSCREENING TESTS NEED TO BE RELIABLE.....	9
2.7 THE PRE-PARTICIPATION SCREENING TESTS.....	10
2.7.1THE ONE-LEGGED HYPEREXTENSION TEST.....	10
2.7.2. THE EMPTY CAN (EC) AND FULL CAN (FC) TESTS.....	10
2.7.3. THE STANDING STORK TEST	13
2.7.4. THE BRIDGING HOLD TEST	14
2.7.5. THE 747 BALANCE TEST.....	14
2.8. SUMMARY	15
CHAPTER 3	16
METHODOLOGY.....	16
3.1. INTRODUCTION	16
3.2. STUDY DESIGN AND STUDY SETTING	16

3.3. SOURCE OF PARTICIPANTS AND SAMPLE SIZE	16
3.4. INCLUSION CRITERIA	16
3.5. EXCLUSION CRITERIA.....	17
3.6. PRE-PARTICIPATORY SCREENING TESTS	17
3.6.1. ONE-LEGGED HYPEREXTENSION TEST.....	18
3.6.2. EMPTY CAN AND FULL CAN SHOULDER IMPINGEMENT TESTS.....	19
3.6.3. STANDING STORK TEST.....	20
3.6.4. BRIDGING HOLD TEST	21
3.6.5. 747 BALANCE TEST.....	22
3.7. ETHICAL CONSIDERATIONS	23
3.8. PROCEDURE	24
3.8.1. PILOT STUDY	24
3.8.2. MAIN STUDY.....	24
3.9. DATA ANALYSIS.....	25
CHAPTER 4	28
4. RESULTS.....	28
4.1. PARTICIPANTS.....	28
4.2. ONE-LEGGED HYPEREXTENSION TEST	29
4.3. EMPTY CAN AND FULL CAN TESTS.....	30
4.4. STANDING STORK TEST	32
4.5. BRIDGING HOLD TEST	33
4.6. 747 BALANCE TEST	35
4.7. SUMMARY	36
CHAPTER 5	37
5. DISCUSSION	37
5.1. INTRODUCTION	37
5.2. PARTICIPANTS.....	37
5.3. RELIABILITY OF ONE-LEGGED HYPEREXTENSION TEST	37
5.4. RELIABILITY OF EMPTY CAN TEST AND FULL CAN TEST	38
5.5. RELIABILITY OF STANDING STORK TEST	39
5.6. RELIABILITY OF BRIDGING HOLD TEST	40
5.7. RELIABILITY OF 747 BALANCE TEST	41
CHAPTER 6	43
CONCLUSION.....	43
6.1. INTRODUCTION	43

6.2 CONCLUSION	43
6.3. LIMITATIONS OF THE STUDY	44
6.4. RECOMMENDATIONS FOR FUTURE RESEARCH	44
6.5. CLINICAL RECOMMENDATIONS	44
CHAPTER 7	46
REFERENCES	46

LIST OF TABLES

Page

Table 3.1: Standardised instructions for pre-participatory screening tests.....	17
Table 3.2: Guidelines for the interpretation of Kappa and Intraclass correlation coefficient Values.....	27
Table 4.1: Demographic profile of the participants.....	28
Table 4.2: Intra-rater agreement of ratings for one-legged hyperextension test (n=31).....	29
Table 4.3: Inter-rater agreement of ratings for one-legged hyperextension test (n=31).....	29
Table 4.4: Intra-rater agreement of ratings for empty can and full can test (n=31).....	30
Table 4.5: Inter-rater agreement of ratings for empty can and full can test (n=31).....	31
Table 4.6: Intra-rater agreement of ratings for standing stork test (n=31).....	32
Table 4.7: Inter-rater agreement of ratings for standing stork test (n=31).....	33
Table 4.8: Intra-rater agreement of ratings for bridginghold test (n=31).....	33
Table 4.9: Inter-rater agreement of ratings for bridginghold test (n=31).....	34
Table 4.10: Intra-rater agreement of ratings for 747 balance test (n=31).....	35
Table 4.11: Inter-rater agreement of ratings for 747 balance test (n=31).....	35
Table 6.1: Summary of Intra-rater and Inter-rater reliability of current study.....	43

LIST OF FIGURES

Page

Figure 3.1: One-legged hyperextension test.....	19
Figure 3.2: Empty can test.....	20
Figure 3.3: Full can test.....	20
Figure 3.4: Standing stork test.....	21
Figure 3.5: Bridging hold test.....	22
Figure 3.6: 747 balance test.....	23

LIST OF ABBREVIATIONS

EC	: empty can test
FC	: full can test
ACL	: anterior cruciate ligament
ICC	: Intraclass correlation coefficient
SEM	: standard error of measurement
K	: Kappa
Kw	: weighted Kappa
p	: p-value
ASIS	: anterior superior iliac spine
PSIS	: posterior superior iliac spine
n	: sample size
SD	: standard deviation
CI	: confidence interval
BMI	: body mass index
SIJ	: sacroiliac joint
FMS	: Functional Movement Screen
Yrs	: years
Kg	: kilogram
m	: meters
SPSS	: Statistical Package for Social Sciences
MVT	: movement
R1	: Rater 1
R2	: Rater 2
L	: Left
R	: Right

APPENDICES

	Page
Appendix 1: Data Collection Form.....	56
Appendix 2: Information Document for Wits Sports Administration.....	58
Appendix 3: Consent Form for Wits Sports Administration.....	60
Appendix 4: Consent Form for Club Manager.....	61
Appendix 5: Protocol Approval by the University of the Witwatersrand Human Research Ethics Committee (Medical).....	63
Appendix 6: Information Document for Participants.....	64
Appendix 7: Consent Form for Participants.....	66
Appendix 8: Consent Form for shooting Videosand taking Photos of Participants.....	67
Appendix 9: Consent Form for Parents/ Guardian of participant under 18years of age	68
Appendix 10: Assent Form for Participants under 18years of age.....	69
Appendix 11: Turnitin Report.....	70

CHAPTER 1

1. INTRODUCTION

1.1. BACKGROUND

In sports rehabilitation, physiotherapists use physical screening tools to ascertain the current musculoskeletal condition of athletes. Screening tests are evaluation tools or outcome measures used as standard practice in physiotherapy, and these include musculoskeletal assessment tools. Screening is best performed early in the pre-season phase of training and is referred to as pre-participatory screening (Meeuwisse et al 1988; Metzl 2000; Croisier et al 2008).

The emphasis in sport is to maintain optimal performance while simultaneously preventing injuries. Among the many techniques used to minimise injury, early identification of risk of injury through pre-participatory screening is one (Madsen et al 2014). Pre-participatory screening tools help the therapist to identify athletes who are prone to injury or re-injury (Jay et al 2014). The main purpose of carrying out pre-participation screening is to lessen injuries, enhance performance and as the end result improve the general wellbeing of the athlete through early intervention (Cook et al 2006). There are many objectives for pre-participatory screening that have been identified, however the overall and most important goal seems to be promotion of health and safety of athletes during training and competitions (Sanders et al 2013). The ultimate goal of musculoskeletal pre-participatory examination is to identify risk (modifiable and non-modifiable) of injury, to prevent injury, to facilitate optimal musculoskeletal health and optimise performance (Ekstrom et al 2007).

Evaluation of athletes presents a unique challenge to the rehabilitation professional. A reliable pre-participatory screening tool or protocol is required to meet the injury prevention objectives of athletes and coaches. The pre-participatory screening tool should be accurate and practical, and testing procedures must be safe and acceptable to health professionals and athletes (Garrick 2004; Maffey and Emery 2006). Uninjured athletes usually can outperform many uninjured non-athletes in standard tests and measures. This is another reason for an examination tool to be developed specifically for athletes; this tool should be sensitive enough to measure higher levels of performance. Validated pre-participatory testing methods have to be used and must contain reliable measures (Maffey and Emery 2006).

Reliability is essential in athlete assessment in order to enable the physiotherapists and other researchers to accurately and objectively report on their findings. Reliability is defined as the ability to reproduce the same results when tested by two different testers (inter-rater reliability) and the same results when tested by the same tester repeatedly (intra-rater reliability). This means that the measurement should be consistent and free from error (Portney and Watkins 2009). The tests included in a pre-participatory screening tool have to be reliable. Reliability is important because it encourages consistency. Consistency ensures that later attempts to assess the participant will provide accurate results. If a test is not reliable and if there are no methods for testing reliability then one cannot determine or conclude whether the calculated quantity is in fact a hazardous component leading to injury.

The reliability of some screening tests used in sports are acceptable whereas the reliability of other tests are not acceptable (Gabbe et al 2004; Dennis et al 2008a; Cools et al 2008; Andrade et al 2012). Yet, often tests with less than acceptable reliability values are used in pre-participatory screening tools. The tests of interest in this study assess factors which are of importance in the recognition of hazardous components and the components tested (intrinsic factors, non-contact related factors e.g. strength and endurance, repetitive strain due to overuse) have been implicated as injury risk factors (Willson et al 2006; Whatman et al 2011; Herbert et al 2013).

Therefore, this research report presents a reliability assessment of the tests commonly used in pre-participatory screening tools. The results obtained from the study may inform the development of a field-based, sports specific pre-participatory musculoskeletal screening protocol.

1.2. RESEARCH PROBLEM

A number of pre-participatory screening tests are used in the early recognition of hazardous components such as poor muscle strength, poor endurance, poor balance and repetitive strain due to overuse, these lead to injury in athletes. The reliability of these tests is either unknown or if the reliability has been established, it was done with use of substandard methods i.e. methods that are of low quality. In the event that unreliable tests are used to screen athletes for potential risk of injury, interventions based upon these findings will probably be inaccurate and not be worthwhile in the quest for injury prevention

strategies.

1.3. RESEARCH QUESTION

What is the intra- and inter-rater reliability of five musculoskeletal screening tests commonly used in sports pre-participatory screening protocols?

1.4. AIM OF STUDY

The aim of this study was to establish the intra- and inter-rater reliability of five musculoskeletal screening tests commonly used in screening protocols in sports.

1.4.1. RESEARCH OBJECTIVES

The objectives of this study were:

- To establish the intra-rater reliability of the one-legged hyperextension test, bridging hold test, 747 balance test, empty can and full can shoulder impingement test and standing stork test.
- To establish inter-rater reliability of the one-legged hyperextension test, bridging hold test, 747 balance test, empty can and full can shoulder impingement test and standing stork test.

1.5. SIGNIFICANCE OF THE STUDY

The known reliability of the screening tests will help to inform the decision to include certain tests in pre-participatory screening tools as well as to assist in evaluating progress during rehabilitation. The tests chosen in this study are tests which are already commonly used in pre-participatory screening tools but lack sound evidence to support their reliability. These tests 'reliability is yet to be established. Demonstrating the reliability of clinical assessment tests that are usually used could advance the refinement of uniformed musculoskeletal screening and identification programmes in sport. These programs could provide a foundation for recognising sports injury hazardous components. Standardised pre-participatory screening tools consisting of reliable screening tests will enable

physiotherapists to utilise this information clinically in making an accurate decision as to whether an athlete needs to be included in a secondary injury prevention programme.

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

The literature related to the tests investigated in this study will be discussed in this chapter. The literature includes pre-participatory screening tests, their usage, their importance in the sporting environment and their reproducibility. This chapter also looks at the choice of pre-participatory screening tests to be analysed in this study. In sports rehabilitation, clinicians use physical screening tools to identify the current musculoskeletal condition of athletes. Screening tests are evaluation tools or outcome measures used as standard practice in physiotherapy, in this case musculoskeletal assessment tools. Screening is best performed early in the pre-season phase of training (Meeuwisse et al 1988; Metzl 2000; Croisier et al 2008).

Non-contact injuries are quite common in sports. These may be due to multiple causes. Injuries at elite level are quite common primarily due to higher intensity of matches and workloads (Orchard et al 2006; Orchard et al 2010). Literature shows that injury surveillance studies which have been conducted on elite cricketers show the injury prevalence (the percentage of players missing due to injury at any given time) was 14% for pace bowlers, 4% for spin bowlers, 4% for batsmen and 2% for wicket keepers. Common injuries seemed to be hamstring strains, side strains, groin injuries, wrist and hand injuries and lastly lumbar soft tissue injuries (Orchard et al 2002; Stretch 2003). Another study conducted across multiple teams during the ICC Cricket World Cup 2011 showed the injury incidence to be 3.7/ 100 player-days, where 0.7 time-loss and 3.0 non-time-loss, with time loss incidence being: for match injury 20.1/1000 player-days, bowling injury 3.3/100 bowling days and batting injuries 2.2/10 000 balls faced. Again lower limb injuries were with highest incidence (Ranson et al 2013). Lower limbs showed to be 43.5% most commonly injured body region (Frost and Chalmers 2014). While Naidoo et al (2007) conducted a detailed analysis of soccer injuries sustained in South African professional soccer team over one competitive season and reported that the injury prevalence for lower limb injuries was 67.1% with a significant $p < 0.05$. In the study the authors reported that defenders and midfielders were more prone to lower limb injuries while goalkeepers and forwards were prone to trunk injuries (Naidoo et al 2007). The above literature suggests that South African elite players are likely to sustain injuries during one competitive season.

The refinement of successful sports injury prevention method, of which pre-participatory screening forms part, depends on good quality clinical evidence. Sports injury prevention is a process that is divided into stages. These stages consists of a number of steps: the first step involves establishing the extent of the injury, the second step includes developing an understanding of the reason an athlete may be susceptible to injury, the third step involves introducing preventative measures and lastly, evaluating their effectiveness (van Mechelen, Hlobil and Kemper 1992; Bahr and Krosshaug 2005; Finch 2006). Sports injury aetiological studies examine the relationship between potential injury hazardous components and injury outcomes. For these studies to be able to recognise intrinsic hazardous components for sports injury, the calculation has to be precise. Measurement has to be repeatable by different raters, and by the same rater at different occasions. The objective of this literature review is to examine the most recent literature pertaining to pre-participatory screening tests used for sports participants as well as their reliability.

