The influence of proprioception, balance and plyometric strength on the occurrence of lower leg injuries in schoolboy rugby players

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"If you eliminate the impossible, whatever remains, however improbable, must be the truth" Sherlock Holmes

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SUMMARY

Keywords: Lower Leg Injuries; Proprioception; Balance; Plyometric Strength; Schoolboy rugby players.

Background: Rugby injuries are a common phenomenon. The aim of medical professionals is to treat these injuries to the best of their abilities, and if possible, to help prevent their occurrence. Bahr and Holme (2003) argue that sports participation carries with it a risk of injury, with the even more weighty issue that it might later even lead to physical disability. Junge, Cheung, Edwards and Dvorak (2004) recommends the development and implementation of preventative interventions to reduce the rate and severity of injuries in Rugby Union. The Medical and Risk Management Committee of USA Rugby (2003) also reports that the key to preventing injuries in any sport is identifying and addressing the risk factors associated with it. Various studies have identified weakness in plyometric strength, proprioception and balance as causes of lower leg and ankle injuries (Margison, Rowlands, Gleeson and Eston, 2005; Stasinopoulos, 2004; Verhagen, Van der Beek, Twisk, Bahr and Mechelen, 2004; Baltaci & Kohl, 2003; Murphy, Connoly and Beynnon, 2003; Moss, 2002; Anderson).

Aims: The aim of this study was to investigate the influence of proprioception, balance and plyometric strength on the occurrence of lower leg injuries in schoolboy rugby players. A further aim was to develop a preventative training programme to address these variables, should they prove to have an influence

on lower leg injuries. The possible inclusion of these tests in talent identification test batteries will also be examined.

Design: A prospective cohort study.

Subjects: A group of 240 schoolboys in U/14, U/15, U/16 and U/18 age groups in two schools (Hoër Volkskool Potchefstroom ("Volkskool") and Potchefstroom Boys High School ("Boys High")) in the North West Province of South Africa was used as the test cohort.

Method: At the beginning of the 2006 rugby season all players were tested for proprioception, balance and plyometric strength. These tests were conducted using a computerised tilt board for proprioceptive testing; Star Excursion Balance Test for Balance and an electronic timing mat for plyometric strength. During the season, weekly injury clinics were held at both schools to document all injuries that occurred following the preceding weekend's matches. A statistical analysis was done on all the data collected from the test batteries and injury clinics. Descriptive statistics (means, standard deviation, minimum and maximum) were used as well as practical significant differences (d-values) (Cohen, 1988). The ratios for left and right leg plyometric strength to bilateral plyometric strength (L+R/Bil) and individual left and right leg plyometric strength to bilateral plyometric strength (L/Bil and R/Bil) were also calculated.

Results: A profile of proprioception, balance and plyometric strength was compiled for schoolboy rugby players using the test data. The U/18 players generally

had the best test results of all the age groups, outperforming U/14, U/15 and U/16 players with most tests. U/15 players outperformed both U/14 and U/16 players. Backline players performed better than loose forwards and forwards in plyometric tests in most age groups. Loose-forwards also outperformed tight-forwards with plyometrics at most age groups. At U/15 and U/16 level, tight-forwards slightly outperformed loose-forwards with Star Excursion Balance Tests. Generally, A-teams performed better than B-teams with all the tests except L+R/Bil; L/Bil and R/Bil. The difference between the teams, however, only had a small to medium effect and cannot be considered practically significant. At U/14 and U/15 levels, there were more practically significant differences between the A- and B-teams, with A-teams outperforming B-teams. The tests could have some value for talent identification at this age level.

A rugby epidemiological study was done on the data collected in the weekly injury clinics. This study recorded 54 injuries at the two schools involved during the 2006 season from April to July. Two hundred and forty players were involved in 10890 hours of play. Eight thousand nine hundred and ten of these player hours were practices and 1980 were match hours. These injuries occurred at a prevalence rate of 4.96/1000 player hours. Match injuries accounted for 77.78% of all injuries with training sessions resulting in the remaining 22.22% of injuries, with a match injury rate of 1 injury per individual player every 3.14 matches. U/14 players showed an overall match injury rate of 11.11/1000 match hours. U/15 players showed a rate of 2.47/1000 match hours. The low rate may be attributed to underreporting of injuries by the U/15 players. U/16 players showed a rate of 22.33/1000 hours, while U/18 players showed an exceptionally high rate of 45/1000 match hours. The tackle

situation was responsible for the highest percentage of injuries (57.14%). Boys High presented with more injuries (57.4%) than Volkskool at a higher prevalence rate (5.60/1000 player hours). In a positional group comparison, backline players presented with 51.85% of injuries. Since backline players only present 46.7% of players in a team, this shows that backline players have a higher risk of injury. A-team players presented with 66.6% of injuries at a prevalence rate of 6.37/1000 player hours. B-team players had an injury rate of 3.43/1000 player hours.

The test values for the players suffering lower leg injuries were compared to those for uninjured players. There were eight players with nine lower leg injuries: one player had injuries of both legs. Six of the injuries were intrinsic of nature and two players had extrinsic injuries. Test values for all five tested players with intrinsic injuries were weaker by a high practically significant margin for the L+R/Bil ratio.

Conclusion: L+R/Bil proved to be the test result with the most influence on the occurrence of intrinsic lower leg injuries. When the individual test results for the players with intrinsic injuries are compared to the percentiles for all players, it becomes visible that the injured players fall in the 20th percentile for both L+R/Bil and Injured leg/Bil ratios. These 20th percentile values could thus be used as a standard for determining the possible occurrence of intrinsic lower leg injuries. These 20th percentile values are 1.012 for R+L/Bil ratios; 0.483 for L/Bil ratios and 0.492 for R/Bil ratios.

This study shows that plyometric ratios for L+R/Bil, L/Bil and R/Bil have an influence on lower leg injuries in schoolboy rugby players. Proprioception and

balance did not have any practically significant effects on the occurrence of these injuries. A preventative training programme was also designed following a study of the literature, combined with these results. The tests could also possibly be integrated in talent identification test batteries at U/14 and U/15 level.

OPSOMMING

Sleutelwoorde: Onderbeenbeserings; Propriosepsie, Balans; Plofkrag; Skoolrugbyspelers.

Agtergrond: Rugbybeserings is 'n algemene verskynsel. Die mediese professies moet hierdie beserings na die beste van hulle vermoëns behandel en indien moontlik te help voorkom. Bahr en Holme (2003) was van mening dat sportdeelname 'n sekere mate van risiko op besering het, met die selfs ernstiger knelpunt dat dit moontlik later tot fisiese ongeskiktheid kan lei. Junge *et al.* (2004) beveel die ontwikkeling en implementering van voorkomende intervensies aan om die voorkoms en erns van rugbybeserings te verminder. Die Mediese en Risikobestuurkomitee van die Verenigde State Rugbyraad (USA Rugby, 2003) beskou die identifisering en aanspreek van risikofaktore van sport as die sleutel tot die voorkoming van beserings in enige sport. Verskeie studies het swakhede in plofkrag, propriosepsie en balans geïdentifiseer as oorsake van onderbeen- en enkelbeserings (Baltaci & Kohl, 2003; Stasinopoulos, 2004; Verhagen *et al.*, 2004; Murphy *et al.*, 2003, Margison *et al.*, 2005; Moss, 2002).

Doelwitte: Die doel van die studie was om die invloed van propriosepsie, balans en plofkrag op die voorkoms van onderbeen beserings in skool rugby spelers te ondersoek. 'n Verdere doelwit was om 'n voorkomende oefenprogram vir die veranderlikes te ontwerp na aanleiding van die resultate, sou dit blyk om 'n invloed te hê op onderbeen beserings. Die moontlike insluiting van die toetse in talentidentifikasie toetsbatterye is ook ondersoek.

Ontwerp: 'n Prospektiewe toetsgroepstudie

Ondersoekpopulasie: 'n Groep van 240 skoolseuns in die O/14-, O/15-, O/16- en O/18- jaar ouderdomsgroepe in twee skole (Hoër Volkskool Potchefstroom ("Volkskool") en Potchefstroom Boys High School ("Boys High")) in die Noordwes provinsie van Suid Afrika is gebruik as toetsgroep.