2.2. SEARCH STRATEGY

A computerised search was accomplished using electronic databases namely PubMed, Google Scholar, Clinical Key, EBSCO, Cochrane Collaboration Reviews and Trials from 1982 to January 2016. The search terms used were: musculoskeletal, pre-participatory, screening tests, reliability, cricket, soccer, sports, inter-rater/observer, and intra-rater/observer in various combinations. Initially the search revealed 1076 studies of which the title and abstract for each article was evaluated. Forty articles fell into the inclusion criteria and their full manuscripts were acquired. The final decision to include and exclude some manuscripts was made after the full manuscripts were evaluated by a sole analyst, the researcher. Succeeding that process, only 35 articles met the criteria and were analysed. The discussion and critical appraisal that follows included the most recent literature pertaining to pre-participatory screening tests and their reliability.

2.3. WHAT ARE PRE-PARTICIPATORY SCREENING TESTS?

Pre-participatory musculoskeletal screening is an assessment for the entire body which is utilised to identify any difficulty that an athlete may have that could influence their ability to achieve their utmost capability. Dallinga et al (2012) conducted a comprehensive

systematic review to depict the prognostic values for lower limb tests and to choose screening tests that can be utilised in the clinic or field to distinguish athletes that are at a threat of injury to the lower limbs. The authors also described the reliability, validity, sensitivity and specificity of the tests and this study showed that per body part (groin, anterior cruciate ligament (ACL), hamstrings, knee and ankle); screening instruments are available to identify athletes at risk for injury. Although this was a comprehensive review of the literature, the study only looked at screening instruments for the lower limbs. Studies that identify screening instruments that include the upper limb extremity tests and the trunk tests in the sporting arena are still lacking. The literature mostly contains outcome measures used in the clinical sphere, for example the Functional Movement Screen (FMS) (Hayen et al 2007, Onate et al 2012).

2.4. THE USE OF PRE-PARTICIPATORY SCREENING TESTS

Screening tests are evaluation tools used as standard practice in physiotherapy (Comerford 2006; Segwick2009; Evershed et al 2014). The motive of screening and testing is to distinguish where pain and dysfunction originate. This is done to recommend specific treatment to restore normal patterns (Frohm et al 2010). Screening tests are used to curb the advancing number of injuries in sports and related healthcare costs. The ability to predict which athlete might become injured is highly relevant and it is important for physiotherapists to have the ability to evaluate and treat injuries. There are many techniques used to minimise injury, and early identification of risk of injury through pre-participatory screening is one of them (Madsen et al 2014). Various risk factors have been identified as attributing factors to non-contact musculoskeletal injuries, hence physiotherapists commonly assess athletes for imbalances in strength, flexibility (Canavan et al 2012), mobility, stability or neuromuscular control (Cook et al 2014, Oliver et al 2014). Studies have demonstrated that diminished neuromuscular power (the capability to influence movements through synchronised muscle activation) such as reduced balance or muscle power; elevate the probability of injury (Frohm et al 2012; Olivier et al 2016). Other studies suggest that decreased range of movement, anatomical imbalance, inadequate core stability and reduced neuromuscular power can raise the chance of injuries due to wear and tear over time (Leetun et al 2004, Kibler et al 2006). These causes can be identified through pre-participatory musculoskeletal screening. An impression associated to the inability to constantly specify which athletes are susceptible to injury is the source of difficulty in injury prevention strategies; hence pre-participatory screening tests are essential.

The ultimate goal of musculoskeletal pre-participation examination is to identify risk (modifiable and non-modifiable) of injury, to prevent injury, to facilitate optimal musculoskeletal health and optimise performance (Ekstrom et al 2007; Lehr et al 2013; Cook et al 2014). The presence of both person-related and environment-related risk factors are the ones that render an athlete susceptible to injury (Bahr and Krosshaug 2005). These hazardous components and the interaction between them expose the athlete to an injury which occurs in a certain circumstance. These hazardous components require being distinguished in order to initiate preventative measures. In a systematic review conducted by Olivier et al (2016), where they assessed and summarised the scientific literature affiliated to person-related and environment-related components interconnected with non-contact injury prone amongst adult cricket players, it is suggested that distinguishing the components affiliated with injury is an extremely important strategy. This step should come before the improvement of effective injury prevention programmes.

2.5. THE IMPORTANCE OF THE CHOICE OF PRE-PARTICIPATORY SCREENING TESTS USED IN SPORTS

Pre-participatory screening tests are important for predicting injuries (Dallinga et al 2012), enhancing performance and ultimately improving the quality of life of the athlete through early intervention (Cook et al 2006). The literature shows the need for sensitive instruments with suitable approaches to uncover distinct weak connections (reduced range of movement, muscle power, instability or inadequate neuromuscular control); and uncover restrictions in function and imbalances (Frohm et al 2012; McCall et al 2014; Mischiati et al 2015). Uninjured athletes can usually outperform many uninjured non-athletes in standard tests and measures. This is another reason for an examination tool to be developed specifically for athletes and this tool should be sensitive enough to measure higher levels of performance. A reliable pre-participatory examination tool or protocol is required to meet the objectives of athletes and coaches. The pre-participatory screening tool should be accurate and practical, and testing procedures must be safe and acceptable to many individuals (Garrick 2004; Maffey and Emery 2006). Validated pre-participatory testing methods have to be used and must contain reliable measures (Maffey and Emery 2006). There is a need to develop screening tools with screening tests that are easily administered, cost effective and suitable for rapid testing of large numbers of athletes i.e.

screening without the use of specialised equipment or machinery and tests that are field-based. Some studies conducted in Australia have looked at pre-participatory screening tests used specifically for cricket and football and these tests were field-based (Dennis et al 2008b). Not all the tests in that screening protocol were tested for reliability.

2.6. PRE-PARTICIPATORY SCREENING TESTS NEED TO BE RELIABLE

Reliability is essential in athlete assessment in order to enable the physiotherapists and other researchers to precisely and objectively report on their findings. Reliability is defined as the ability to reproduce the same results when tested by two different testers (inter-rater reliability) and to reproduce the same results when tested by the same tester repeatedly (intra-rater reliability). This means producing measurements that are consistent and free from error (Portney and Watkins 2009). The tests included in a pre-participatory screening tool have to be reliable. Both validity and reliability are important, as a test cannot be considered valid if the results are inconsistent (Atkinson and Nevil 1998). Reliability is essential because it encourages consistency which ascertains that subsequent attempts to assess the participant will provide accurate results. If a test is not reliable and if there are no methods of testing reliability then one cannot determine or conclude whether the measured quantity is in fact a risk factor for injury.

To give an example of the importance of reliability: in a study by O Conner et al (2015) the inter-rater and intra-rater reliability of a popularly used screening test, the Modified Active Knee Extension Test for assessment of hamstring flexibility, was established. This test utilised inexpensive, readily available equipment for screening, which makes it a good test to use in the clinical arena. The study found high intraclass correlation coefficient (ICC) values for the inter-rater reliability (right leg = 0.98; left leg = 0.99) and intra-rater reliability (right leg = 0.78; left leg = 0.79). This study suggests that the test is reliable, that the different testers and/or the same tester will consistently be able to assess the flexibility of the hamstring muscle in an individual using the Modified Active Knee Extension test. In addition to the high level of reliability, poor muscle flexibility has been recognised as one of the hazardous components leading to injury which alludes to its predictive validity (Witvrouw et al 2003, Bradley and Portas 2007, Canavan et al 2012). If a test is both reliable and valid, then the test can be added to the pre-participation screening tool. This study is concerned with the reliability testing of five popular pre-participatory screening tests used in sports.

2.7 THE PRE-PARTICIPATION SCREENING TESTS

In this section the literature on the following tests will be reviewed: the one-legged hyperextension test, the empty can test and full can test, the standing stork test, the bridging hold test and the 747 balance test. These screening tests are relevant in sporting codes like cricket and soccer considering the different positions athletes play in each sporting code.

2.7.1 THE ONE-LEGGED HYPEREXTENSION TEST

The one-legged hyperextension test is used to assess for lumbar spondylolysis or stress fracture of the pars interarticularis (Masci et al 2006). Active spondylolysis in athletes has been described in most sports. It is said that activity that requires repetitive lumbar extension and rotation pose a higher risk (Wiesel 2002; Masci et al 2006). In a systematic review by Alqarni et al (2015), which was aimed at reviewing the diagnostic capability of clinical tests to discover lumbar spondylolysis and spondylolisthesis, it was found that the one-legged hyperextension test showed moderate sensitivity (50%- 73%) and a low specificity (17%- 32%) to determine lumbar spondylolysis as these are identifiable causes of low back pain in athletes (Alqarni et al 2015). Although this was a comprehensive systematic review, the study included only four studies and the findings were based on two studies for spondylolysis (Masci et al 2006 and Gregg et al 2009). The studies reviewed also differed in their methodology as Masci et al (2006) conducted a prospective cohort study, while Gregg et al (2009) conducted a retrospective cohort study. The results of these studies were circumscribed by the lack of reliability testing and the usage of radiographic equipment. None of the studies did specific reliability testing for this screening test.

2.7.2. THE EMPTY CAN (EC) AND FULL CAN (FC) TESTS

The empty can test is utilised for identifying ruptures in the supraspinatus tendon (Beaudreuil et al 2009). This test is also acknowledged as the Jobe's test which was described initially in 1982. This test was directed at sequestering supraspinatus activity to some extent (Jobe and Mayne 1982). In 1996, the full can test was developed. This test

was established to animate supraspinatus to the same degree as that of the empty can test (Kelly et al 1996). It was established as an alternative to the empty can test, as external rotation usually induces low levels of pain than internal rotation (Beaudreuil et al 2009). It was noted in the literature that the internal rotation of the glenohumeral joint in the empty can test position may locate the greater tuberosity of the humerus nearer to the acromion, bringing on a reduction in the magnitude of the subacromial space, thereby extending the danger for subacromial encroachment of the rotator cuff, thus generating shoulder pain (Timmons et al 2013). Timmons et al (2013) also suggested that the rise in pain in the empty can position might be because of the absence of consortium among the scapula positions e.g. greater scapula upward rotation.

Although the empty can and full can tests are used to diagnose subacromial impingement, these tests are also used in screening protocols to predict injury in pain free individuals. This is mainly due to the functions of the glenohumeral joint, scapula and the muscles around it, where injury can be sustained through repetitive microtrauma due to overuse. In sports, it is customary, for the arm to be in continuous motion, unhampered against various outside forces such as in throwing. The subacromial space contains the rotator cuff tendons. The subacromial space outlet accommodates for the digression of the supraspinatus tendon into the subacromial space. The supraspinatus squeezes, abducts and gives a minute external rotation force to the glenohumeral joint. From kinematic shoulder representations, supraspinatus strength during full power isometric scapular plane abduction at the 90 degrees position is 117N (Hughes and An 1996). Furthermore, supraspinatus activity rises as resistance rises during scapula plane motion, reaching at 30- 60 degrees for any resistance. The full can test might be favoured over the empty can in supraspinatus testing mainly because the internally rotated humerus in the empty can test blocks the greater tuberosity preventing it to give way from under the acromion during humeral elevation (Hughes and An 1996). This may raise subacromial encroachment risk due to reduced subacromial space width. With repetition and overuse of the shoulder this may cause pain. A reduced ratio of the force exerted may force the supraspinatus to exert more effort and raise its tensile stress (this is a problem in the healing tendon) (Escamilla et al 2009). The humeral internal rotation in the empty can test, stresses both the postero-inferior capsule and rotator cuff. Stress in these structures plays a part in anteriorly tilting and internally rotating the scapula, this protracts the scapula. The above is important clinically because as reported by Smith et al (2006), comparatively to a neutral scapular position, scapular protraction substantially reduces glenohumeral internal rotation and

external rotation power by 13- 24% and 20%. Additionally, scapular protraction has been demonstrated to reduce subacromial space width thus raising the risk of encroachment (Solem-Bertoft et al 1993). Therefore in individuals who do not usually complain of shoulder soreness and who test positive for these tests, the pain may be due to the above kinematic functions.

A few studies include the diagnostic accuracy of these tests (Itoi et al 1999; Kim et al 2006; Somerville et al 2014; Lasbleiz et al 2014). These authors propose that the empty can test and the full can test demonstrate acceptable diagnostic accuracy with full and/or partial thickness ruptures of the supraspinatus tendon. The strength of these studies is that they included large sample sizes which enabled them to provide relatively precise calculations of the specificity and sensitivity of the tests. However, the limitations of these studies were, to some degree, the potential for detection bias as the physical examinations were conducted by the surgeon who also conducted the surgical evaluation. The patients who were examined were consecutive shoulder patients with various shoulder symptoms and these patients were handled in the surgical departments and their attributes were not typical of the population in general or population seen in a sporting environment and lastly, none of the studies looked at reliability of these tests. The reliability of diagnostic tests does not depend on preciseness only but also the duplicability of the test (Gjørup1997).

A more recent study shows the sensitivity of the empty can test to be 84.3%, the specificity 74.5% and accuracy 82% for detecting a torn supraspinatus tendon; this study also showed the full can test sensitivity to be 78.9%, specificity to be 80.9% and accuracy to be 79% for detecting a torn supraspinatus tendon (Lui et al 2016). This was a prospective study of 200 participants scheduled to undergo an arthroscopic procedure. The study exhibited the same limitations as previous studies such as detection bias and patient characteristics not being typical of the people seen in general or in the sporting environment as the patients in those studies had a diagnosis related to shoulder pain and/or weakness or dislocation already. This study analysed the inter-observer reliability of the hug-up test only and not of the other tests included in the study (empty can test and full can test).

Different authors are of the opinion that, due to the close connection between the structures in the shoulder, no one test can discerningly distinguish an injury in any of the rotator cuff tendons and the outcome from muscle tests may involve a numerous structures (Somerville et al 2014; Lee et al 2014; Lui et al 2016). Therefore, it is suggested

in the literature that the results from the empty can test should be interpreted in conjunction with the results from the full can test and other impingement tests (Hegedus et al 2008). Inter-rater reliability for the empty can test is found to be kappa (k)=0.45–0.67 (Michener et al 2009). Their study utilised the test to test subacromial impingement syndrome, the participants presented with shoulder pain and only detection of weakness was taken as positive while testing. The literature does not seem to have studies to establish the reliability of the empty can test in determining supraspinatus integrity.

In a cross-sectional diagnostic study conducted by Sandenbergh and Marais (2006), the full can test's reliability as a diagnostic tool was compared to that of ultrasonic diagnosis of a muscle tear. The full can test had about 50% correlation with the ultrasonic diagnosis of a muscle tear. This study's data analysis process is questionable as it does not show how the correlation was calculated. The reliability of this test was not as high as the researchers expected. Their study looked at patients at a shoulder clinic and not sports participants. There are no studies in the literature which established reliability between physiotherapists and within physiotherapists for the full can test.

2.7.3. THE STANDING STORK TEST

The standing stork test is utilised to distinguish which side of the innominate bone moving on the sacrum is dysfunctional (Tong et al 2006). This test assesses the capabilities of the pelvis to uphold stability while load is being transferred between the spine and the lower extremities (Hungerford et al 2007). Studies have shown that optimal function of the lumbo-pelvic hip complex provides stability for the efficient generation of force and energy transfer to the distal segments (Kibler et al 2006). This is a movement that is vital in athletic performance and needed to decrease the danger of injury. A study conducted to evaluate the ability of physiotherapists to examine intra-pelvic movement with the stork test on the weight-bearing leg showed good inter-therapist reliability (k =0.67) (Hungerford et al 2007). However, the study was conducted on participants with pelvic girdle pain and not on sports participants. The study had 33 participants and participants were predominantly females. The study used a 2- and 3-point scale to determine a negative or positive result in the stork test. Depending on whether a 2- or a 3-point scale was used, the inter-rater reliability differed accordingly, as the increase in choices statistically decreases reliability (Hungerford et al 2007). The study of Tong et al (2006) showed the inter-rater reliability for the standing stork test to be poor (k =0.27) with a p -value of 0.07,

meaning those findings in that study were insignificant even to the population being studied. The study consisted of a small sample size (n=24) and this was conducted on women with low back pain and not on athletes or a sporting population.

2.7.4. THE BRIDGING HOLD TEST

The Bridging Hold Test is used to evaluate gluteal strength and endurance (Dennis et al 2008a) and it also assesses the stability of the trunk and the pelvis. The presence of enough core stability boosts body function by combining proximal and distal components in capability generation, balance and motion, where this stability is associated with the dominance of trunk over pelvic movements in reaction to any state of agitation or unease the body is placed under (Andrade et al 2012). A study in Brazil with 32 volunteers showed intra-rater reliability to be $\kappa=0.32$ to 0.58 and the inter-rater reliability to be $\kappa=0.80$. The study was conducted on a general population and not on athletes or a sporting population (Andrade et al 2012). The study used two-dimensional analysis of movement using a software program (SIMI Motion Twin) to determine degree of pelvic tilt. This type of equipment is not easily accessible in the field environment during musculoskeletal screening. Other studies did not use computed equipment but rather differed in their statistical calculations (Dennis et al 2008a; Dennis et al 2008b). Therefore this test was included in this study without the use of computer software for analysis.

2.7.5. THE 747 BALANCE TEST

The 747 Balance test is also known as the “Single Leg Romanian Deadlift” (Strauts and Tate 2015). This test is used to assess balance, coordination and stability. This test is more applicable to sports because many sporting activities demand a combination of strength, flexibility, speed and coordination in a single leg body position to create successful outcomes (Gamble 2004). Currently there is minimal research that has been done on the single leg Romanian Deadlift exercise or as a screening test. No studies were found on the reliability of this test.

2.8. SUMMARY

Literature related to the different screening tests for pre-participatory screening tests included in this study shows that more research is needed. An opening exists in the literature regarding reliability studies of screening tests used for injury identification and injury prevention. In cases where reliability was available, the studies were not done on a sporting population and/or expensive equipment was used.

CHAPTER 3

METHODOLOGY

3.1. INTRODUCTION

This chapter gives a detailed account in words of the methodology used in this study. It looks into the study aspects that have been utilised to answer the research question, i.e. study design, source of participants, sample size and a full description of procedures. Ethical issues inherent in this study are also discussed.

3.2. STUDY DESIGN AND STUDY SETTING

A reliability study was conducted. Data collection took place at the University of the Witwatersrand's cricket and football clubs during the month of August 2015. Data collection took place on the sporting grounds.

3.3. SOURCE OF PARTICIPANTS AND SAMPLE SIZE

Players aged between 18 to 31 years from the University of Witwatersrand Cricket Club and Bidvest Wits Football Club were requested to take part in the study. The sample size was set according to research done by Sim and Wright (2005). Effect sizes were calculated using Cohen's d where effect sizes of 0.2, 0.5 and 0.8 were understood as small, medium and large, respectively (Cohen 1992). A priori power analysis using G-Power based on the medium effect size 0.5 was used for sample size calculation. This means that the power analysis for estimating sample size to achieve adequate power of 80% was conducted before data was collected. This sample size was a conservative 36.

3.4. INCLUSION CRITERIA

The participants were healthy, uninjured, male cricket and football players.

3.5. EXCLUSION CRITERIA

Players who had undergone surgery to the spine or limbs in the past were not included.

3.6. PRE-PARTICIPATORY SCREENING TESTS

The following tests were included in this study: the one-legged hyperextension test, bridging hold test, 747 balance test, the empty can and full can shoulder impingement test and the standing stork test. A video recorder was used in the different tests for digital storage purposes. The execution of each test and instructions given by the raters were standardised (Table 3.1) by the researcher. This was to ensure that the participants understood what was expected of them when executing the screening test. The results obtained from all the tests were recorded on a data sheet (Appendix 1). During testing the participants wore their sporting attire as data were collected during their practice sessions. Testing was conducted by Nosipho Zumana (Researcher and rater 1) and a research assistant (Rater 2). Depending on the stage of the practice session, the participants were tested before warm-up, after warm-up and during practice session. The coach released a player at a time away from practice, therefore all tests were conducted and participant returned to the practice session. Not all players were able to attend sessions before practice as most of them came from lectures in the different venues of the university and walked to the sporting grounds. The re-test was done at the same stage for each participant. The tests were randomly conducted.

The table below shows the standardised instructions for the pre-participatory screening tests (Table 3.1).

Table 3.1 Standardised Instructions for pre-participatory screening tests by the researcher

Pre-participatory Screening tests	Researcher's Standardised Instructions
One-legged hyperextension test (Masci et al 2006)	"stand on the left leg and raise the right leg with the right hip and knee slightly bent, then bend your back backwards and tell me if you feel any pain"
Empty can test (Cools et al 2008)	"stand with arms stretched out to 90 degrees in scapula plane and thumbs both facing down, keep

	this position and do not let me push you, tell me if you feel any pain while keeping the position”
Full can test (Cools et al 2008)	“stand with arms stretched out to 90 degrees in scapula plane and thumbs both facing up towards the sky, keep this position and do not let me push you, tell me if you feel any pain while keeping the position”
Standing stork test (Tong et al 2006)	“Stand here and bend your right hip and knee to 90 degrees as if you are about to “Toyi-Toyi”.
Bridging hold test (Dennis et al 2008a)	“lie on your back on the floor with both knees bent about 90 degrees, then lift the buttocks from the floor and straighten your knee until you have a straight line between your shoulder, pelvic-hip and knee and keep this straight position for as long as you can until you have a straight line between your shoulder, pelvic-hip and knee and keep this straight position for as long as you can”
747 Balance test (Fuchek 2000)	“Stand on one leg with the non-weight bearing leg straight behind you and the arms abducted out to the side as in the flying position. Lift your leg behind you until you have a straight line between your shoulder, pelvic-hip and knee and keep this straight position for as long as you can”

3.6.1. ONE-LEGGED HYPEREXTENSION TEST

This is a pain provocation test which is used to assess for lumbar spondylolysis or stress fracture of the pars interarticularis. Masci et al (2006) described execution of this test stating that while standing, facing away from the tester, the athlete is asked to stand on the left leg and raise the right leg with the right hip slightly flexed and the right knee flexed to about 80 degrees. The athlete is then asked to perform lumbar extension. The rater asks the athlete if any pain is felt (yes or no). This test is then repeated on the other leg. The test is considered positive if it reproduces pain in the athlete's back (Masci et al 2006).



Figure3.1. One-legged Hyperextension Test

3.6.2. EMPTY CAN AND FULL CAN SHOULDER IMPINGEMENT TESTS

This test is used to identify if the rotator cuff muscles are a potential cause of shoulder impingement or pain. The empty can test is performed first, thereafter it is followed by the full can test. Cools et al (2008) describes that during the empty can test the athlete stands with both shoulders elevated to 90 degrees in the scapula plane and the thumbs facing down to the floor. This elevation is resisted by applying pressure on the mid-forearm. With the full can test Cools et al (2008) also states that the athlete stands, both shoulders elevated to 90 degrees in the scapula plane. The shoulders were externally rotated so that the thumbs were facing up to the roof. The rater then placed a downward pressure over mid-forearm and resisted further elevation. If the athlete had pain during the empty can and full can test of the dominant arm then the athlete is likely to have rotator cuff pathology on that side (Cools et al 2008). The athlete answers “yes” if there is pain and “no” if there is no pain. Yes or no was recorded.



Figure3.2. Empty Can Test



Figure3.3 Full Can Test

3.6.3. STANDING STORK TEST

This test is used to establish the side of the dysfunction of the innominate bone moving on the sacrum. Tong et al (2006) describes execution of this test stating that with the athlete standing, the rater kneels behind the athlete, the rater's left thumb palpates the inferior slope of the posterior superior iliac spine (PSIS) and the right thumb palpates the mid line

of the sacrum at the same level. The athlete then flexes the left hip and knee to 90degrees. The sacroiliac joint movement is regarded as normal when the thumb on the PSIS moves upward and abnormal when the thumb does not move or when it moves downward. The findings are recorded as normal for upward movement and abnormal for downward movement or no movement. The test is then repeated on the right side (Tong et al 2006).



Figure3.4. Standing Stork Test

3.6.4. BRIDGING HOLD TEST

This test is to assess gluteal strength and endurance. Dennis et al (2008a) describes the test stating that the athlete is positioned supine on the floor with both knees bent at about 90 degrees. The athlete is then instructed to lift the hips and pelvis off the floor to attain a straight line between the shoulder, pelvis and knee. The left and right anterior superior iliac spine (ASIS) remains level and there is no arching in the lower back. The athlete is then instructed to extend the left knee and maintain the position. A stopwatch is used and started as soon as knee extension position of the non-supported leg is achieved. The athlete holds the position for as long as possible. The stopwatch is then stopped. The time held is recorded in seconds and the reason for termination of the test is recorded (Dennis et al 2008a).The test is then repeated on the other side. There was also a research assistant to help with video recording this test for digital storage purposes in order for future researchers who want to observe how this test was conducted on field environment

as opposed to looking at the test in a laboratory or consultation room. The reasons for termination of the test include fatigue, pain or cramping in the lower back, gluteal or hamstring muscles or participant was unable to maintain ASIS level or keep shoulder, pelvis and knee in straight line.



Figure3.5. Bridging Hold Test

3.6.5.747 BALANCE TEST

This test is to assess the balance of an athlete. This test is also called the 'Single Leg Romanian Dead Lift' (Strauts and Tate 2015). The athlete stands on one leg with his non-weight bearing leg behind him and the arms abducted out to the side (flying position). A stopwatch is used to time the athlete as to how long the balance can be maintained (Fuchek 2000). There was also a research assistant to help with video recording the test for digital storage purposes. The test is terminated if the athlete cannot maintain ASIS alignment, has low back pain, pain or cramping of the gluteal muscles, pain or cramping of the hamstring muscles or cannot maintain shoulder, hip and knee in a straight line or has general fatigue. The time held is recorded in seconds and the reason for termination of the test is recorded



Figure3.6. 747 Balance Test

3.7. ETHICAL CONSIDERATIONS

Permission was requested from the Wits Sports Administration to access Wits Cricket and Football Club players (Appendix 2, Appendix 3 and Appendix 4). The protocol for this study was approved by the University of the Witwatersrand Human Research Ethics Committee (Medical) (Protocol Number: M150626; Appendix 5). The players were given an information letter explaining the study and procedure (Appendix 6). Participants were also informed also that their participation was voluntary and that they were free to refuse to participate or withdraw from the study at any time without suffering any negative consequences. Participants also voluntarily gave consent for a video to be taken while performing the tests and understood that refusal to be videotaped did not have any negative consequences. Informed written consent was obtained from all participants (see attached Appendix 7 and 8) and informed written consent was obtained from the parents of those participants who were under 18 years of age (Appendix 9). Informed written assent was also obtained from participants who were under 18 years of age (Appendix 10). This occurred prior to conducting the study. The information received was to be used only for the purpose intended for in this study and was to be released only to the participants. Players were assigned a study number to ensure confidentiality. The key to the study numbers assigned was kept safely in the possession of the researcher only. All participants' information remained confidential throughout the study.