Metode: Aan die begin van die 2006-rugbyseisoen is alle spelers getoets vir propriosepsie, balans en plofkrag. Die toetse is uitgevoer deur gebruik te maak van 'n gerekenariseerde tiepbord vir propriosepsie-toetsing, die "Star Excursion Balance Test" vir balanstoetsing en 'n elektroniese tydberekeningsmat vir plofkrag. Deur die loop van die seisoen is weeklikse beseringsklinieke gehou by beide skole om beserings te dokumenteer wat voorgekom het na die vorige naweek se wedstryde. 'n Statistiese ontleding is gedoen op die data wat ingesamel is uit die toetsbatterye en beseringsklinieke. Beskrywende statistiek (mediane, standaard-afwyking, minimum en maksimum waardes) is gebruik, asook prakties beduidende verskille (d-waardes) (Cohen, 1988). Die verhoudings van linker- en regterbeen plofkragwaardes tot bilaterale plofkragwaardes (L+R/Bil) en linker- en regterbeen individuele plofkragwaardes tot bilaterale plofkragwaardes (L/Bil en R/Bil) was ook bereken.

Resultate: 'n Profiel van propriosepsie, balans en plofkrag is saamgestel vir skoolrugbyspelers uit die resultate van die toetsdata. Die O/18-spelers het oor die algemeen die beste toetsresultate uit al die groepe gehad. Die O/15-spelers het beter presteer as beide die O/14- en O/16-groepe. Agterlynspelers het in alle

ouderdomsgroepe beter resultate as losvoorspelers en vaste voorspelers vertoon in plofkragtoetse. Losvoorspelers het ook in meeste ouderdomsgroepe beter gevaar met plofkragtoetse as vaste voorspelers. Op O/15- en O/16-vlak het vaste voorspelers beter presteer as losvoorspelers met die "Star Excursion Balance Tests". A-spanne het in die algemeen beter presteer as B-spanne met alle toetse, behalwe L+R/Bil; L/Bil en R/Bil. Die verskil tussen die spanne het egter net 'n klein tot medium effek gehad op praktiese beduidendheid. Op O/14 en O/15 vlakke was daar meer prakties beduidende verskille met hoë effek tussen A- en B-spanne, met A-spanne wat beter presteer het. Die toetse kan moontlik van waarde wees vir talentidentifisering op hierdie ouderdomsvlak.

'n Rugby-epidemiologiese studie is ook gedoen op die data wat tydens die weeklikse beseringsklinieke gekollekteer is. Die studie het 54 beserings gedokumenteer by die twee betrokke skole in die 2006 seisoen van April tot Julie. Tweehonderd en veertig spelers was betrokke by 10890 ure van spel. Agtduisend negehonderd en tien van die ure was tydens oefeninge en 1980 was wedstrydure. Hierdie beserings het voorgekom teen 'n insidensie tempo van 4.96/1000 speler-ure. 77.78% van beserings was in wedstryde en die oorblywende 22.22% in oefeninge. Die wedstryd beseringstempo was 1 besering per speler elke 3.14 wedstryde. O/14-spelers het 'n wedstrydbeseringstempo van 11.11/1000 wedstrydure getoon. Die O/15-spelers het 'n beseringstempo van slegs 2.47/1000 wedstrydure getoon. Hierdie lae tempo is moontlik toe te skryf aan die onderrapportering van beserings deur die O/15-spelers. Die O/16-spelers het 'n beseringstempo van 22.33/1000 wedstrydure getoon en O/18 spelers 'n buitengewone hoë beserings tempo van 45/1000 wedstrydure. Die laagvatsituasie was verantwoordelik vir die hoogste presentasie van beserings

(57.14%). Boys High het met meer beserings gepresenteer (57.4%) teen 'n hoër insidensietempo (5.60/1000 spelerure) as Volkskool. In 'n vergelyking van die posisionele groepe het agterspelers gepresenteer met 51.85% van beserings. Aangesien agterspelers slegs 46.7% van spelers in die span uitmaak, wys dit dat hulle 'n hoër beseringsrisiko het. A-span spelers het 66.6% van die beserings getoon teen 'n besringstempo van 6.37/1000 spelerure. B-span spelers het 'n beseringstempo van 3.43/1000 speler ure getoon.

Die toetswaardes vir die spelers wat onderbeenbeserings ondervind het is ook vergelyk met dié van die onbeseerde spelers. Daar was agt spelers met nege onderbeenbeserings; een speler het beserings aan beide onderbene gehad. Ses beserings was intrinsieke beserings en twee spelers het ekstrinsieke beserings gehad. Toetswaardes vir die vyf getoetste spelers met intrinsieke beserings was hoog prakties beduidend swakker vir die L+R/Bil-verhouding.

Gevolgtrekking: Die L+R/Bil-verhouding het getoon dat dit die toetswaarde was met die grootste invloed op intrinsieke onderbeenbeserings. Wanneer die individuele resultate van die spelers met intrinsieke beserings vergelyk word met die persentiele van al die spelers, kan gesien word dat die beseerde spelers almal in die 20ste persentiel val vir beide L+R/Bil en (Beseerde been)/Bil-plofkragverhoudings. Die 20ste persentielwaardes kan dus gebruik word as 'n standaard om die moontlike voorkoms van intrinsieke onderbeenbeserings te bepaal. Die 20ste persentiel waardes is 1.012 vir die R+L/Bil-verhouding; 0.483 vir die L/Bil-verhouding en 0.492 vir die R/Bil-verhouding.

Die studie bewys dat plofkragverhoudings van L+R/Bil, L/Bil en R/Bil 'n invloed het op die voorkoms van onderbeenbeserings in skool rugbyspelers. Propriosepsie en balans het nie enige praktiese beduidende effekte op die voorkoms van onderbeen beserings getoon nie. 'n Voorkomende oefenprogram is ook ontwerp aan die hand van die resultate en bestaande literatuur. Die toetse kan ook moontlik geïntegreer word in talentidentifikasie toetsbatterye op O/14- en O/15-ouderdomsvlakke.

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LIST OF ABBREVIATIONS

BH	**Boys High**
CPR	**Cardio Pulmonary Resuscitation**
L/Bil	**Left leg plyometric to Bilateral plyometric Ratio**
L+R/Bil	**Left plus Right leg plyometric to Bilateral plyometric ratio**
LCL	**Lateral Collateral Ligament**
IP	**Interphalangeal**
MCL	**Medial Collateral Ligament**
NAIRS	**National Injury Registration System**
NZ$	**New Zealand Dollar**
R	**Rand**
R/Bil	**Right leg plyometric to Bilateral plyometric Ratio**
SEBT	**Star Excursion Balance Test**
TMT	**Tarso Metatarsal**
U/10	**Under 10 year old**
U/11	**Under 11 year old**
U/12	**Under 12 year old**
U/13	**Under 13 year old**
U/14	**Under 14 year old**
U/15	**Under 15 year old**
U/16	**Under 16 year old**
U/17	**Under 17 year old**
U/18	**Under 18 year old**
U/19	**Under 19 year old**
UK	**United Kingdom**
USA	**United States of America**
VS	**Volkskool**

CHAPTER 1

INTRODUCTION AND PROBLEM STATEMENT

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CHAPTER 1

INTRODUCTION AND PROBLEM STATEMENT

1.1 INTRODUCTION

Injuries in every kind of sport are a common phenomenon. One of the aims of medical professionals is to treat these injuries to the best of their abilities and if possible, to prevent these injuries from occurring. Schoolboy rugby in South Africa is no exception. Roux, Goedeke, Visser, Van Zyl and Noakes (1987:308) report that 1 injury occurs for every 142 boy-hours of match play (7.04 per 1000 hours). These figures were also subject to a 43% under-reporting of injuries (thus actually 10.06 per 1000 hours of play). The incidence during practice was 1 injury for every 1825 boy-hours of play (0.548 per 1000 hours). Of the total amount of injuries, 37% was of the lower limb (3.72 per 1000 hours of play). Nathan, Goedeke and Noakes (1983:135) show that 25.3% of injuries that occurred at a single South African school in the 1982 season were of the lower limb.

Research by Rotem and Davidson (2001) conducted over a 30 year period found an acute injury occurrence of 18.8/1000 hours of rugby play as reported by a casualty station at Newington College in Australia. Of these, 4.72 injuries/1000 hours of play were of the lower limb and 2.03 injuries/1000 hours were of the lower leg, ankle and foot. In a study of 18 years of acute injuries at the same school from 1969 to 1986 an incidence of 17.6 injuries/1000 hours of play was reported by Davidson (1987). 26.2% of these injuries (4.61/1000 hours) were of the lower limb.

It is thus imperative that injury prevention strategies be created to decrease the amount of injuries sustained in a thousand hours of play and to increase the amount of participation.

A good way to develop power and prevent re-injury or any injury at all is to use plyometric methods (Moss, 2002; Brukner & Kahn, 2001:101). Research published in the Journal of Strength and Conditioning explains that plyometric exercise made runners faster and improved their running economy (Eck, 2003). Plyometrics also enhance the athlete's ability to develop power. This leads to improvements in performance and rehabilitation (Chu, 1999).

Malliou, Gioftsidou, Paes, Beneka and Godolias (2004) found that the application of a specific balance training programme on healthy young soccer players can improve their proprioception and prevent lower limb injuries. A proprioceptive balance board training programme was also shown to be effective in preventing recurrence of ankle injuries in volleyball players (Verhagen *et al.*, 2004). Clinically important improvements in static and dynamic balance as well as reduction in self-reported athletic injuries over 6 months among high school students participating in a regular physical education programme who used a simple 6-week home-based proprioceptive balance training programme was also found by Emery, Cassidy, Klassen, Rosychuk and Rowe (2005). The findings of Rothermel, Hal, Hertel and Denegar (2004) supported the effectiveness of traditional balance training in healthy subjects as well. Little research has been conducted on the influence of balance on schoolboy rugby injuries.

It is generally agreed that, under normal conditions, the somatosensory and visual subsystems are the primary mediators of balance and postural awareness (Lephart, Swanik & Boonriong, 1998). The somatosensory system is often referred to as proprioception. Balance and proprioception are usually addressed together when it comes to rehabilitation.

1.2 PROBLEM STATEMENT

No studies have been done to investigate the influence of proprioception, balance and plyometric strength on the occurrence of lower leg injuries. Proprioceptive, balance and plyometric testing will be combined to form a test battery, which will then be used to test a cohort of schoolboy rugby players and to determine whether these parameters have any influence on the occurrence of lower leg injuries through the rugby season.

1.3 AIM

1. To determine the influence of proprioception, balance and plyometric strength on the incidence of lower leg injuries in schoolboy rugby players.
2. To create a suitable training programme to address these parameters if they prove to have an influence on lower leg injuries.
3. To determine whether proprioception, balance and plyometric testing could be integrated into existing test protocols as a rugby talent identification measure.

1.4 METHOD

1.4.1 Literature Review

To find literature relevant to the subject, searches were conducted using the following media as well as sports and sport medical journals:

- Internet
- EbscoHost (Academic Search Elite)
- Eric (Psychological database)
- Sabinet
- South African Journals
- Medline
- Pubmed
- Science Direct
- Sportdiscus

A manual search of the North-West University, Potchefstroom Campus, library computer catalogue was performed to find relevant books on the subject.

1.4.2 Empirical Investigation

1.4.2.1 Research Design

A prospective cohort study was used, which involves that a group of people is chosen who do not have the outcome of interest (in this study, lower leg injuries). The investigator then measures a variety of variables that might be relevant to the development of the condition (proprioception, balance and plyometric strength). Over a period of time the people in the sample are observed to see whether they develop the outcome of interest (that is, clinics that monitor injuries) (Mann, 2003).

1.4.2.2 Choice of Subjects

240 Schoolboy rugby players (U/14 A + B, U/15 A + B, U/16 A + B, U/18 A + B Teams) of two schools (Hoër Volkskool Potchefstroom ("Volkskool") and Potchefstroom Boys High School ("Boys High")) were used as subjects in this study. These 2 schools play in the same league, and are of similar size and rugby playing strength. Both schools are well known, strong rugby schools.

1.4.2.3 Procedures and Methods of Data Collection

Permission was obtained from the school principles as well as the parents or legal guardians of the players involved in the study before commencement. All the players were tested for balance, proprioception and explosive jumping strength by a qualified physiotherapist at the beginning of the rugby season in March 2006. An injury history questionnaire was completed prior to commencement of the physical testing. This questionnaire was only used to determine whether players had any current injuries which would exclude them from testing, as research by Grabbe, Finch, Benneli and Waiswelner (2003) shows that self-reported retrospective injury data are unlikely to provide a detailed enough description of injury patterns to be used for epidemiological research. There is also an underreporting of injuries.

All injuries sustained by the players during the season were evaluated by a qualified physiotherapist at a free sports clinic once a week. This decision is based on the findings of Roux *et al.* (1987) that monitoring rugby injuries through correspondence leads to underreporting of such injuries. Injuries evaluated at these clinics were carefully recorded. The amount of exposure to play and practice sessions of all the players was also recorded for statistical purposes.

At the end of the season, in July 2006, a statistical analysis was done of all injuries sustained by the players in the two different schools during the season and expressed as a ratio of the amount of injuries per 1000 hours of play. The lower leg injuries in this injury analysis were compared to pre-season proprioception, balance and plyometric test values in these schoolboy rugby players. Conclusions were then drawn regarding the influence of the test values of plyometric strength proprioception and balance on the occurrence of these injuries. This is similar to the research design of Trojian and McKeag (2006) who investigated the influence of a pre-season single leg balance test on subsequent ankle injuries during the athletic season and research by Wang, Chen, Shiang, Jan and Lin (2006), who did pre-season testing of ankle strength, single leg postural sway and ankle dorsiflexion range and then analysed these test results to note any correlation with ankle injuries during a high school basketball season.

A sub-aim was to note whether the obtained test values differed significantly between A and B teams and whether the tests could then be integrated as part of a rugby talent identification test battery.

1.4.2.3.1 Test Battery

1.4.2.3.1.1 Balance Test: Star Excursion Balance Test

Balance testing was done using the Star Excursion Balance Test (SEBT). This test is used widely for the testing of dynamic postural control (Gribble, 2003). The SEBT is performed with the participants standing in the middle of a grid formed by eight lines extending out at 45° angles from each other. The participant is then asked to reach as far as possible along each of the eight lines, make a light touch on the line, and return

the reaching leg back to the centre, while maintaining a single-leg stance with the other leg in the centre of the grid and then return to a double-leg stance without allowing the contact to affect overall balance. The terminology of excursion directions is based on the direction of reach in relation to the stance leg. When reaching in the lateral and posterolateral directions, participants must reach behind the stance leg to complete the task. Participants were allowed to practice reaching in each of the eight directions six times before commencement of the testing (Gribble & Hertel, 2003:92).

Subjects had to reach in each of the eight directions once and the distance was then recorded by measuring the distance with a ruler.

1.4.2.3.1.2 Computerised Proprioception Test

The computerised balance test provides an indication of balance function by measuring the duration that the edges of a tilt board can be maintained off the ground. The test was conducted with eyes closed to eliminate the visual components of balance and to focus more on the proprioceptive feedback by the lower limb joints to the brain (Techno Therapy, 1992:14).

The results of the test were expressed as a percentage of the total time (30 seconds) that the balance board sides could be kept off the ground. An acceptable general score with open eyes is usually 75% but top sportsmen should get scores above 80% for an acceptable score. An acceptable score with the eyes closed is between 50% and 60%. Athletes should attain values between 60% and 70%. (Techno Therapy, 1992:14).

1.4.2.3.1.3 Plyometric Test

A plyometric test was conducted using a computerised vertical jump test. This test measures the distance a player can leap straight into the air with his hands on his hips by measuring the time he is airborne. This was conducted with both legs together as well as with separate legs and was recorded as the height jumped in centimetres. The player stands on a Tapeswitch sensory mat which is connected to a Psion handheld computerised organiser. When the player's feet leave the sensory mat upon jumping, the Psion organiser determines the elapsed time spent in the air and converts this to a height measurement in centimetres.

1.4.2.3.2 Statistical data processing

Statistical software was used for data analysis. Descriptive statistics (means and standard deviation) was used as well as practical significant differences (d-values) (Cohen, 1988). The influence of initial test values on lower leg injuries was described, and statistical differences between A and B team players were also explored. A detailed analysis was done of all injuries sustained during the season, with special focus on lower leg injuries. Injuries were expressed as the amount of injuries occurring in 1000 playing hours. This method of expression is widely used in injury statistics (Malliou *et al.*, 2004; Verhagen *et al.*, 2004; Rotem & Davidson, 2001; Roux *et al.*, 1987). If statistics taken from Roux *et al.* (1987) are integrated into the 240 players in this study, each playing 4.5 hours of rugby per week in a 10 week season, there should be approximately 40.1 lower limb injuries in the 10 800 playing hours during the season.

1.5 SUMMARY

This chapter gave a short introduction and overview of the research into the influence of proprioception, balance and plyometric strength in schoolboy rugby players on the occurrence of lower leg injuries. An overview of how the literature was found and the empirical investigation was discussed. The statistical method was also discussed briefly.

CHAPTER 2

LITERATURE REVIEW: RUGBY EPIDEMIOLOGY

2.1 INTRODUCTION

2.2 BRIEF HISTORY OF RUGBY

2.3 DEFINING AN INJURY

2.4 RUGBY INJURIES

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2.6 PREVALENCE RATE OF INJURIES

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2.10 SUMMARY

CHAPTER 2

LITERATURE REVIEW: RUGBY EPIDEMIOLOGY

2.1 INTRODUCTION

The prevention of sports injuries should be on the forefront of research into the subject, as prevention is always better than cure. It is generally much harder to treat an existing sports injury than it is to take preventative measures to prevent it from happening in the first place. Junge *et al.* (2004:168) points out that: "it is commonly accepted that sport is beneficial for physical and mental health, but it is also associated with a certain risk of injury".