3.8. PROCEDURE

3.8.1. PILOT STUDY

A pilot study was done following the same procedure as the main study, using the guideline of 10% (n=3 cricketers) of the sample size of the main study (n=35). A pilot study was performed to familiarise the raters with the testing procedures and to ensure uniformity in and during testing. This was also to assist in estimating the time required to complete each test. Difficulties that arose from the pilot study were noted and corrected before conducting the main study.

The participants were given an information session about the purpose of the study and the procedure which was to be followed. Written consent was obtained from the participants. The pilot study revealed logistical issues in that the raters' instructions differed, raters were not sufficiently skilled in the procedure and the time of day influenced athlete performance.

Data collected from the pilot study were not included in the analysis of the main results due to changes which were made to the study procedure following the pilot study. These changes included making the instructions on how to conduct the tests standard, for the raters to become sufficiently proficient in performing the tests, being flexible about the time of conducting the tests i.e. if athlete A was tested before training sessions then follow up testing would also be done before the training session.

3.8.2. MAIN STUDY

Data collection was arranged on a date and time most convenient for the teams. Data collection took place at the respective sporting grounds where the team's training sessions occurred. Thirty five athletes participated in the study which took place over a period of two weeks where day 1 was for assessment 1 and day 2 was for assessment2. Assessment 1 and assessment 2 were on two consecutive days. These assessments occurred with the athlete being exposed to the same conditions as assessment 1. This was either before the practice session, during practice sessions or after practice sessions.

The screening tests were conducted by two qualified physiotherapists, each with at least five years clinical practice experience (Rater1 and Rater2). There was also a research assistant to help with the video recording of the Bridging hold test and the 747 Balance

test. Each rater assessed an individual participant by conducting the tests in the following order 1). One-legged hyperextension test, 2). Bridging hold test, 3). 747 balance test, 4). Empty can with full can shoulder impingement test and 5). Standing stork test; for each participant. There was no rest period between testing of each participant within an assessment. All the tests were performed separately by each rater. The 747 balance test, as it is an observational test, the raters both observed the athlete as the athlete performed the test. The bridging hold test is also an observational test and both raters observed the athlete as the athlete was performing the test. Raters observed at the same time without communication between the raters. This was a time management strategy as the athlete had to go back onto the field for their match preparation session. Rater1 gave the standardised instructions. Each rater had her own stopwatch to use during testing. With the empty can test, full can test and the standing stork test the raters individually conducted the tests on participants. Rater1 was followed by Rater2, noting their individual findings in order to determine inter-rater reliability. The raters did not communicate during screening. For the 747 balance test and the Bridging hold test, the raters did not stop the athlete, they wrote the time, noting when the position could no longer be held or maintained by the athlete and the reason that caused the participant to be unable to maintain the position as observed by the rater. The Raters were unaware of each other's results; they were blinded to each others' findings during testing. The raters kept their individual recordings until after the study was concluded. Assessment 2 was for intra-rater reliability. The raters did not communicate during this screening. During this, the same testing procedure as above was repeated within 24 hours after assessment 1. This was to minimise the risk of change in the participants' biomechanical and physiological state. Furthermore, the tests included pain provocation tests which needed a longer period for recovery.

All the tests were performed as single measures, raters were only allowed to communicate with participants for instructional purposes and standardised instructions were used. Rater 1 also demonstrated the test to be conducted.

3.9. DATA ANALYSIS

All data were recorded on data collection sheets during the testing sessions whereafter all collected data were entered onto an Excel spreadsheet by the main researcher. All analyses were performed using Statistical Package for Social Sciences (SPSS) data

analysis software 23 version. The missing data were not included in the analysis. Descriptive analysis was used to describe the basic features of data in this study. For inter-rater reliability, the results obtained from Rater1 were compared to the results obtained from Rater 2 in the same session. For intra-rater reliability, the results obtained from each rater in the first session were compared to the same rater's results obtained in the second session.

Cohen's kappa was used to determine rater agreement as outcomes are nominal i.e. categorical data for example with the one-legged hyperextension test, empty can, full can impingement test and the standing stork test. The Intraclass Correlation Coefficient was used for continuous data i.e. ratio data for example the Bridging hold test and the 747 Balance test. Kappa statistics assesses the degree of agreement among raters over and above that expected by coincidence (Cohen 1960; Sim and Wright 2005). In this study Cohen's kappa was applied to establish reliability both inter- and intra-rater. A Kappa of 1 suggests perfect agreement; whereas a kappa of zero (0) suggests agreement that is obtained by coincidence (Viera and Garrett 2005) (see Table 3.2). A range of statistical methods have been used to calculate intra-rater and inter-rater reliability. The intraclass correlation coefficient (ICC) is the measure most referenced by sports injury researchers working with screening protocols that collect continuous data (Bennell et al 1998; Atkinson and Nevill 1998; Gabbe et al 2004). The ICC shows both extent of uniformity and compatibility among ratings (Bruton et al 2000). This study used the two-way random effect for the inter-rater reliability and a mixed random effect for the intra-rater reliability as defined by Shrout and Fleiss (1979). This model was used because the same participant from the random sample of the population was measured more than once.

Applying the guidelines suggested by Landis and Koch (1977) for understanding of k-values shown in Table 3.2 and noting that there is no guideline noting satisfactory level of reliability using ICC, this study will also use Table 3.2 for the interpretation of the ICC values. Chinn (1991) proposes that any measure should have an intraclass correlation coefficient of at least 0.6 to be helpful. This reliability for continuous data will be considered with a combination of approaches i.e. standard error of measurement (SEM) and ICC as some authors have suggested that no sole reliability approximate should be utilised for reliability studies (Rankin and Stokes 1998; Atkinson and Nevill 1998). The study applied a confidence level of 95% ($p < 0.05$) as the criterion for determination of statistical significance. The p-value measures how compatible data are with the null hypothesis i.e. how compatible data are with the strength of agreement within a rater and strength of

agreement among raters as a p-value less than 0.05 would imply that the observed difference in the sample does reflect the population.

The table below shows the guidelines used for the explanation of Kappa and ICC values (Table 3.2).

Table 3.2 Guidelines for the explanation of Kappa and ICC values as by Landis and Koch (1977)

VALUE OF k* or ICC	STRENGTH OF AGREEMENT
< 0.00	Poor
0.0 – 0.20	Slight
0.21 – 0.40	Fair
0.41 – 0.60	Moderate
0.61 – 0.80	Substantial
0.81 – 1.00	Excellent

**k indicates Kappa; ICC indicates Intraclass Correlation Coefficient*

CHAPTER 4

4. RESULTS

This chapter presents analyses and interprets the results as per objectives of the study i.e. establishing the intra-rater and inter-rater reliability of pre-participatory screening tests used in sports participants. Kappa=1 will only occur in the instance where the ratings from both the raters agree on each and every athlete observed. $K = (Po - Pe) / (1 - Pe)$

4.1. PARTICIPANTS

The study had 35 athletes who participated in the initial assessment and 11% (n=4) of the athletes dropped out as they could not return for the second assessment. Reasons for not being able to return were clashes with class attendance or change in training times. Therefore, data from 89% (n=31) were eligible for analysis. The demographic profile of the participants is presented in Table 4.1 below.

Table 4.1 Demographic profile of the participants (n=31)

	Median	Mean(± SD)	25 th Percentile	75 th Percentile	Minimum	Maximum
Age (yrs)	18.0	18.6 (±1.5)	18.0	19.0	16.0	24.0
Weight(kg)	70.0	74.9(±9.4)	69.0	84.0	60.0	100.0
Height(m)	1.8	1.8(± 0.1)	1.7	1.9	1.5	1.9

*SD = standard deviation

Table 4.1 shows that the participants' median age was 18.0. The median height of the sample was 1.8m and median weight of the sample was 70.0kg.

4.2. ONE-LEGGED HYPEREXTENSION TEST

Table 4.2 represents the intra-rater reliability of the one-legged hyperextension test.

Table 4.2 Intra-rater agreement of ratings for One-Legged Hyperextension test (n=31)

	Test	Trial 1		Trial 2		Kappa (95%CI)	SEM	P- Value
		Rating (yes)	Rating (no)	Rating (yes)	Rating (no)			
		n(%)	n(%)	n(%)	n(%)			
Rater 1	Left	10(32.3%)	21(67%)	7(22.6%)	24(77.4%)	0.6(0.3–0.9)	0.2	0.001*
	Right	11(35.5%)	20(64.5%)	5(16.1%)	26(83.9%)	0.5(0.2–0.8)	0.2	0.001*
Rater 2	Left	13(11.9%)	18(58.1%)	6(19.4%)	25(80.6%)	0.4(0.1–0.7)	0.2	0.022*
	Right	11(35.5%)	20(64.5%)	4(12.9%)	27(87.1)	0.4(0.1–0.7)	0.2	0.004*

*Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; SEM- Standard Error of Measurement; %- percentage

Table 4.2 illustrates the Kappa value for the one-legged hyperextension test to have moderate strength of agreement on the left and right side for the first rater, with a statistically significant p-value. It then shows fair strength of agreement for the second rater on the left and right side.

Table 4.3 represent the inter-rater reliability of the one-legged hyperextension test.

Table 4.3 Inter-rater agreement of ratings for one-legged hyperextension test (n=31)

Test		Rater 1		Rater 2		Kappa (95%CI)	SEM	P- Value
		Rating (yes) n (%)	Rating (no) n(%)	Rating (yes) n (%)	Rating (no) n(%)			
Trial1	Left	10(32.3%)	21(67.7%)	13(41.9%)	18(58.1%)	0.8(0.6-1.0)	0.1	<0.001*
	Right	11(35.5%)	20(64.5%)	11(35.5%)	20(64.5%)	0.8(0.6-1.0)	0.1	<0.001*
Trial2	Left	7(22.6%)	24(77.4%)	6(19.4%)	25(80.6%)	0.9(0.7-1.1)	0.1	<0.001*
	Right	5(16.1%)	26(83.9%)	4(12.9%)	27(87.1%)	0.9(0.6-1.1)	0.1	<0.001*

*Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; SEM- Standard Error of Measurement; %- percentage

Table 4.3 shows substantial strength of agreement between the raters with statistically significant p-values during the first assessment and excellent strength of agreement between the raters for the second assessment with statistically significant p-values.

4.3. EMPTY CAN AND FULL CAN TESTS

Table 4.4 represents the intra-rater reliability of the empty can and full can tests.

Table 4.4 Intra-rater agreements of ratings for empty and full can tests (n=31)

	Test	Trial 1		Trial 2		Kappa (95%CI)	SEM	P- Value
		Rating (yes) n (%)	Rating (no) n(%)	Rating (yes) n (%)	Rating (no) n(%)			
Rater 1	Empty Can	2(6.5%)	29(93.5%)	1(3.2%)	30(96.8%)	0.6(0.2–1.1)	0.2	<0.001*
	Full Can	1(3.2%)	30(96.8%)	1(3.2%)	30(96.8%)	0.1(0.1–0.2)	0.1	0.326
Rater 2	Empty Can	0(0%)	31(100%)	1(3.2%)	30(96.8%)	0.8(0.4-1.2)	0.2	<0.001*
	Full Can	1(3.2%)	30(96.8%)	1(3.2%)	30(96.8%)	0.6(0.2–1.1)	0.2	<0.001*

*Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; SEM- Standard Error of Measurement; %- percentage

1

Table 4.4 illustrates the Kappa value for the empty can test to have moderate strength of agreement with statistical significant p-value for the first rater and the full can test to have no agreement within the first rater, whereas for the second rater the kappa value for the empty can test has substantial strength of agreement and the full can test has moderate strength of agreement with both p-values statistically significant for the second rater.

¹ The measurements of empty can test and full can test refer to the dominant side.

Table 4.5 represent the inter-rater reliability of the empty can and full can tests.

Table 4.5 Inter-rater agreement of ratings for empty can and full can tests (n=31)

Test		Rater 1		Rater 2		Kappa (95%CI)	SEM	P-Value
		Rating (yes) n (%)	Rating (no) n(%)	Rating (yes) n (%)	Rating (no) n(%)			
Trial 1	Empty Can	2(6.5%)	29(93.5%)	0(0%)	31(100%)	-0.05(-0.1- 0.01)	0.03	0.790
	Full Can	1(3.2%)	30(96.8%)	1(3.2%)	30(96.8%)	0.5(0.03-0.9)	0.2	0.003*
Trial 2	Empty Can	1(3.2%)	30(96.8%)	1(3.2%)	30(96.8%)	0.8(0.4-1.2)	0.2	<0.001*
	Full Can	1(3.2%)	30(96.8%)	1(3.2%)	30(96.8%)	0.8(0.5-1.1)	0.1	<0.001*

**Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; SEM- Standard Error of Measurement; %- percentage*

Table 4.5 shows no agreement in the first assessment for the empty can test and moderate strength of agreement for the full can test between the raters. The second assessment for both the tests shows substantial strength of agreement ($k=0.8$) with statistically significant values.

4.4. STANDING STORK TEST

Table 4.6 represents the intra-rater reliability of the standing stork test.

Table 4.6 Intra-rater agreement of ratings for the Standing Stork test (n=31)

Test		Trial 1			Trial 2			Kappa	SEM	P-
		Motion Detected by Rater (%)			Motion Detected by Rater (%)			(95%CI)		Value
		Up	Down	No Mvt	Up	Down	No Mvt			
R 1	L	16	4	11	14	13	3	-0.06	0.1	0.560
		(51.6%)	(12.9%)	(35.5%)	(45.2%)	(41.9%)	(9.7%)	(-0.27–0.1)		
1	R	17	6	8	11	18	2	-0.15	0.1	0.174
		(54.8%)	(19.4%)	(25.8%)	(35.5%)	(58.1%)	(6.5%)	(-0.4-0.4)		
R 2	L	0	16	15	0	22	9	0.1	0.2	0.609
		(0%)	(51.6%)	(48.4%)	(0%)	(70.9%)	(29%)	(-0.2-0.4)		
2	R	0	24	7	0	27	4	-0.2	0.1	0.247
		(0%)	(77.4%)	(22.6%)	(0%)	(87.1%)	(12.9%)	(-0.3--0.1)		

**Denotes statistical significance ($p < 0.05$); Abbreviations: R1 – Rater 1; R2 – Rater 2 L – Left; R – Right; CI - Confidence Interval; n - sample size; %- percentage; SEM- Standard Error of Measurement; Mvt - Movement*

Table 4.6 illustrates a low value of Kappa for the standing stork and a high p-value. This shows no agreement within each rater.