Numerous injuries occur every year with sport as the main cause. This results in decreased physical activity and work time lost in addition to medical costs (Murphy, Connoly & Beynnon, 2003). Babić, Mišigoj-Duraković, Matasić and Jančić (2001) also indicate that sports injuries are an important source of health care costs in developed countries. In a study by Dixon (1993), it was found that in New Zealand, rugby injuries reported to accident and emergency departments at public hospitals; in-patient costs and claims from the Accident Rehabilitation & Compensation Insurance Corporation amounted to NZ$19 270 538 in the 1990 rugby season. Upton (1999) estimates that there were 91 276 injuries in the South African rugby playing population in 1999. The average cost of a single injury was estimated at R1 318. The total cost of these 1999 rugby injuries accumulated to R126 633 344. Bahr and Holme (2003) argue that sports participation carries with it a risk of injury, with the even more serious issue that it might later lead to physical disability.

This chapter deals with literature focusing on rugby, rugby history, rugby injuries and prevalence rates as well as existing strategies for injury prevention. It creates a background and motivation for this study.

2.2 BRIEF HISTORY OF RUGBY

Many believe that rugby was born in 1823 when William Webb Ellis "with fine disregard for the rules of football (soccer) as played in his time, first took the ball in his arms and ran with it, thus originating the distinctive feature of the Rugby game"(Rugby Football History, 1998). Although it is worth pointing out that this is *apocryphal* as there is little in the way of evidence to substantiate this view it is, however the popular view: so much so, in fact, that the international committee named the Rugby World Cup Trophy the "William Webb Ellis Trophy" (Rugby Football History, 1998).

According to Dobson and Van der Merwe, as quoted in Noakes and Du Plessis (1996:10), it is probable that the origins of all ball games played by teams on fields between goal posts, including rugby, soccer and hockey, can be traced to a common medieval English ancestor. In this ancestral "game", residents of neighbouring villages would gather at a convenient site approximately halfway between their respective villages. The aim of their game was to transport the object of the game, a ball or similar object, through the doorway (goalposts) of the home of one of the two villages' leaders.

The game commenced when the ball or similar object was thrown into the centre of the assembled "players" to start the game. Thereafter it was likely that anything was

acceptable, since there were few, if any, rules governing the game. There were no restrictions on clothing, equipment, the number or age of participants or modes of transport. It was believed that some players participated on horseback, some carried swords and many carried staves. Drownings and ambushes were common as rivals took the opportunity to settle simmering feuds and other private animosities (Noakes & Du Plessis, 1996:10).

Noakes and Du Plessis (1996:11) further explain that given this opportunity for public mayhem, it is natural that these games were not well received by those in authority. The socialisation of these activities seems to have occurred when they were first restricted to the geographical limitations imposed by a playing field. This happened mostly at the English public schools, especially Rugby, Westminster, Eton, Marlborough, Winchester, Charterhouse and Cheltenham in the 19th century. The schools perceived in these "manly" sports the opportunity to cool the physical ardour of their charges, at the same time preparing the "muscular (English) Christians" to extend the British values to the furthest outposts of the Empire. The football games developed at each of these famous schools had their own unique characteristics; there was no uniform game common to all schools.

The games that developed in each of these schools were different to a certain extent because each school evolved its own peculiar rules according to the facilities that were available and possibly also to the prevailing ethos at the different schools. The games that developed at Eton and Rugby differed in part because of the larger playing fields at Rugby, which allowed for a game in which the ball could be carried – the

"handling" game - while the smaller playing fields at Eton favoured the development of the "dribbling" game (Noakes & Du Plessis, 1996:10).

The game of football as played at Rugby school (Rugby, England) between 1750 and 1823 permitted handling of the ball, but no-one was allowed to run with it in their hands towards the opposition's goal. There was no fixed limit to the number of players per side and sometimes there were hundreds taking part in a kind of enormous rolling maul (Rugby Football History, 1998).

Rugby school, for example, had developed Rugby football from football and played this game according to Rugby rules. The question as to why the game of Rugby school became so popular in preference to the games of other schools, such as Eton, Winchester or Harrow, was probably largely due to the reputation and success of Rugby school under Dr Arnold, and this also led most probably to its adoption by other schools; for in 1860 many schools besides Rugby played football according to Rugby rules (Rugby Football History, 1998).

By 1863, the distinction between rugby and soccer had become clearer. This distinction led to a famous quote much favoured by rugby players: "Rugby is a game for hooligans played by gentlemen, whereas soccer is the exact opposite." (Noakes & Du Plessis, 1996:11).

2.3 DEFINING AN INJURY

There is a variety of definitions of *injury* used in literature when describing the severity of injuries to players. Garraway and Macleod (1995:1485) conclude that

"injuries that necessitated leaving the field of play or practice and missing the remainder of the match or practice, but did not cause the player to miss subsequent matches or practices for at least 7 days, are classified as transient". More severe injuries were classified according to the amount of time that passed before the resumption of training or playing. If this period is no longer than 28 days, the injury is classified as mild; if it is 29-84 days, the injury is moderate and if it is more than 84 days, it is classified as a severe injury. This definition is also used by Lee and Garraway (1996) in their comparison between club and school player injuries.

Junge *et al.* (2004) use the National Injury Registration System (NAIRS) to define injuries according to the amount of time of missed training or playing and distinguish three categories: up to one week, 8–21 days and more than 21 days. Nathan *et al.* (1983) simply define an injury as one that was severe enough to prevent a player from participating for at least seven days after the injury. Injuries are then further graded as Grade I, II and III. These grades are used to describe injuries which kept a player out of the game for up to one week, up to 3 weeks or more than 3 weeks respectively.

A different grading was formulated by McManus (2000) in an article devised to standardise rugby epidemiology research. A minor injury is defined as an injury in a game or practice which did not necessitate the player to stop participating. When a player misses one week, it is considered a mild injury. Moderate injuries cause a player to miss two weeks of play and severe injuries cause a player to miss more than 2 weeks of play. It is considered important to report injuries sustained during a game that did not necessitate the player leaving the field, as these injuries could account for underreporting of the real injury rate.

Injuries can also be divided into intrinsic and extrinsic injuries. Intrinsic factors are inherent characteristics of an individual, specific to that individual, and include age, sex, anthropometric variables, fitness, psychological characteristics, health status and injury history (Quarrie, Alsop, Waller, Bird, Marshall & Chalmers; 2001). Proprioception, balance and plyometric strength can be considered to be among these intrinsic characteristics. Quarrie *et al.* (2001) further show that extrinsic characteristics are external to the individual and include the nature of the sport, environmental conditions and equipment. Intrinsic injuries occur without the interference of extrinsic factors, whereas extrinsic injuries can be linked to external causes.

The definition of "injury" as described in the article of McManus (2000) will be used for this study. This is done because of the relatively short length of the rugby season of the participating schools in this study, which stretches over approximately 10 weeks. According to the definition of Garraway and Macleod (1995), in this setting a player could be out for the entire season with an injury which would only be graded as moderate.

2.4 RUGBY INJURIES

One of the earliest research articles on rugby injuries was published in the Journal of the Irish Medical association by Dr TCJ O'Connell in 1954. Even then, he was of the opinion that "even minor injuries in these days are of a much more serious economic import to students, young business men, manual workers and members of the professions than they were in the good old days. Employers are not so inclined to take a lenient view of absence from work which may be due to sports injuries, whilst in

recent years the premium for accident injuries for sports (and especially rugby football) has become almost prohibitive for younger players." (O'Connoll, 1954:20)

Garraway and Macleod (1995:1485) stress that "Rugby injuries are an important source of morbidity in young men". In contrast to this, Davidson (1987:120) concludes that schoolboy rugby injuries present little chance of disfigurement. He also argues that young players, especially those that are not very adept at the game, run hardly any risk of injury at all. Davidson (1987:120) also claims that "Any decision whether or not a school should offer rugby as a sport should be based not so much upon the game's alleged potential for injury, as upon whatever relevance and importance it is deemed to have on the early physical and mental development of children". Lee and Garraway (1996) also point out that schoolboy rugby is much safer than senior club rugby and the outcome of injuries that do occur, is less disruptive.

A comparison done by Junge *et al.* (2004) between New Zealand youth playing rugby and soccer, found that rugby union football was associated with a significantly higher rate of injury than soccer. Junge *et al.* (2004) also recommend the development and implementation of preventative interventions to reduce the rate and severity of injury.

O'Connell (1954:20) recognised the main risks of rugby at that time, which are still quite valid in the modern game. He found that most injuries arose from physical contact with:

1) Other players
2) The playing field, goal post and touch flags
3) The ball.

He also identified four main phases in the game were injuries due to physical contact with other players were most likely to occur. These were:

1) The scrum
2) The tackle
3) Loose play
4) The line-out.

Roux (1992) identifies 6 major risk factors for rugby injuries. These are:

1) Age of the player: Players of older age groups were found to be at an increased risk of injury. This is supported by Meyers (1980) who also found a significant trend of increasing incidence of injury from lower to higher grades of play.
2) Level of play: Players in higher levels of play are more prone to injuries.
3) Match play: Matches generally led to higher injury rates than practice sessions.
4) Playing position: Fullbacks, wings and eighth-men are of the playing positions that had a greater risk to be injured
5) Phase of play: Tackling, being tackled and the ruck and maul account for 75% of all injuries (Noakes & Du Plessis; 1996:97). These 3 phases of play accounted to 70% of all rugby injuries in the cohort that was under scrutiny in research conducted by Sugarman (1983) on 33 schools during the 1981 season playing Rugby Union in Australia. 46% of all injuries occurred during the tackle situation and were sustained either by the player being the tackler or the one being tackled. Another 24% of injuries occurred in rucks and mauls, with less than 1% of the injuries observed by Sugarman (1983) taking place in the

scrums and line-outs. This contrast with O'Connell (1954) could possibly be attributed to the dramatic rule changes that have occurred between 1954 and 1983. It is, however, very similar to the findings of Noakes and Du Plessis (1996). Garraway and Macleod (1995:1487) point out that "the challenge now is to sustain the popularity of the game while lessening the hazard of high velocity contact in the tackle".

6) Time of season: The last factor identified by Noakes and Du Plessis (1996:97) as a risk factor for injuries was the fact that most injuries occurred in the early part of the season and again after the mid-season break.

Quarrie *et al.* (2001) emphasise the importance of previous injury as a predictor of rugby injury incidence and of missing play. It also shows the importance of considering both the incidence rate and severity of injury when identifying risk factors for injuries in sport.

Upton, Roux and Noakes (1996) observe that players' knowledge of techniques known to prevent rugby injuries was inadequate and too little attention was paid at the start of the rugby season to training and coaching to reduce injury risk. Coaching errors may therefore predispose players to injury. Lee and Garraway (1996) also advocated a more intensive period of pre-season training to reduce the number and intensity of injuries at the beginning of the season.

Babić *et al.* (2001) found that there were no statistically significant differences in anthropometric characteristics, body composition and constitution of injured and

uninjured players in the Croatian rugby project. However, they identified lower club positions in the league; forward positions in a team; beginning of autumn or spring season and also being tackled as risk factors for injuries.

Lee, Garraway and Arnell (2001a) are of the opinion that injury risk is more likely to be related to rugby training (type of activities undertaken in rugby training, or personalities and characteristics of players undertaking training more frequently) than to overall player fitness. Players who were injured at the end of the previous season were more likely to be injured in the following season. This could possibly be because they do not allow previous injuries to heal sufficiently before returning to the game, or the intensity of their participation may increase the risk of injury. This study was conducted amongst a total of 803 players from 22 Scottish clubs in the 1997-1998 season who provided details of rugby training, injuries sustained and physical activity undertaken during the 16 week summer period and their perceived fitness before the start of the season.

Alsop, Morrison, Williams, Chalmers and Simpson (2005) found that the amount of time warming up and playing out of position had no significant effect on the risk of rugby injury. However, it was found that calm weather conditions and playing on a hard ground was associated with increased risk of injury. The influence of these factors may be indirect, through adaptation to the conditions in which a game is played. Upton (1999) remarks that it is a dangerous practice to play inexperienced rugby players in unfamiliar positions, especially in the front row of the scrum.

Hattingh (2003:181) reports that biomechanical and postural data collected from junior elite rugby players in South Africa showed significant shortcomings in dynamic mobility and core positional stability. A disturbingly high percentage of chronic overuse injuries that were monitored correlated with these correctable biomechanical and postural findings.

2.5 PREVENTATIVE STRATEGIES

O'Connell (1954:23-24) identified the following criteria for the prevention of injuries:

1) Training: It should be strongly emphasised that adequate and consistent training is necessary if many of the muscle and ligament injuries are to be avoided: "No bandages or straps, nor indeed any form of protective mechanism, can take the place of fully trained muscles." Warming up is also very important, especially for faster running backline players. He recommends that an injured player be allowed to train for a week or ten days before returning to play- this is a rehabilitation principle still in use today.

2) Protective Devices: Scrum caps, shin guards and shoulder pads are devices recommended to reduce injuries in rugby football players. Boots should also be chosen carefully to offer maximum protection without weighing a player down unnecessarily.

3) Field of play: Goal posts should be padded and corner flags should be flexible and also padded. Flints and small stones should be removed from the field prior to play and also any animal excrement, which may lead to tetanus. Most of these recommendations by O'Connell in 1954 are now commonly accepted norms when it comes to prevention of rugby injuries.

Nathan *et al.* (1983) identify the following preventative measures to reduce the number of injuries in schoolboy rugby players:

1) Prevention should be aimed at specific age groups and levels of play. These measures should be increased as the age of players increase, as younger players generally have fewer injuries. A-team players also need to be targeted more than B-team players.

2) Particular attention must be paid to players in positions at greater risk of injury. Nathan *et al.* (1983) showed hookers as these players.

3) Matches warrant more emphasis of injury prevention than training.

4) "Match fitness" could be a problem and needs to be addressed, as is illustrated by the higher prevalence of injuries in April and July, following school holiday breaks.

5) Improved tackling and falling techniques should be taught in order to reduce the high incidence of injuries during these activities.

6) The wearing of gum guards should be made compulsory in order to reduce the high incidence of concussion. Concussed players should also be kept out of play for the correct periods of time by coaches, to allow total clinical recovery.

7) With the exception of late tackles, it appears that referees have adequate control over games to minimise foul play in general.

8) Training staff should also be educated in the initial handling of acute injuries to bone, tendons, muscles and ligaments as these injuries are relatively easy to diagnose. A doctor on the site of matches in this study would have seen about 3.3 injuries on a match day, of which only one would be serious. This begs the question of whether it would really be justified to have a doctor on site for every match.

The Medical and Risk Management Committee of USA Rugby (2003) states that the key to preventing injuries in any sport is identifying and addressing the risk factors associated with it. In rugby, these risk factors include coaching, equipment, playing surface and conditioning:

1) Coaching: The most effective way to prevent injuries in youth rugby is to ensure that all programmes are headed by trained coaches. At the very least, coaches should be certified; have training in first aid and CPR and should have an emergency plan in the event of serious injury (USA Rugby, 2003).

2) Conditioning: Proper conditioning is an effective way to prevent unnecessary injuries and coaches should provide pre-season conditioning programmes. Compared to those in good shape, unfit rugby players are far more likely to trip and sprain an ankle during a game or even sustain a growth plate fracture. Rugby is a "mixed" aerobic/anaerobic sport. There are short bursts of intense activity within a framework of ongoing aerobic demand. Rugby-specific interval training is needed for this. Weight training and stretching are also very important for the rugby player. Particular attention should be paid to strengthening the base of the neck and the shoulders, areas where many rugby injuries occur. Stretching should also be emphasised, given the demands for rapid flexibility, bending, twisting and turning in such activities as covering a loose ball or getting up quickly from a maul or ruck (USA Rugby, 2003).

3) Playing surface: Injuries in youth can be reduced if there are proper and safe playing conditions, which include fields free of potholes, glass and other debris. Goal posts should also be padded for players' protection (USA Rugby, 2003).

4) Equipment: Players should comply with the kit requirements found in the laws of the game. In particular, boots and studs should follow the law prescriptions. The use of mouth guards is also recommended, which help prevent injury to the mouth, teeth, lips, cheeks and tongue. Mouth guards also protect against blows that otherwise might have caused concussions or jaw fractures (USA Rugby, 2003).

A high number of injuries in rugby union are as a result of the tackle (Noakes & Du Plessis, 1996:97; Garraway & Macleod, 1995; Sugarman, 1983). This is also the case in rugby league, as shown by Gabbett (2004). Gabbett (2004:856) also recommends that "injury prevention strategies designed to minimise tackling injuries will reduce the overall incidence of injuries in rugby league". Rugby union injuries will be affected in the same way by these measures, as the tackle is universal to both games. Injury prevention strategies that address defensive skills, correct tackling technique, correct falling technique and methods to minimise the absorption of impact forces in tackles may reduce the incidence and severity of tackling injuries (Gabbett, 2004). Bird, Waller, Marshall, Alsop, Chalmers and Gerrard (1998) stress that identifying the causes of injuries in the tackle; lower limb injuries and dealing with the issue of foul play should be priority areas for the prevention of rugby injuries.