Table 4.7 represents the inter-rater reliability of the standing stork test.

Table 4.7 Inter-rater agreement of ratings for Standing Stork test (n=31)

Test		Rater 1			Rater 2			Kappa	SEM	P-
		Motion Detected by Rater			Motion Detected by Rater			(95%CI)		Value
		(%)			(%)					
		Up	Down	No Mvt	Up	Down	No Mvt			
Trial 1	L	16 (51.6%)	4 (12.9%)	11 (35.5%)	0 (0%)	16 (51.6%)	15 (48.4%)	0.3 (0.1-0.4)	0.1	0.738
	R	17 (54.9%)	6 (19.4%)	8 (25.8%)	0 (0%)	24 (77.4%)	7 (22.6%)	0.1 (-1.1-1.3)	0.6	0.102
Trial 2	L	14 (45.2%)	13 (41.9%)	3 (9.7%)	0 (0%)	22 (70.9%)	9 (29%)	0.3 (0.2–0.4)	0.1	0.722
	R	11 (35.5%)	18 (58.1%)	2 (6.5%)	0 (0%)	27 (87.1%)	4 (12.9%)	-0.06 (-0.2-0.1)	0.1	0.415

*Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; %- percentage; SEM- Standard Error of Measurement; Mvt - Movement

Table 4.7 shows no agreement between the raters.

4.5. BRIDGING HOLD TEST

Table 4.8 represents intra-rater reliability of the bridging hold test.

Table 4.8 Intra-rater agreement of the ratings for Bridging hold test (n=31)

	Test	Trial 1	Trial 2	ICC (95%CI)	SEM	P-Value
		Seconds held	Seconds held			
		Mean (±SD)	Mean (±SD)			
Rater 1	Left	26.3 (±10.8)	17.3 (±12.5)	0.3 (-0.4 – 0.6)	15.7	0.039*
	Right	21.0 (±8.7)	18.1 (±10.4)	0.5 (0.2 – 0.7)	11.5	0.001*
Rater 2	Left	22.9 (±12.4)	16.5 (±12.5)	0.4 (0.1 – 0.7)	15.8	0.007*
	Right	18.2 (±8.5)	16.3 (±10.1)	0.4 (0.1 – 0.7)	11.9	0.008*

*Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; ICC- Intraclass Correlation Coefficient; SEM- Standard Error of Measurement; SD- Standard deviation

Table 4.8 shows the intraclass correlation coefficient to have fair strength of agreement on the left side and moderate strength of agreement on the right side for the first rater. It shows fair agreement on the left side and right side for the second rater.

Table 4.9 represents the inter-rater reliability of the bridging hold test.

Table 4.9 Inter-rater agreement of ratings for Bridging Hold test (n=31)

	Test	Rater 1	Rater 2	ICC (95%CI)	SEM	P- Value
		Seconds Held Mean ($\pm$ SD)	Seconds Held Mean($\pm$ SD)			
Trial 1	Left	26.3 ($\pm$ 10.8)	22.9 ($\pm$ 12.4)	0.8 (0.7 – 0.9)	9.1	0.039*
	Right	21.0 ($\pm$ 8.7)	18.2 ($\pm$ 8.5)	0.7 (0.4 – 0.8)	9.2	0.001*
Trial 2	Left	17.3 ($\pm$ 12.5)	16.5 ($\pm$ 12.5)	0.9 (0.8 – 0.9)	6.9	0.007*
	Right	18.1 ($\pm$ 10.4)	16.3 ($\pm$ 10.1)	0.8 (0.6 – 0.9)	9.4	0.008*

**Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; ICC- Intraclass Correlation Coefficient; SEM- Standard Error of Measurement; SD- Standard Deviation*

Table 4.9 shows the intraclass correlation coefficient for the bridging hold test to be substantial on the left side and on the right side for the first assessment. It shows excellent agreement between the raters for the left side and substantial agreement between the raters on the right side for the second assessment. These values show to have a significant p-value.

4.6. 747 BALANCE TEST

Table 4.10 represents the intra-rater reliability of the 747 balance test.

Table 4.10 Intra-rater agreement of ratings for the 747Balance test (n=31)

	Test	Trial 1 Seconds held Mean ($\pm$ SD)	Trial 2 Seconds Held Mean($\pm$ SD)	ICC (95%CI)	SEM	P- Value
Rater 1	Left	17.8 ($\pm$ 9.1)	15.8 ($\pm$ 10.9)	0.6 (0.3 – 0.8)	11.7	<0.001*
	Right	16.5 ($\pm$ 9.7)	15.2 ($\pm$ 10.8)	0.3 (-0.1 – 0.6)	13.9	0.063
Rater 2	Left	15.7 ($\pm$ 10.1)	15.2 ($\pm$ 8.4)	0.4 (0.1 – 0.7)	11.9	0.007*
	Right	15.3 ($\pm$ 7.5)	16.4 ($\pm$ 9.3)	0.2 (-0.4 – 0.7)	11.6	0.143

**Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; ICC- Intraclass Correlation Coefficient; SEM- Standard Error of Measurement; SD- Standard Deviation*

Table 4.10 illustrates the intraclass correlation coefficient to be moderate with a statistically significant p-value on the left side for the first rater. It shows fair agreement on the left side for the second rater. There is no agreement within each rater for the right side.

Table 4.11 represent the inter-rater reliability of the 747 balance test.

Table 4.11 Inter-rater agreement of ratings for 747 Balance test (n=31)

		Rater 1	Rater 2			
	Test	Seconds held	Seconds Held	ICC (95%CI)	SEM	P- Value
		Mean (±SD)	Mean(±SD)			
Trial 1	Left	17.8 (±9.1)	15.7 (±10.1)	0.7 (0.5 – 0.9)	9.3	<0.001*
	Right	16.5 (±9.7)	15.3 (±7.5)	0.2 (0.0 – 0.7)	11.3	0.013*
Trial 2	Left	15.8 (±10.9)	15.2 (±8.4)	0.4 (0.1 – 0.7)	11.9	0.007*
	Right	15.2 (±10.8)	16.4 (±9.3)	0.2 (-0.2 – 0.5)	11.6	0.143

* Denotes statistical significance ($p < 0.05$); Abbreviations: CI - Confidence Interval; n - sample size; ICC- Intraclass Correlation Coefficient; SEM- Standard Error of Measurement; SD- Standard deviation

Table 4.11 shows the intraclass correlation coefficient for the 747 balance test to be substantial on the left side and slight on the right side for the first assessment. The agreement between the raters is fair on the left side for the second assessment. The p-values for the first assessment are statistically significant whereas for the right side of the second assessment the results show no agreement.

4.7. SUMMARY

Chapter 4 presented an analysis of the data gathered from the participants. The results indicate that reliability varies among the different tests. The empty can test showed to have the highest intra-rater reliability followed by the one-legged hyperextension and the bridging hold test. The one-legged hyperextension test had the highest inter-rater reliability ($k=0.9$), followed by the Bridging hold test ($ICC= 0.9$), then the full can test. These results had statistically significant p-values and could be useful in clinical practice. The following chapter focuses on the interpretation of the data.

CHAPTER 5

5. DISCUSSION

5.1. INTRODUCTION

This chapter will focus on the interpretation of the results. The aim of this study was to investigate the reliability of the pre-participatory screening tests frequently used in sport. The data could be utilised to recognise hazardous components leading to injury and may ultimately enlighten the development of an effective injury prevention protocol. The tests selected for consideration in this study are clinical tests used for calculation of different components, used in pre-participatory screening of athletes in sports. These clinical tests are administered with ease, they are cost effective and do not require highly specialised equipment.

5.2. PARTICIPANTS

The demands of most sporting codes have increased due to increased professionalism of sport. It has been confirmed that specific physical attributes or measurement profiles show whether the athlete would be acceptable for competition at a prominent level in a specific sport (Sahu 2015). Research has shown that the physique and build of football players (Nikolaidis and Karydis 2011) and cricket players (Stuelcken et al 2007) are also important for success and performance at an elite level. In the current study the median age, weight (body mass), height (stature) were found to be similar to that of previous studies where physique and body composition were suggested to contribute to performance (Stuelcken et al 2007; Santos et al 2014). Rodriguez et al (2010) suggested that height impacts the ability of an athlete to play certain positions whereas body weight influences an athlete's speed, endurance and power (Rodriguez et al 2010). These contribute to the athlete's optimal sports performance. In this study it was noted that there are different body weights and heights for the different positions for each sporting code. The results of that go beyond the scope of this research report.

5.3. RELIABILITY OF ONE-LEGGED HYPEREXTENSION TEST

The results of this test suggest fair to moderate agreement within each rater while the results suggest substantial to excellent agreement between therapists. There are no

previous reliability studies found with which to compare these results. The inter-rater agreement may be higher than the intra-rater agreement because the athletes' pain experience during testing might have differed between the two assessment days. During testing some athletes experienced pain on performing this screening test in the first assessment but not in the second assessment. Other athletes who did not experience pain in the first assessment did experience pain in the second assessment, which may contribute to different test results when tested during the second assessment and which influenced the reliability. The pain is thought to be caused by compressive forces on the pars interarticularis during lumbar extension (Weber and Woodall 1991). The two raters performed the test on the same day while the intra-rater reliability was based on assessments done over two consecutive days.

One weakness of this test is that the range of movement into lumbar extension is not measured as part of this test and the lower reliability might also be due to an athlete having decreased their lumbar extension range to a point just before pain is felt and reporting that no pain was felt. Masci et al (2006) suggested bone scintigraphy continue to be the first line examination tool for active sportsmen with low back pain. Studies showed the bone scintigraphy test to have moderate sensitivity to diagnose lumbar spondylolysis (Weir and Smith 1989; Ralston and Weir 1998; Alqarni et al 2015). The current study proposes that the one-legged hyperextension test be the first line screening test used on the sporting field for diagnosing lumbar spondylolysis, although refinements to this test in terms of range of motion of lumbar extension is needed.

5.4. RELIABILITY OF EMPTY CAN TEST AND FULL CAN TEST

The intra-rater reliability of the empty can test showed to have moderate to substantial agreement with statistically significant p-values and a very small margin of error; this indicates that the results are trustworthy, and that the results of this sample are close to the number one would get if the whole population had been tested (Hopkins 2000). The inter-rater reliability of the empty can test was shown to vary from poor to substantial agreement and the poor agreement was of statistical insignificance (which means the results could well have been due to chance). The results of the first assessment for the empty can test may have been due to some athletes having experienced pain during execution of the screening test. Previous studies investigating the reliability of the empty can test are similar to this study, where they had moderate inter-rater strength of

agreement (Michener et al 2009) while this study had substantial inter-rater reliability for the second rater. The findings between this study and the previous study done were not similar in the sense that the kappa coefficient for the empty can test was between 0.45-0.67 for the two raters conducting the test (Michener et al 2009) while in this study we found intra-rater reliability of $k = 0.6-0.8$ and inter-rater reliability of $k=0.8$ for the second rater. Meanwhile, in a study lead by Ostor et al (2004) the results differed as the inter-rater reliability showed to have fair agreement ($k=0.49$). This study had three raters (consultant, registrar and a nurse) conducting the test. Musculoskeletal screening tests conducted on the field-environment require a person trained in musculoskeletal physiotherapy to be able to produce reliable results. Previous studies have suggested a high value for specificity and accuracy of the empty can test to detect a torn supraspinatus tendon (Lui et al 2016). The reliability of diagnostic tests does not depend only on accuracy but also on reproducibility of the test (Gjørup 1997). Now this study suggests moderate to substantial intra-rater reliability of this screening test. The empty can test is usually used to diagnose rotator cuff tear (Hegedus et al 2008; Somerville et al 2014) and this study has shown it to be a reliable screening test.

The full can test showed no agreement within the first rater and a statistically significant value for the second rater. The inter-rater agreement for the full can test showed to have moderate to substantial agreement with statistical significant p-values. This inter-rater reliability for the full can test showed to have a small margin of error. This difference of the raters for intra-rater reliability may be due to the fact that the athlete that felt pain during initial testing did not experience any pain in the second assessment by the first rater on the second day. Another reason might be the variation in the amount of resistance applied by the rater between the first and second assessment. There were no previous studies to compare the full can test. To the researcher's understanding this is the first inter- and intra-rater reliability study conducted for the full can test.

5.5. RELIABILITY OF STANDING STORK TEST

The stork test showed to have poor intra-rater agreement and poor to fair inter-rater agreement and these results were statistically insignificant. The reasons that lead to such low agreement may be due to the observational and palpatory nature of this test as the rater's ability to recognise the configuration of movement taking place at the innominate bone and the sacrum was not the same. One rater could have noted the innominate as

having appeared not to be moving or moving downward (caudad) as opposed to moving upward (cephalad). Robinson et al (2007) showed that reliability for palpatory tests was poor ($k = -0.06$) which is similar to this study. Previous studies investigating the reliability of the standing stork test differ with the current study. Hungerford et al (2007) showed moderate inter-rater agreement when the 3-point scale was used (upward, neutral or downward) and showed good inter-rater reliability when the 2-point scale was utilised to establish a negative and positive outcome in the stork test. The current study only used the 3-point scale. Hungerford's study (2007) had three raters as opposed to this study which had two raters. The more raters there are to examine the participants, the more likely it is that the researcher will find reliable results. Tong et al (2006) showed slight inter-rater agreement ($k = 0.27$) for noting the presence or absence of SIJ dysfunction. This study (Tong et al 2006) also had an increased p-value meaning those results were of statistical insignificance thus there was no inter-rater agreement and the evaluation was only among two raters. These results show to be similar with the current study.

The above explanation may have also been applicable to the poor intra-rater reliability achieved. In addition to the fact that 24 hours lapsed in between the two testing sessions for intra-rater reliability, the poor reliability may also have been due to movement patterns of the innominate having changed and altered stabilisation strategies during load transfer by the athlete (Kibler et al 2006; Goode et al 2008). The strength of agreement of this screening test demonstrated qualities of having no practical use in both intra-rater and inter-rater reliability.

5.6. RELIABILITY OF BRIDGING HOLD TEST

The intra-rater reliability for the bridging hold test showed to have fair to moderate agreement and those values had statistical significance which means that the results obtained in this sample are close to the number one would get if the whole population had been tested i.e. the results are trustworthy. This intra-rater reliability measurement showed to have an increase in the SEM i.e. an elevation in the estimate of amount of error in the test, which indicates that there is a high number of errors that could have occurred during testing. The inter-rater reliability showed to have substantial to excellent agreement; the results were of statistical significance. These results had a small SEM i.e. this showed a more precise measurement capacity of the raters. These results could have a large margin of error as the reasons for terminating the test depended on rater observations. The

reasons for terminating the test were either due to fatigue or pain or cramping in the lower back, gluteal or hamstring muscles or the athlete was unable to maintain ASIS level or keep the shoulder, pelvis and knee in a straight line. The testing of the same athlete could have been terminated for one reason in the first assessment and a different reason in the second assessment e.g. an athlete could have had pain cramping in the hamstring during the first assessment and may have been unable to maintain the ASIS level during the second assessment. Fatigue could have been the reason for low intra-rater reliability as the results compared the left side with the right side and the right side was always tested first.

The results in this study are homogeneous to the outcomes of Andrade et al (2012) in terms of intra-rater reliability ($k = 0.32 - 0.58$) and inter-rater reliability ($k = 0.80$). Andrade et al (2012) used the bridging hold test with one-sided knee extension to analyse the ability of the raters to measure pelvic straightening up in a transverse plane through a two dimensional programme. In that study the participants all held the position for 10 seconds then the raters observed the alignment digitally, whereas in this study the participants held the position until they could not maintain it any longer and the reason for termination was judged by the raters. Dennis et al (2008a) showed similar results of moderate reliability ($ICC = 0.56$) for intra-rater. The difference with this study was that Dennis et al (2008a) utilised video footage to observe intra-rater reliability and their study used different statistical methods to determine the ICC. A number of studies of musculoskeletal screening tests, even in a clinical setting, show low intra-rater reliability (Moreland et al 1997; Loundon et al 2002; Monnier et al 2012; Whatman et al 2015). These show that visual observation was used as a means of measurement. The tests also contained more than one component (motor control, endurance, strength, etc.) that could be measured, similar to this study. The bridging hold test is quite technical and the criteria for termination of the test need to be refined.

5.7. RELIABILITY OF 747 BALANCE TEST

Intra-rater reliability for the 747 balance test was shown to be moderate with statistical insignificant values for the right side and a high margin of error. This may be due to a number of reasons for ending the test. The reasons for ending the test were either due to fatigue or pain or cramping in the lower back, gluteal or hamstring muscles or the athlete was unable to maintain ASIS level or keep the shoulder, pelvis and knee in a straight line.

The inter-rater reliability was substantial, with a high margin of error. This high margin of error may be attributed to the fact that there was more than one reason for termination of the test and that the raters observed this in real time without the usage of video footage for replay, rather than the raters' ability (Atkinson and Nevill 1998). Visual observation is a common key tool used in clinical practice, even in sport, for the prevention and management of musculoskeletal injuries. This type of assessment is a prerequisite for clinicians (Whatman et al 2015) as it allows the advantage of instantaneous evaluation of changes in performance. Real time observational studies conducted also showed poor intra- and/or inter-rater reliability of the various musculoskeletal screening tests (DiMattia et al 2005; Ortqvist et al 2011; Nilstad et al 2014). These screening tests observed components such as flexibility, endurance (Ortqvist et al 2011), balance (DiMattia et al 2005; Nilstad et al 2014) and muscle strength (DiMattia et al 2005; Ortqvist et al 2011; Nilstad et al 2014).

The inter-rater reliability results also showed an ICC of 0.2 on the right, meaning slight agreement between the raters and this value was of statistical insignificance. The researcher suspects the side with most errors is the right side - it has shown insignificant results as this side was tested first, then for the left side the athlete has learned the technique and therefore performed better than when the right side was tested. The "learning" effect analysis (Dennis et al 2008b; Casey, Wang and Osterling 2012; Zetou et al 2012; Cug and Wikstrom 2014) during this reliability assessment was not conducted. This was the first study to conduct a reliability study on this type of screening test.

CHAPTER 6

CONCLUSION

6.1. INTRODUCTION

This chapter will focus on the conclusions drawn from the data analysis, the limitations of the study, make recommendations for further research and also give clinical recommendations. The objectives of the study were to establish the intra-rater and inter-rater reliability of the one-legged hyperextension test, empty can and full can shoulder impingement test, standing stork test, bridging hold test and 747 balance test.

6.2 CONCLUSION

This study has presented the reliability of simple field-based clinical tests commonly used. This study shows there is moderate to substantial intra-rater reliability for the empty can test. This study also shows there is substantial to excellent inter-rater reliability for the one-legged hyperextension test, the bridging-hold test, and substantial inter-rater reliability for the full can test. Therefore the use of these screening tests is recommended in pre-participatory screening protocols for sports participants. The table below (Table 6.1) shows a summary of the reliability found in this study.

Table 6.1 Summary of Intra-rater and Inter-rater Reliability of current study

RELIABILITY		
Screening test	Intra-rater	Inter-rater
One-legged hyperextension test	Fair - moderate	Substantial - excellent
Empty can test	Moderate - substantial	No agreement (1 st Assessment) Substantial (2 nd Assessment)
Full can test	No agreement (Rater 1) Moderate (Rater 2)	Moderate - substantial
Standing stork test	No agreement	No agreement
Bridging hold test	Fair - moderate (Rater 1) Fair (Rater 2)	Substantial - excellent
747 Balance test	Fair - moderate (Left side) No agreement (right side)	Fair – substantial (left side) No agreement (right side)

6.3. LIMITATIONS OF THE STUDY

The outcomes of this study give details with regard to the reliability of the frequently used musculoskeletal screening tests, although shortcomings to this study must be recognised. The age spread of the participants was proportionately marginal and the generalisation to the wider population cannot be assured. The sides of testing of all tests should have been randomised just as the order of testing was randomised. Another shortcoming of the study was that the same day inter-rater and intra-rater reliability could not have worked due to time constraints and fatigue would set in with athletes and the athlete might have still stopped himself before the point of pain on the later assessment sessions.

6.4. RECOMMENDATIONS FOR FUTURE RESEARCH

Additional developments are required to evolve a reliable field-based screening protocol to ensure that it is feasible to precisely distinguish hazardous components leading to injury for position specific types of injuries. Further in-depth research still has to be done for the 747balance test as this test consists of a number of components which need to be assessed individually e.g. components such as motor control, muscle strength, including balance and endurance. Future research has to find a way to stabilise the amount of resistance applied during empty can and full can tests. Furthermore, a measuring tool for lumbar extension in the one-legged hyperextension test could be incorporated into the screening test. It was not within the capacity of this study to assess the predictive validity of these tests and although a report on the reliability can be given, the ability of these tests to predict injury and therefore to be helpful as part of a screening tool, needs to be determined.

6.5. CLINICAL RECOMMENDATIONS

The outcomes of the study are encouraging. The study supports the utilisation of the one-legged hyperextension test, bridging-hold test and full can test between therapists. It is proposed that physiotherapists involved in pre-participatory screening of athletes regard the utilisation of the testing approach outlined here as a guide in testing protocols. The usefulness of these tests can be kept within the current screening tools and it is worth further investigating the injury predictive ability of these tests, especially when looking at back pain and muscle endurance and balance of sports participants. It is also

recommended that the standing stork test be removed as a field-based screening test; intrapelvic motion can be observed in the consulting room. Researcher also recommends that the screening tests with poor reliability (no agreement among the raters or no agreement within a rater), should be considered for removal from the screening tools. This is to avoid time wastage and for creating space for more reliable screening tests.

CHAPTER 7

REFERENCES

- Alqarni AM, Schneiders AG, Cook CE, Hendrick PA 2015 Clinical tests to diagnose lumbar spondylolysis and spondylolisthesis: a systematic review, *Physical Therapy in Sport*, 16:268-275
- Andrade JA, Figueiredo LC, Santos TR, Paula AC, Bittencourt NF, Fonseca ST 2012 Reliability of transverse plane pelvic alignment measurement during the bridge test with unilateral knee extension, *Revistabrasileira de fisioterapia*, 16(4):268-74
- Atkinson G, NevillAM 1998 Statistical methods of assessing measurement error (reliability) in variables relevant to sports medicine, *Sports Medicine*, 26(4):217-238
- Bahr R, Krosshaug T 2005 Understanding injury mechanisms: A key component of preventing injuries in sport, *British Journal of Sports Medicine*, 39:324-329
- Beaudreuil J, Nizard R, Thomas T, Peyre M, Liotard JP, Boileau P, Marc T, Dromard C, Steyer E, Bardin T, Orcel P, Walsh G 2009 Contribution of clinical tests to the diagnosis of rotator cuff disease: a systematic literature review, *Joint Bone Spine*, 76:15–19
- Bennell K, Talbot R, Wajswelner H, Techvanich W, Kelly D 1998 Intra-rater and inter-rater reliability of a weight-bearing lunge measure of ankle dorsiflexion, *Australian Journal of Physiotherapy*, 44:175-180
- Bradley PS, Portas MD 2007 The relationship between pre-season range of motion and muscle strain injury in elite soccer players, *Journal of Strength Conditioning Research*, 21(4):1155-1159
- Bruton A, Conway JH, Holgate ST 2000 Reliability: what is it, and how is it measured?, *Physiotherapy*, 86(2):94–99
- Canavon PK, Roucarati M, Lyles K 2012 Off-season screening of an NCAA Division 1 Men`s Basketball team, *International Journal of Athletic Therapy and Training*, 17(5):28–32
- Casey AF, Wang X, Osterling K 2012 Test-retest reliability of the 6-minute test in individuals with Down Syndrome, *Archives of Physical Medicine and Rehabilitation*, 93(11):2068-2074

- Chinn S 1991 Repeatability and method comparison, *Thorax*, 46:454–456
- Cohen J 1960 A coefficient of agreement for nominal scales, *Education and Psychological Measurement*, 20:37–46
- Cohen J 1992 A power primer, *Psychological Bulletin*, 112(1):155-159
- Comerford MJ 2006 screening to identify injury and performance risk: movement control testing – the missing piece of the puzzle, *SportEx medicine*, 21-26, www.sportex.net, [Accessed 14June 2016]
- Cook G, Burton L and Hoogenboom B 2006 Pre-participation screening: The use of fundamental movements as an assessment of function– Part1, *North American Journal of Sports Physical Therapy*, 1(2):62-72
- Cook G, Burton L, Hoogenboom B, Voight M 2014 Functional Movement screening: the use of fundamental movements as an assessment of function – part 1, *The International Journal of Sports Physical Therapy*, 9(3):396–409
- Cools AM, Cambier D, Witvrouw EE 2008 Screening the athlete's shoulder for impingement symptoms: a clinical reasoning algorithm for early detection of shoulder pathology, *British Journal of Sports Medicine*, 42:628-635
- Crosier JL, Govinteaume S, Binet J, Genty M, Ferret JM 2008 Strength imbalances and prevention of hamstring injury in professional soccer players: a prospective study, *American Journal of Sports Medicine*, 36(8):1469-1475
- Cug M, Wikstrom EA 2014 Learning effects associated with the least stable level of the Biodex stability system during dual and single limb stance, *Journal of Sports Science and Medicine*, 13:387:392, <http://www.jssm.org> (Accessed 14November 2016)
- Dallinga JM, Benjaminse A, Lemmink KA 2012 Which screening tools can predict injury to the lower extremities in team sports? A systematic review, *Sports Medicine Journal* 42(9):791-815
- Dennis RJ, Finch CF, Elliot BC, Farhart PJ 2008 The reliability of musculoskeletal screening tests used in cricket, *Physical Therapy in Sport*, 9:25-33.
- Dennis RJ, Finch CF, Mc Intosh AS 2008 Use of field-based tests to identify risk factors for injury to fast bowlers in cricket, *British Journal of Sports Medicine*, 42:477-482