A biomechanical and postural correction programme was formulated by Hattingh (2003) to reduce the amount of chronic overuse injuries that occurred in junior elite rugby players. This consisted of individual programmes which included a pre-season programme, a maintenance programme, an advanced-norm programme and also an off-season programme. These specific stretching and strengthening programmes were

designed to address individual biomechanical abnormalities that lead to chronic overuse injuries.

Erasmus (2006) implemented an adapted form of the biomechanical programme proposed by Hattingh (2003) for injury prevention in a 120 U/15 and U/16 schoolboy rugby players in the North West Province in South Africa. This study was run over a 2 year period and positive results were recorded for the reduction of intrinsic injuries amongst the experimental groups in the study.

Jakoet and Noakes (1998:47), however, suggest that there is a probability that the only effective interventions that might reduce the injury risk at international level would be the introduction of laws that reduce the speed of the game, the size of the players and the amount of contact in the game.

2.6 PREVALENCE RATE OF INJURIES

Nathan *et al.* (1983) monitored the rugby injuries occurring in a single South African school. Teams from under 10 to under 19 were monitored on an ongoing basis throughout the season. The results of hours per injury were adapted to injuries per 1000 player hours in Table 2.1.

Table 2.1 Injuries per 1000 hours. Adapted from Nathan *et al.* (1983:133)

Age Group	**Injuries Per 1000 hours of play**
U/10	None
U/11	1.02
U/12	1.63
U/13	1.02
U/14	1.69
U/15	4.80
U/16	3.35
U/19	7.75

A broader study was conducted by Roux *et al.* (1987), in which 26 schools of the Cape Province in South Africa were monitored during one 18 week season. A total number of 3 350 rugby matches were played. 6 of these schools were monitored closely and 20 were monitored through correspondence. The injury incidence for the 6 closely monitored schools was 2.34/1000 boy hours (Schoolboy playing hours). The 20 schools monitored via correspondence showed an injury rate of 1.36/1000 boy hours. It was likely that this discrepancy was due to underreporting of injuries via correspondence.

Upton (1999) conducted a study with the same 25 schools used by Roux (1992) and Roux *et al.* (1987). This study was conducted via correspondence in the 1991 rugby season. This study by Upton (1999) shows an injury prevalence rate of 1.60/1000 player hours. In matches, the injury prevalence rate was 7.09/1000 match hours. Table 2.2 shows the injury prevalence rate for matches, practices and total for Upton (1999).

Table 2.2 Injuries per 1000 hours. Adapted from Upton (1999)

Age Group	Injuries Per 1000 hours of match play	Injuries per 1000 hours of practice	Total injuries per 1000 boy hours
U/14	3.46	0.34	0.73
U/15	6.94	0.49	1.58
U/16	6.17	0.45	1.32
U/19	9.80	0.67	2.27

An epidemiological study was conducted by Jakoet (1993) at the South African Craven Week for high schools of 1993. This study showed a prevalence rate of 13.0/1000 player hours at the tournament for U/19 elite schoolboy players for matches and practices combined. The incidence for match injuries in this tournament was 21.6/1000 match hours.

Davidson (1987) conducted a study on the injury rate of acute schoolboy injuries at all matches at one private school in Australia for the period of 1969-1986. The injuries monitored in this study showed a rate of 17.6/1000 player hours. The high rate of injury can be attributed to only match injuries being brought into the equation. A four season study spanning 1980-1983 was conducted by Sparks (1985) at one English public school. The injury rate observed in this study was 19.4/1000 player hours. This included school team matches, house matches as well as practices and training. This is considerably higher than the findings of Nathan *et al.* (1983) and Roux *et al.* (1987).

In research conducted by McManus and Cross (2004) on 44 elite Western Australian junior rugby union players, an injury incidence rate of 13.26/1000 player hours was found. This research was conducted on U/15 and U/16 players. This figure is similar to the findings by Jakoet (1993) in the 1993 Craven Week in South Africa, who found a prevalence rate of 13.0/1000 player hours for elite U/19 schoolboys.

Garraway and Macleod (1995) researched injuries among 1169 players from all the senior rugby clubs within the Scottish borders for games played in the 1993-94 rugby season. For players younger than 16 years, an injury prevalence rate of 3.70 injuries/1000 player hours was observed. This rate jumped to 10.07 injuries/1000 player hours for players in the 16 to 19 year old age bracket. This is substantially higher than findings by Roux *et al.* (1987), and slightly higher than the findings of Nathan *et al.* (1983) for players of the same age. It is, however, nearly 50% lower than the findings of Sparks (1985). The prevalence rate noted by Garraway and Macleod (1995) more than doubled to 21.92 injuries/1000 player hours for the age bracket of 20 to 24 years old. The injury rate for 25 to 29 year olds and 30 to 34 year

olds was 19.78/1000 player hours and 18.88/1000 player hours respectively. This once again points to the high intensity of senior rugby when compared to the school version of the game.

Injury prevalence increases even further at an international level as is shown in research by Jakoet and Noakes (1998). In the 1995 Rugby World Cup Tournament there was a frequency of 30 injuries/1000 player hours in the preliminary round matches and a frequency of 43 injuries/1000 player hours in the 7 final round matches. These findings showed that the high levels of skill and fitness of international players are not sufficient to offset the greater risk of injury which is a consequence of the more physical and faster nature of the modern international game.

Research conducted Bird *et al.* (1998) for the New Zealand Rugby injury and performance project yielded some valuable data on rugby injuries. An article was published on the epidemiology of a season of rugby injury. Detailed information was collected for 4 403 player games and 8 653 player practices. The injury rate was higher for games than for practices. They found a prevalence rate of 6.2 injuries per 100 player games in schoolboy players. The injury rate for schoolboy practices was 0.9 per 100 player practices. The rate for Senior A- and B-teams was 14.0 and 10.7 per 100 player games respectively for match injuries and 1.6 and 1.4 per 100 player practices respectively for training injuries. These rates, however, cannot be compared to the other studies due to different expression of the injury statistics.

Lee and Garraway (1996) perfomed a prospective cohort study on 1705 players from nine Edinburgh schools and also 1 216 players from 26 senior Scottish Rugby union

clubs. The prevalence rate of injuries for schoolboys was 86.8 per 1000 player seasons. Senior club players presented with a prevalence rate of 367.0 injuries per 1000 player seasons, which was substantially higher than the schoolboy rate. The prevalence rate of injuries amongst schoolboys also increased with age.

2.7 LOWER LIMB INJURIES

According to the National Collegiate Athletic Association injury surveillance system for 2000-2001 done in the United States of America, the most common injury sites are the ankle, knee and lower leg amongst collegiate soccer, field hockey, basketball, and lacrosse athletes. 59% of injuries in a study conducted on American football players were of the lower extremity, with the knee, ankle and thigh being the most common injury sites (Murphy *et al.*, 2003).

In studies conducted on rugby injuries many studies show that the most common site of rugby injuries is the lower limb (Babić *et al.*, 2001; Bottini *et al.*, 2000; Jakoet & Noakes, 1998; Bird *et al.*, 1998; Garraway & Macleod, 1995; Jakoet, 1993; Roux *et al.*, 1987). Studies by Lee and Garraway (1996); Davison (1987) and Nathan *et al.* (1983) show that a higher percentage of injuries was recorded in the upper limb than in any other body parts. One study conducted by Myers (1980) shows that the highest percentage of injuries was recorded in the head and neck area.

In the study by Roux *et al.* (1987) 37% of all the injuries monitored were of the lower limb. This was the highest percentage of injuries for any specific anatomical region in the body. If shoulder (9%) and upper limb (25%) injuries are separated in the Lee and Garraway (1996) study, it also shows that the highest percentage (31%) of injuries

occurred in the lower limbs of schoolboys. This study was conducted in a comparative fashion between schoolboy and club rugby players. In club players, the prevalence of lower limb injuries increased to 41% of the total injuries.

In research conducted on senior international players during the 1995 Rugby World Cup, Jakoet and Noakes (1998) found that 42% of all injuries during the tournament were of the lower limb. This corresponds with the data of Lee and Garraway (1996). Babić *et al.* (2001) found that 47.62% of injuries in the Croatian-Slovenian rugby first league in the 1996/97 season were of the lower limb. The prevalence of lower limb injuries were found to be 51.7% amongst elite Australian rugby union players who represented Australia in the Wallaby team between 1994 and 2000. The Australian National team played 91 matches during this period (Bathgate, Best, Craig & Jamieson, 2002).

Bird *et al.* (1998) conducted a study on injury occurrence amongst 356 club rugby players of both genders in Dunedin, New Zealand. 258 of these players were male. In this study it was found that 42.5% of injuries occurring during games were of the lower limb. In practice sessions the number of lower limb injuries escalated to 58.4%.

Bottini, Poggi, Luzuriaga and Secin (2000) shows a 42.6% occurrence of lower limb injuries in Argentinean rugby players in the 1991-1997 rugby seasons. One thousand two hundred and ninety six rugby games were monitored, which included 38 933 players. However, no division is made between senior and youth players where injuries of the lower limb are concerned. Individual injuries of the lower limb, namely pulled muscles, ankle ligament distension, knee trauma and knee ligament distension

show that senior players have a higher prevalence than youth players. Thus, there is a definite upward trend in the prevalence of lower limb injuries as the level of rugby intensifies.

2.8 LOWER LEG INJURIES

For the purpose of this study, the lower leg will be defined as the area distal to the tibial tuberosity. This includes the ankle and the foot. Of the 51.7% of lower limb injuries recorded by Bathgate *et al.* (2002) in Australian elite rugby players, 19.6% were of the lower leg. A comprehensive study was conducted among 33 schools by the Australian Schools Rugby Union in 1981, and Sugarman (1983) report that 17.5% of the injuries which occurred during the 3 059 games used for the survey were of the lower leg. This figure was almost similar to that of the Elite Australian rugby player, showing that a high percentage of lower leg injuries occurs at all ages. Sparks (1985) also report a 15.1% incidence of lower leg injures in research spanning a four season period amongst pupils of one English public school. However, he found that injuries increase with age due to physical maturation.

Rotem and Davidson (2001) reviewed the acute injury statistics as gathered at an Australian private school's Saturday match casualty station over a 30 year period. This study shows an incidence rate of 10.8% for lower leg injuries in that period. This is lower than the injury rates reported by Bathgate *et al.* (2002) and Sugarman (1983), and could have been influenced by the fact that only acute match injuries were used by Rotem and Davidson (2001), and it excluded training injuries and chronic overuse injuries. Rotem and Davidson (2001) suggest that the risk of injury increases with age, grade and competitive level. This corresponds with the findings of Sparks (1985).

Babić *et al.* (2001) report a 20.63% occurrence of ankle and foot sprains, strains and dislocations. This shows that one fifth of all injuries in the 1996/1997 season in Croatia were of the ankle. The incidence was more than two times higher than in more developed Scottish rugby.

2.9 PERMANENT INFLUENCE ON LIFE

The incidence of any injury that might result in permanent negative effects on the body, such as arthritis, should be lowered if possible. Injuries have a definite influence on players' subsequent lifestyles. In a study conducted in Scotland, Lee, Garraway, Hepburn and Laidlaw (2001b) found that 8% of a cohort of 1 169 men that were part of a rugby epidemiology survey on injuries in 1993-1994 ceased to play rugby due to ankle and foot injuries in the form of strains, sprains or dislocations.

The impact of sport-related lower limb injuries may be life-long, as there is evidence that that knee and ankle injuries may result in an increased risk of osteoarthritis in later life (Emery *et al.*, 2005).

A study conducted among retired professional soccer players in the UK showed that the prevalence of Osteo-Arthritis in retired soccer players is greater than observed in the general population, particularly amongst players that retired due to injury (Drawer & Fuller, 2001).

Engebretsen and Bahr (2005:312) justify the need for research into the new field of prevention of sports injuries with three important points: It should firstly ask

important questions not answered by others. Secondly, this new field should potentially create truly new knowledge, lead to new ways of thinking and improve health of patients. Lastly, results from this research should be publishable in respected peer-reviewed journals and presentable at high quality meetings. Gabbett (2004:856) stresses that the implementation and evaluation of effective injury prevention strategies are dependant on the identification of injury risk factors. Myers (1980:17) quotes Bannister as suggesting that "documentation of the nature and severity of sporting injuries is essential before guidelines for prevention or preparation for management can be formulated". Junge *et al.* (2004) also recommend the development and implementation of preventative interventions to reduce the severity and rate of injury.

2.10 SUMMARY

This chapter examined literature on rugby injuries. It looked at a brief history of rugby and the origins of the game. Definitions of injury in different literature were examined and the definition to be used in this study was discussed. Rugby epidemiology of different studies was discussed and also current injury prevention strategies. An analysis of prevalence rates of rugby injuries and specifically of lower limb and lower leg injuries was presented. Finally, the permanent influence that rugby injuries might have on a player's life was also investigated. This study aims to determine the influence of proprioception, balance and plyometric strength in schoolboy rugby players on the occurrence of lower leg injuries. Based on the assessment of this influence, a preventative intervention will be designed to reduce the occurrence of lower leg injuries in schoolboy rugby players.

CHAPTER 3

LITERATURE REVIEW: ANATOMY OF THE LOWER LEG AND PHYSIOLOGY OF PLYOMETRICS, PROPRIOCEPTION AND BALANCE

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CHAPTER 3

LITERATURE REVIEW: ANATOMY OF THE LOWER LEG AND PHYSIOLOGY OF PLYOMETRICS, PROPRIOCEPTION AND BALANCE

3.1 INTRODUCTION

This chapter examines the anatomy of the lower leg, to provide a structural background for injuries to the lower limb that are investigated in this study. The chapter also investigates the physiology of plyometrics, proprioception and balance and the influence these variables have on lower leg injuries, as well as its involvement in rugby talent identification. The lower leg will be defined as the area inferior to the tibial tubercle for the purposes of this study.

3.2 ANATOMY OF THE LOWER LEG

3.2.1 Osteology of the Lower Leg

The two large bones of the lower leg are the tibia and the fibula. The majority of the weight is supported by the tibia ("shin bone"). The tibia articulates with the talus inferiorly and the condyles of the femur superiorly. The smaller fibula or "calf bone" is mainly for muscle attachment, but also provides stability to the ankle joint as the lateral malleolus. The interosseous membrane connects the bodies (shafts) of the tibia and fibula and consists of strong oblique fibres (Moore, 1992: 432).

3.2.1.1 The Tibia

"The tibia is the medial and much the stronger of the two bones of the leg; excepting the femur it is the longest bone of the skeleton. It is prismoid in section in its shaft and has expanded extremities. Its lower end is smaller than the upper, and on its medial side a stout process, termed the medial malleolus, projects downwards beyond the rest of the bone. The anterior border of the shaft is a conspicuous, sharp crest, which curves medially at the lower end towards the medial malleolus." (Warwick & Williams, 1973: 366)

The flat superior surface of the tibia consists of the lateral and medial tibial plateaus. The intercondylar eminence on the superior surface of the tibia fits into the intercondylar notch between the condyles of the femur. The head of the fibula articulates with the lateral condyle of the tibia at an inferior facet. The tibial tuberosity is a prominent facet on the anterior surface of the tibia, into which the patellar ligament or "ligamentum patellae" inserts (Moore, 1992: 432).

The tibia is mostly responsible for the transmitting of loads between the upper leg and the foot. The fibula, which is a thin, relatively weak bone, is only involved in load transmission between the upper leg and foot to a small extent. The main purposes of the fibulae are to help form the ankle joint inferiorly and to provide attachment areas for the muscles responsible for movement of the ankle and foot. The proximal end of the fibula, which articulates with the tibia, is called the head. The fibula head articulates with the lateral tibial condyle to form the proximal, or superior, tibiofibular joint (Watkins, 1999: 83).

3.2.1.2 The Fibula

The shaft of the fibula has four faces of varying width and length running along the length of it. The distal end of the fibula is known as the lateral malleolus of the ankle. The medial aspect of the distal end of the fibula articulates with the lateral aspect of the talus to form the lateral part of the ankle joint. The medial part of the fibula shaft immediately above the articular surface of the lateral malleolus articulates with the lateral aspect of the distal end of the tibia, forming the distal tibiofibular joint (Watkins, 1999: 84).

3.2.1.3 The Foot Bones

There are 26 bones in the foot. These are the 7 tarsals, the 5 metatarsals, and the 14 phalanges, or toe bones. The foot articulates with the lower leg at the ankle joint. This joint is between the tibia, fibula, and the talus. The talus is the second largest tarsal. It's superior articular surface is called the trochlear surface and has a convex pulley-shape. This surface articulates with the trochlear surface of the tibia. The trochlear surface is continuous with the articular surfaces which articulate with the lateral and medial malleoli. The talus articulates with the calcaneus by means of two, or in some cases, three articular facets. These facets constitute the subtalar joint. The subtalar joint is also referred to as the talocalcaneal joint. The talus articulates with the navicular bone anteriorly, to form the talonavicular joint. (Watkins, 1999: 84).