- DiMattia M, Livengood A, Uhl T, Mattacola C, Malone T 2005 What is the validity of the single-leg squat test and its relationship to hip-abduction strength?, *Journal of Sports Rehabilitation*, 14:108-123
- Ekstrom RA, Donatelli RA, Carp KC 2007 Electromyographic analysis of core trunk, hip and thigh muscles during 9 rehabilitation exercises, *Journal of Orthopaedic and Sports Physical Therapy*, 37 (12):754-62
- Escamilla RF, Yamashiro K, Paulos L, Andrews JR 2009 Shoulder Muscle Activity and Function in Common Shoulder Rehabilitation Exercises, *Sports Medicine*, 39(8):663-685, doi: 10.2165/00007256-200939080-00004
- Evershed J, Burkett B, Mellifont R 2014 Musculoskeletal screening to detect asymmetry in swimming, *Physical Therapy in Sport*, 15:33–38
- Finch C 2006 A new framework of research leading to sports injury prevention, *Journal of Science and Medicine in Sport*, 9:3-9
- Frohm A, Heijne A, Kowalski J, Myklebust G 2012 A nine-test screening battery for athletes: a reliability study, *Scandinavian Journal of Medicine and Science in Sports*, 22: 306-315, doi:10.1111/j.1600-0838.2010.01267.
- Frost WL, Chalmers DJ 2014 Injury in elite New Zealand cricketers 2002-2008: descriptive epidemiology, *British Journal of Sports Medicine*, 48(12): 1002-1007. Doi: 10.1136/bjsports-2012-091337
- Fuchek D 2000 Prevention and treatment of ankle sprains, *RunnerWeb.com*, www.runnersweb.com/running/deb_may2000.html, [Accessed 09 December 2014]
- Gabbe BJ, Bennell KL, Wajswelner H, Finch CF 2004 Reliability of common lower extremity musculoskeletal screening tests, *Physical Therapy in Sport*, 5:90- 97
- Gamble P 2004 Physical preparation of elite-level rugby union football, *Strength and Conditioning Journal*, 26(4):10–23
- Garrick J 2004 Pre-participation orthopaedic screening evaluation, *Clinical Journal Sports Medicine*, 14:123-126
- Gjørup T 1997 Reliability of diagnostic tests, *Acta Obstetrica et Gynecologica Scandinavica Supplement*, 166(166):9-14

Goode A, Hegedus EJ, Sizer P, Brismee JM, Linberg A, Cook CE 2008 Three-dimensional movements of the sacroiliac joint: A systematic review of the literature and assessment of clinical utility, *The Journal of Manual and Manipulative Therapy*, 16(1):25-38

Gregg CD, Dean S, Schneiders AG 2009 Variables associated with active spondylolysis, *Physical Therapy in Sport*, 10:121–124

Hayen A, Dennis RJ, Finch CF 2007 Determining the intra- and inter-observer reliability of screening tools used in sports injury research, *Journal of Science and Medicine in Sport*, 10:201-210.

Hebert JJ, Koppenhaver SL, Teyhen DS, Walker BF, Fritz JM 2013 The evaluation of lumbar multifidus muscle function via palpation: reliability and validity of a new clinical test, *The Spine Journal*. Available online at: <http://dx.doi.org/10.1016/j.spinee.2013.08.056> [accessed 12 December 2014]

Hegedus EJ, Goode A, Campbell S, Morin A, Tamaddoni M, Moorman CT 3rd 2008 Physical examination tests of the shoulder: A systematic review with meta-analysis of individual tests, *British Journal of Sports Medicine*, 42:80-92 doi:10.1136/bjism.2007.038406

Hopkins WG 2000 Measures of reliability in sports medicine and science, *Sports Medicine*, 30:1-15

Hughes RE, An KN 1996 Force analysis of rotator cuff muscles, *Clinical Orthopaedic Related Research*, 330:75-83

Hungerford BA, Gilleard W, Moran M, Emmerson C 2007 Evaluation of the ability of Physical Therapists to palpate intrapelvic motion with the stork test on the support side, *Journal of the American Physical Therapy Association*, 87:879-887

Itoi E, Kido T, Sano A, Urayama M, Sato K 1999 which is more useful the “full can test” or the “empty can test” in detecting the torn supraspinatus tendon?, *The American Journal of Sports Medicine*, 27(1):65–68

Jay K, Sundstrup E and Andersen LL 2014 Reliability of a simple Physical Therapist screening tool to assess errors during resistance exercises for musculoskeletal pain, *Biomed Research International*, 2014: 961748

Jobe FW, Maynes DR 1982 Delineation of diagnostic criteria and a rehabilitation program

for rotator cuff injuries, *American Journal of Sports Medicine*, 10:336-339

Kelly BT, Kadrmas WR and Speer KP 1996 The manual muscle examination for rotator cuff strength. An electromyographic investigation, *American Journal of Sports Medicine*, 24:581-588

Kibler WB, Press J, Sciascia A 2006 The role of core stability in athletic function, *Sports Medicine Journal*, 36:189-198

Kim E, Jeong HJ, Lee KW, Song JS 2006 Interpreting positive signs of the supraspinatus test in screening for torn rotator cuff, *Acta Medica Okayama*, 60(4):223–228

Landis JR, Koch GG 1977 The measurement of observer agreement for categorical data, *Biometrics* 33:159-174

Lasbleiz S, Quintero N, Ea K, Petrover D, Aout M, Laredo JD, Vicaut E, Bardin T, Orcel P, Beaudreuil J 2014 Diagnostic value of clinical tests for degenerative rotator cuff disease in medical practice, *Annals of Physical and Rehabilitation Medicine*, 57:228-243

Lee C, Itoi E, Kim S, Lee S, Suh K 2014 Comparison of muscle activity in the empty-can and full-can testing positions using 18F – FDG PET/CT, *Journal of Orthopaedic Surgery and Research*, 9: 85 doi: 10.1186/513018-014-0085-4 <http://www.josr-online.com/content/9/1/85> [Accessed 26 April 2016]

Leetun DT, Ireland ML, Willson JD, Ballantyne BT, Davis IM 2004 Core Stability measures as risk factors for lower extremity injury in athletes, *Medicine and Science in Sports and Exercise*, 36(6):926-34

Lehr ME, Plisky PJ, Butler RJ, Fink ML, Kiesel KB, Underwood FB 2013 Field – expedient screening and injury risk algorithm categories as predictors of noncontact lower extremity injury, *Scandinavian Journal of Medicine and Science in Sports*, 23:e225–e 232

Loudon JK, Wiesner D, Goist-Foley HL, Asjes C, Loudon KL 2002 Intrarater reliability of functional performance tests for subjects with patellofemoral pain syndrome, *Journal of Athletic Training*, 37(3):256-261

Lui Y, Ao Y, Yan H, Cui G 2016 The hug-up test: a new, sensitive diagnostic test for supraspinatus tears, *Chinese Medical Journal*, 129(2):147-153

Madsen NL, Drezner JA, Salerno JC 2014 The pre-participatory physical evaluation: an analysis of clinical practice, *Clinical Journal of Sports Medicine*, 24(2):142-149

- Maffey L, Emery C 2006 Physiotherapist Delivered Preparticipation Examination: Rationale and Evidence, *North American Journal of Sports Physical Therapy*, 1(4):176-186
- Masci L, Pike J, Malora F, Phillips B, Bennell K, Brukner P 2006 Use of the one-legged hyperextension test and magnetic resonance imaging in the diagnosis of active spondylolysis, *British Journal of Sports Medicine*, 40: 940- 946 DOI: 10.1136/bjsm.2006.030023
- McCall A, Carling C, Nedelec M, Davison M, Gall F, Berthoin S, DuPont G 2014 Risk Factors, testing and preventative strategies for non-contact injuries in professional football: current perceptions and practices of 44 teams from various premier leagues, *British Journal of Sports Medicine*, 48:1352–1357
- Meeuwisse WH and Fowler PJ 1988 Frequency and predictability of sports injuries in intercollegiate athletes, *Canadian Journal of Sport Science*, 13:35-42
- Metzl JD 2000 The adolescent pre-participation physical examination: Is it helpful? *Clinical Sports Medicine*, 19:577-592
- Michener LA, Walsworth MK, Doukas WC, Murphy KP, 2009 Reliability and diagnostic accuracy of 5 physical examination tests and combination of tests for subacromial impingement, *The American Congress of Rehabilitation Medicine*, 90:1898–1903
- Mischiati CR, Comerford M, Gosford E, Swart J, Ewings S, Botha N, Stokes M, Mottram SL 2015 Intra and inter-rater reliability of screening for movement impairments: movement control tests from the foundation matrix, *Journal of Sports Science and Medicine*, 14:427-440
- Monnier A, Heuer J, Norman K, Äng B 2012 Inter- and intra-observer reliability of clinical movement-control tests for marines, *BioMed Central Musculoskeletal Disorders*, 13:263, doi:10.1186/1471-2474-13-263
- Moreland J, Finch E, Stratford P, Balsor B, Gill C 1997 Interrater reliability of six tests of trunk muscle function and endurance, *Journal of Orthopaedic and Sports Physical Therapy*, 26(4):200-208, doi:10.2519/jospt.1997.26.4.200
- Nikolaidis PT, Karydis NV 2011 Physique and body composition in soccer players across adolescence, *Asian Journal of Sports Medicine*, 2(2):75-82
- Nilstad A, Andersen TE, Kristianslund E, Bahr R, Myklebust G, Steffen K, Krosshaug T

2014 Physiotherapists can identify female football players with high knee valgus angles during vertical drop jumps using real-time observational screening, *Journal of Orthopaedic and Sports Physical Therapy*, 44(5):358-365, doi:10.2519/jospt.2014.4969

O'Connor SO, McCaffrey N, Whyte E, Moran K 2015 Reliability of a Modified Active Knee Extension test for assessment of hamstring flexibility, *International Journal of Athletic Therapy and Training*, 20(4):32–36

Oliver JL, De Ste Croix M, Lloyd R, Williams C 2014 Altered neuromuscular control of leg stiffness following soccer-specific exercise, *European Journal of Applied Physiology*, doi:10.1007/s00421-014-2949-z

Olivier B, Taljaard T, Burger E, Brukner P, Orchard J, Gray J, Botha N, Stewart A, Mckinon W 2016 Which extrinsic and intrinsic factors are associated with non-contact injuries in adult cricket fast bowlers?, *Sports Medicine*, 46:79-101

Onate JA, Dewey T, Kollock RO, Thomas KS, van Lunen BL, DeMaio M, Ringleb SI 2012 Real-time intersession and interrater reliability of the functional movement screen, *Journal of Strength and Conditioning Research*, 26(2):408-415, doi:10.1519/JSC.0b013e318220e6fa

Orchard J, James T, Alcott E, Carter S, Farhart P 2002 Injuries in Australian cricket at first class level 1995/1996 to 2000/2001, *British Journal of Sports Medicine*, 36: 270-275

Orchard J, James T, Kountouris A, Portus M 2010 Changes to injury profile (and recommended cricket injury definitions) based on the increased frequency of Twenty20 cricket matches, *Open Access Journal of Sports Medicine*, 1 63-76

Orchard J, James T, Portus M 2006 Injuries to elite male cricketers in Australia over a 10-year period, *Journal of Science and Medicine in Sport*, 9: 459-467

Ortqvist M, Moström EB, Roos EM, Lundell P, January PM, Werner S, Broström EW 2011 Reliability and reference values of two clinical measurements of dynamic and static knee position in healthy children, *Knee Surgery, Sports Traumatology and Arthroscopy*, 19(12):2060-2066, doi:10.1007/s00167-011-1542-9

Ostor AJK, Richards CA, Prevost AT, Hazleman BL, Speed CA 2004 Interrater reproducibility of clinical tests for rotator cuff lesions, *Annals of Rheumatic Disease*, 63: 1288-1292, doi: 10.1136/ard.2003.014712

- Portney LG, Watkins MP 2009 Reliability of Measurements. In: Portney LG, Watkins MP. Foundations of clinical research: Applications to practice. 3rd Ed. New Jersey: Prentice Hall, Ch5
- Ralston S, Weir M 1998 Suspecting lumbar spondylolysis in adolescent low back pain, *Clinical Pediatric (Phila)*, 37(5):287-293
- Rankin G, Stokes M 1998 Reliability of assessment tools in rehabilitation: an illustration of appropriate statistical analyses, *Clinical Rehabilitation*, 12:187-199
- Ranson C, Hurley R, Gugless L, Mansingh, Cole J 2013 International cricket injury surveillance: a report of five teams competing in the ICC Cricket World Cup 2011, *British Journal Sports Medicine* 47: 637-643
- Robinson HS, Brox JI, Robinson R, Bjelland E, Solem S, Telje T 2007 The reliability of selected motion-and pain provocation tests for sacroiliac joint, *Manual Therapy*, 2(1):72-79
- Rodriguez NR, DiMarco NM, Langley S 2010 Nutrition and athletic performance, *Medscape.com*, www.medscape.com/viewarticle/717046_6 (Accessed 30 December 2016)
- Sahu DP 2015 Comparative study on body segments and BMI between cricket players and hockey players, *International Journal of Physical Education, Sports and Health*, 1(3):6-9
- Sandenbergh R, Marais A 2006 Reliability of diagnostic tests in rotator cuff muscle pathology, *South African Journal of Physiotherapy*, 62(3):6 –12
- Sanders B, Blackburn TA and Boucher B 2013 Pre- participation screening- The Sports Physical Therapy perspective, *International Journal of Sports Physical Therapy*, 8(2):180-193
- Santos DA, Dawson JA, Matias CN, Rocha PM, Minderico CS, Allison DB, Sardinha, Silva AM 2014 Reference values for body composition and anthropometric measurements in athletes, *PLos One*, 9(5):e97846, doi:10.1371/journal.pone.0097846
- Sedgwick C 2009 Pre-season musculoskeletal screening, *Sportex Dynamics*, 22:7-11, www.sportex.net[Accessed 12 December 2015]
- Shrout PE, Fleiss JL, 1979 Intraclass correlations: Uses in assessing rater reliability, *Psychological Bulletin*, 86:420–428

Sim J, Wright CC 2005 The Kappa statistic in reliability studies: use, interpretation, and sample size requirements, *Journal of the American Physical Therapy Association and Royal Dutch Society for Physical Therapy* 85:257-268

Solem-Bertoft E, Thuomas KA, Westerberg CE 1993 The influence of scapular retraction and protraction on the width of the subacromial space. An MRI study, *Clinical Orthopaedics and Related Research*, 296:99-103

Somerville LE, Willits K, Johnson AM, Litchfield R, LeBel M, Moro J, Bryant D 2014 Clinical assessment of physical examination maneuvers for rotator cuff lesions, *The American Journal of Sports Medicine*, 42(8):1911–1919 Doi: 10.1177/0363546514538390

Strauts J, Tate K 2015 Exercise Highlight: Single leg Romanian deadlift and variations, *Journal of Australian Strength Conditioning*, 23(3):43-48

Stretch RA, Venter DJ 2003 Cricket injuries- a longitudinal study of the nature of injuries in South African cricketers, *British Journal of Sports Medicine*, 37: 250-253

Stuelcken M, Pyne D, Sinclair P 2007 Anthropometric characteristics of elite cricket fast bowlers, *Journal of Sports Science*, 25(14):1587-1597, doi: 10.1080/02640410701275185

Timmons MK, Lopes-Albers AD, Borgsmiller L, Zirker C, Ericksen J, Michener LA 2013 Differences in scapular orientation, subacromial space and shoulder pain between the full can and empty can tests, *Clinical Biomechanics*, 28(4):391-401

Tong HC, Heyman OG, Lado DA, Isser MM 2006 Interexaminer reliability of three methods of combining test results to determine side of sacral restriction, sacral base position and innominate bone position, *The Journal of the American Osteopathic Association*, 106:464-468

Van Mechelen W, Hlobil H, Kemper HC 1992 Incidence, severity, aetiology and prevention of sports injuries, A review of concepts, *Sports Medicine*, 14:82-99, <http://dx.doi.org/10.2165/00007256-199214020-00002> [Accessed 26 April 2016]

Viera AJ, Garrett JM 2005 Understanding Interobserver agreement: The Kappa Statistics, *Family Medicine*, 37(5):360–363

Weber MD, Woodall WR 1991 Spondylogenic disorders in gymnasts, *Journal of Orthopaedic Sports Physical Therapy*, 14:6-13

Weir MR, Smith DS 1989 Stress reaction for pars interarticularis leading to spondylolysis.

A cause of adolescent low back pain, *Journal of Adolescent Health Care*, 10(6):573-577

Whatman C, Hing W, Hume P 2011 Kinematics during lower extremity functional screening tests- Are they reliable and related to jogging? *Physical Therapy in Sport*, 12:22-29

Whatman C, Hume P, Hing W 2015 The reliability and validity of visual rating of dynamic alignment during lower extremity functional screening tests: a review of the literature, *Physical Therapy Reviews*, 20(3):210-224

Wiesel SW 2002 The dilemma of spondylolysis; inadequate evidence, poorly documented outcomes, *The Back Letter*, 17(4):37–45

Willson JD, Ireland ML and Davis I 2006 Core strength and lower extremity alignment during single leg squats, *Journal of the American College of Sports Medicine*, 945-952

Witvrouw E, Daneels L, Asselman P, D'Have T, Cambier D 2003 Muscle flexibility as a risk factor for developing muscle injuries in male professional soccer players. A prospective study, *American Journal of Sports Medicine*, 31:41-46

Zetou E, Vernadakis N, Tsetsedi M, Kampas A, Michalopoulou M 2012 The effect of coordination training program on learning tennis skills, *The Sport Journal*, www.thesportjournal.org (ISSN:1543-9518), [Accessed 27 November 2016]

APPENDIX 1

DATA COLLECTION FORM

RATER1		RATER2	
--------	--	--------	--

Participant Number: _____

Group:

Test	Order in which test is performed	Trial	Finding
One-legged Hyperextension Left (Yes/ No)	1.1.		
One-legged Hyperextension Right (Yes/ No)	1.2.		
Bridging Hold Left (seconds)	2.1.		
Bridging Hold Right (seconds)	2.2.		
747 balance test Left (seconds)	3.1.		
747 balance test Right (seconds)	3.2.		
Empty Can Test (Yes/ No)	4.1		
Full Can Shoulder Impingement test (yes/ no)	4.2		

Standing Stork Test Left (moves caudal/ no movement)	5.1.		
Standing Stork Test Right (moves caudal/ no movement)	5.2.		

APPENDIX 2

INFORMATION DOCUMENT FOR WITS SPORTS ADMINISTRATION

Dear Colleagues

I, Nosipho Portia Zumana, am a 2nd year Master's student in Physiotherapy at the University of Witwatersrand. As part of my studies I am doing research on the reliability of pre-participatory screening tests used in sports.

I would like to request your permission to gain access and to invite the Wits Cricket Club to participate in this research study.

The importance of this study

Screening tests form an integral part of elite sporting codes including cricket. Studies have shown that early identification of risk of injury allows for early intervention through secondary injury prevention programmes aimed at reducing the risk of injury. Screening tests are commonly used to identify injury risk.

The aim of this study is to determine the intra- and inter-rater reliability of five screening tests commonly used as part of cricket screening tools. This means that the researcher would like to determine the degree of agreement observed when a measurement of a test is repeated under identical conditions by the same rater (intra-rater) and that the measurement taken by different raters is consistent and raters adhere to the same standards (inter-rater). There is no direct benefit to participate in this study, however once the reliability has been established, the study findings will assist the therapist's clinical decision making process when considering which tests to include in the pre-participatory screening tools and this could lead to the development of standardised musculoskeletal screening in cricket and sport in general.

What are the participants expected to do?

Should the participant agree to participate in this study, he will be placed into one of two groups. He will be asked to perform five pre-participatory screening tests under the guidance of two experienced physiotherapists. The tests will be performed randomly at the discretion of the physiotherapist. There will be videos and photos taken during the study. The participant's identity will remain protected. The study will take approximately

90minutes of your time.

Participation is voluntary and refusal to participate will not have any negative consequences. Video shooting and photo taking is also voluntary and refusal to be videotaped will not have any negative consequence. The participants may withdraw from the study at any time without fear of suffering any negative repercussions.

What are the risks in taking part in this study?

There are no additional risks other than the normal risks which players are exposed to when going through the screening process. Each participant will receive feedback on their performance, especially noting any risks. There is no monetary reward for participating in this study.

Confidentiality

To ensure confidentiality of participants is maintained, study numbers will be used instead of participant names. Each player will be assigned a study number. The key to these study numbers will be kept in the possession of the researcher only. Participants are to write only their names in the consent form that will be provided.

Information obtained from participants will be used only for the purpose this study is intended for.

More information requests

Should you have any questions or need more information, I am readily available to clarify any queries and handle your concerns. Alternatively you can contact me on 073 3390145 or email me at nosiphozumana@yahoo.com.

Should you have any ethical related concerns, please contact Professor Cleaton Jones on 011-717 2700 at the Human Research Ethics Committee of the University of Witwatersrand..

If you are willing to grant permission for the Wits Cricket Club players to participate in this study, kindly complete and sign the attached consent form.

Kind Regards

NosiphoZumana

APPENDIX 3

CONSENT FORM FOR WITS SPORTS ADMINISTRATION

Kindly complete and sign below.

I, _____, hereby give permission to allow access to Wits Cricket Club players based on the information provided in the information sheet.

I understand what is expected of the players and agree to grant access for players to be invited to participate in the screening tests research to be conducted.

I understand that I am not obliged to agree and can withdraw permission at any point.

Signature : _____

Witness : _____

Date : _____



ADRIAN CARTER

Head of Sport

Tel :011- 717 9419e-mail : adrian.carter@wits.ac.za



WITS
UNIVERSITY

20 July 2015

Dear Nosipho Zumana,

Many thanks for considering one of our sporting clubs to assist with your research.

I have consulted with our head coach and he is more than willing to have you assess his players, I therefore give you permission to contact Neil Levenson to make the necessary arrangements to carry out these assessments.

His contact details are as follows:

Neil Levenson

011 717-9435

082 301-9414

Neil.levenson@wits.ac.za

Wishing you every success in your endeavours.

Kind regards,

A handwritten signature in dark ink, appearing to read 'Adrian Carter'.

ADRIAN CARTER

HEAD OF SPORT

APPENDIX 4

CONSENT FORM FOR CLUB MANAGER

Kindly complete and sign below.

I, _____, hereby give permission to allow Wits Cricket Club players to take part in this study based on the information provided in the information sheet.

I understand what is expected of the players and agree to allow them to participate in the screening tests research to be conducted.

I understand that I am not obliged to agree and can withdraw permission at any point.

Signature : _____

Witness : _____

Date : _____

APPENDIX 5



R14/49 Ms Nosipho Portia Zumana

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150626

NAME: Ms Nosipho Portia Zumana
(Principal Investigator)

DEPARTMENT: Physiotherapy
University of the Witwatersrand Sports Ground

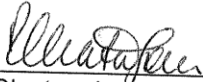
PROJECT TITLE: The Reliability of the Pre-Participatory Screening
Tests used in Cricket

DATE CONSIDERED: 26/06/2015

DECISION: Approved unconditionally

CONDITIONS:

SUPERVISOR: Dr Benita Olivier and Mr Lonwabo Godlwana

APPROVED BY: 
Professor P Cleaton-Jones, Chairperson, HREC (Medical)

DATE OF APPROVAL: 27/07/2015

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 Secretary in Room 10004, 10th floor, Senate House, University.
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.**

Principal Investigator Signature _____

Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

APPENDIX 6

INFORMATION DOCUMENT FOR PARTICIPANTS

Dear Player

I, Nosipho Portia Zumana, am a 2nd year Master's student in Physiotherapy at the University of Witwatersrand. As part of my studies I am doing research on the reliability of pre-participatory screening tests used on sports participants.

I would like to invite you to participate in this research study.

The importance of this study

Screening tests form an integral part of elite sporting codes including cricket. Studies have shown that early identification of risk of injury allows for early intervention through secondary injury prevention programmes aimed at reducing the risk to injury. Screening tests are commonly used to identify injury risk.

The aim of this study is to determine the intra- and inter-rater reliability of five screening tests commonly used as part of cricket screening tools. This means that the researcher would like to determine the degree of agreement observed when a measurement of a test is repeated under identical conditions by the same rater (intra-rater), that the measurement taken by different raters is consistent and that raters adhere to the same standards (inter-rater). There is no direct benefit to participate in this study, however once the reliability has been established, the study findings will assist the therapist's clinical decision making process when considering which tests to include in the pre-participatory screening tools and this could lead to the development of standardised musculoskeletal screening in cricket and sport in general.

What are you, the participant, expected to do?

Should you agree to participate in this study, you will be divided into one of two groups. You will be asked to perform five pre-participatory screening tests under the guidance of two experienced physiotherapists. The tests will be performed randomly at the discretion of the physiotherapist. There will be videos and photos taken during the study. As a participant, your identity will remain protected. The study will take approximately 90 minutes of your time.

Participation is voluntary and refusal to participate will not have any negative consequences. Video shooting and photo taking is also voluntary and refusal to be videotaped will not have any negative consequences. You may withdraw from the study at any time without fear of suffering any negative repercussions.

What are the risks of taking part in this study?

There are no additional risks that you will be exposed to other than the normal risks you are exposed to when undergoing your yearly screening procedure. Each participant will receive feedback on their performance, especially noting any risks. There is no monetary reward for participating in this study.

Confidentiality

To ensure confidentiality of participants is maintained, study numbers will be used instead of participant names. Each player will be assigned a study number. The key to these study numbers will be kept in the possession of the researcher only. Participants are to write their names only in the consent form attached.

Information obtained from participants will be used only for the purpose this study is intended for.

More information requests

Should you have any questions or need more information, I am readily available to clarify any queries and handle your concerns. Alternatively you can contact me on 073-3390145 or email me at nosiphozumana@yahoo.com.

Should you have any ethical related concerns, please contact Professor Cleaton Jones on 011-7172700 at the Human Research Ethics Committee of the University of Witwatersrand..

If you are willing to participate in this study, kindly complete and sign the attached consent form.

Kind Regards

NosiphoZumana

APPENDIX 7

CONSENT FORM FOR PARTICIPANTS

Kindly complete and sign below.

I, _____, hereby give permission to take part in this study based on the information provided in the information sheet.

I understand what is expected of me and agree to participate in the research to be conducted on screening tests.

I understand that I am not obliged to take part in this study and can withdraw at any point.

Signature : _____

Witness : _____

Date : _____

For Official Use:

Participant Number: _____

APPENDIX 8

CONSENT FORM FOR SHOOTING VIDEO AND TAKING PHOTOS OF PARTICIPANTS

Kindly complete and sign below.

I, _____, hereby give permission for the shooting of the video and taking photos in this study based on the information provided in the information sheet.

I understand that my identity will remain protected throughout the research.

I understand that I am not obliged to take part in this study and can withdraw at any point.

Signature : _____

Witness : _____

Date : _____

For Official Use:

Participant Number: _____

APPENDIX 9

CONSENT FORM FOR PARENTS/ GUARDIAN OF PARTICIPANT UNDER 18years OF AGE

Kindly complete and sign below.

I, _____, hereby give permission for my son to take part in this study based on the information provided in the information sheet.

I understand what is expected of my son and agree to let him participate in the research to be conducted on screening tests.

I understand that he is not obliged to take part in this study and can withdraw at any point.

Signature : _____

Witness : _____

Date : _____

For Official Use:

Participant Number: _____

APPENDIX 10

ASSENT FORM FOR PARTICIPANTS UNDER 18years OF AGE

Kindly complete and sign below.

I, _____, hereby give permission to take part in this study based on the information provided in the information sheet.

I understand what is expected of me and agree to participate in the research to be conducted on screening tests.

I understand that I am not obliged to take part in this study and can withdraw at any point.

Signature : _____

Witness : _____

Date : _____

For Official Use:

Participant Number: _____

APPENDIX 11

TURNITIN REPORT

% **16** SIMILARITY INDEX

% **12**
INTERNET SOURCES

% **7**
PUBLICATIONS

% **6**
STUDENT PAPERS