The calcaneus is the largest tarsal bone and is often referred to as the heel bone. On the posterior aspect of the calcaneus there is a large tuberosity, termed the calcaneal tuberosity. The calcaneus articulates with the cuboid anteriorly on the lateral aspect of the foot. This articulation is called the calcaneocuboid joint. The midtarsal joint

constists of the calcaneocuboid and talonavicular joints, which run continuous with each other. The navicular articulates anteriorly with the medial, middle, and lateral cuneiforms, which lie side by side. The lateral cuneiform also articulates with the medial portion of the cuboid bone. The cuneiform bones articulate with the bases of the first, second, and third metatarsals (Watkins, 1999: 84).

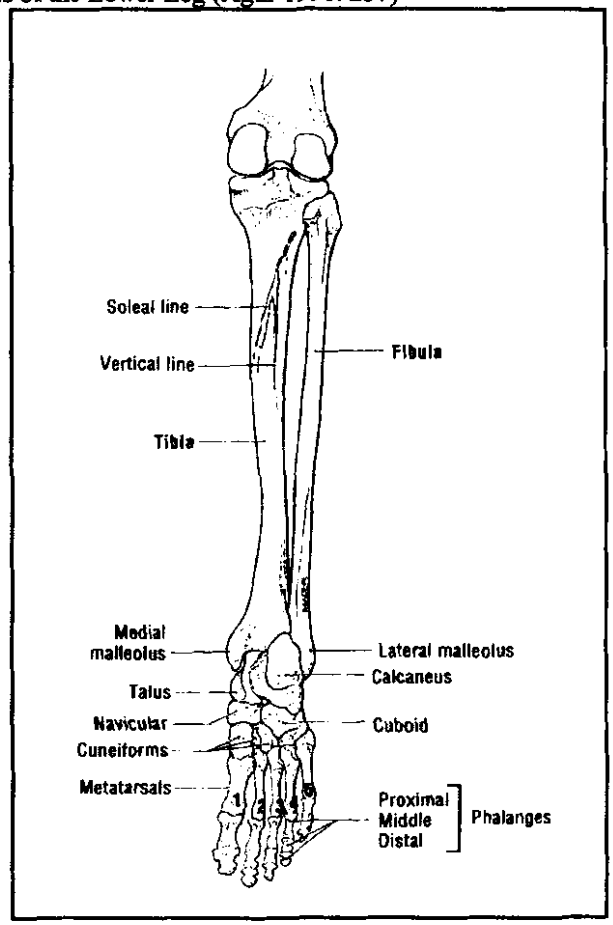
The cuboid articulates with the bases of the fourth and fifth metatarsal bones anteriorly. The joints between the tarsals and the metatarsals are referred to as the tarsometatarsal joints. The first metatarsal is shorter with greater girth than the other four metatarsals. The lateral four metatarsals usually increase in girth from the second through to the fifth, while their length stays more or less the same (Watkins, 1999: 84).

"The tarsals and metatarsals are arranged in the form of two longitudinal arches (medial and lateral) and a single transverse arch. The medial longitudinal arch is formed by the calcaneus, talus, navicular, the three cuneiforms, and the first, second, and third metatarsals. The lateral longitudinal arch, which is much flatter than the medial arch, is formed by the calcaneus, cuboid, and the fourth and fifth metatarsals. In combination, the longitudinal arches form a single arched structure between the posterior and inferior aspect of the calcaneus and the heads of the metatarsals. The transverse arch runs across the foot from medial to lateral and is formed by the anterior five tarsals and the bases of the metatarsals. The shape of the arch is due to the cuboid, the middle and lateral cuneiforms and the bases of the middle three metatarsals, which are wedge shaped in coronal section. Muscles largely maintain the

arches, which function to cushion impact loads on the foot occurring in activities such as walking, running, jumping and landing" (Watkins, 1999: 85).

In total, there are 14 phalanges in each foot. The great toe, or hallux in Latin, has only a proximal- and a distal phalanx. The lateral four digits of each foot have three phalanges each. These are the proximal, middle and distal phalanges. Phalanges consist of a proximal base, a body or shaft in the middle and a distal head (Moore, 1992: 441).

Figure 3.1 Bones of the Lower Leg (Agur 1991: 257)



3.2.2 Muscles of the Lower Leg

There are three muscle compartments in the lower leg. They are the anterior, posterior and lateral compartments.

3.2.2.1 Anterior Compartment

There are four muscles located in the anterior compartment of the lower leg. These are Tibialis anterior, Extensor hallicus longus, Extensor digitorum longus and Peronius tertius. The compartment can be divided into the upper- and lower parts, each with two muscles. Only the Tibialis anterior muscle originates from the tibia. The other three muscles originate from the interosseus membrane between the tibia and fibula, and the fibula itself. All four muscles are dorsiflexors of the ankle and extensors of the toes (Meiring, Liebenberg, Van Heerden, Jacobs, Vorster, Scheepers & Greyling, 2000:645).

Figure 3.2 Muscles of anterior compartment of lower leg. A: Tibialis anterior. B: Extensor digitorum longus. C: Extensor hallucis longus and Peronius tertius (Moore, 1992: 445).

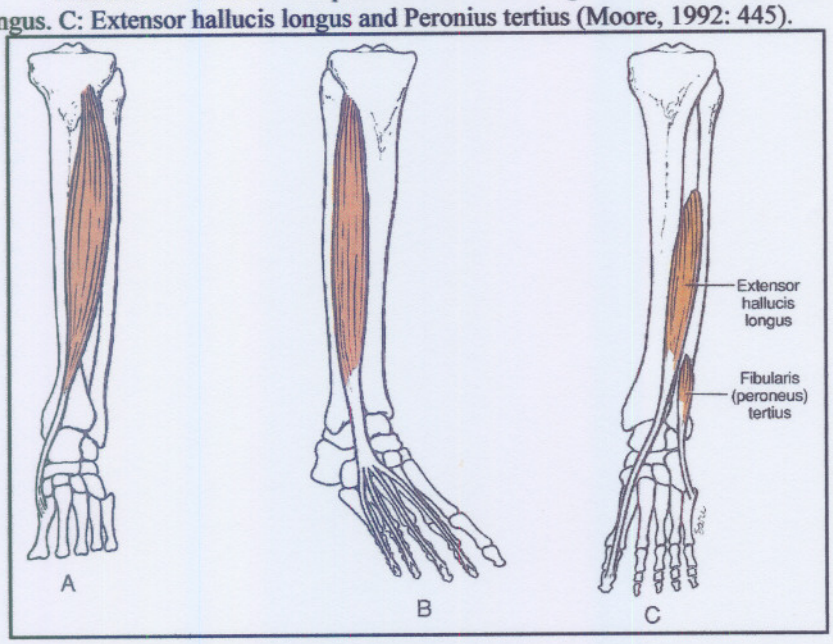


Table 3.1 Muscles of anterior compartment of lower leg (Moore, 1992: 445).

Muscle	Proximal attachment	Distal Attachment	Innervation	Main Action
Tibialis anterior	Lateral condyle and superior half of lateral surface of tibia	Medial and inferior surfaces of medial cuneiform bone and base of first metatarsal	Deep Fibular (peroneal) (L4, L5)	Dorsiflexes and inverts foot
Extensor hallucis longus	Middle part of anterior surface of fibula and interosseus membrane	Dorsal aspect of base of distal phalanx of great toe (hallux)	Deep Fibular (peroneal) (L5, S1)	Extends great toe and dorsiflexes foot

Extensor digitorum longus	Lateral condyle of tibia, superior three quarters of anterior surface of fibula and interosseus membrane	Middle and distal phalanges of lateral four digits	Deep Fibular (peroneal) (L5, S1)	Extends lateral four digits and dorsiflexes foot.
Peroneus tertius	Inferior third of anterior surface of fibula and interosseus membrane	Dorsum of base of fifth metatarsal bone	Deep Fibular (peroneal) (L5, S1)	Dorsiflexes ankle and aids in eversion of foot

3.2.2.2 Lateral Compartment

"The lateral compartment is situated between the deep fascia, anterior and posterior intermuscular septa and the lateral surface of the fibula." It contains the Peroneus longus and Peroneus brevis muscles (Meiring *et al.*, 2000:648).

Figure 3.3 Muscles of lateral compartment of lower leg. A: Peroneus longus. B: Peroneus brevis. (Moore, 1992: 448).

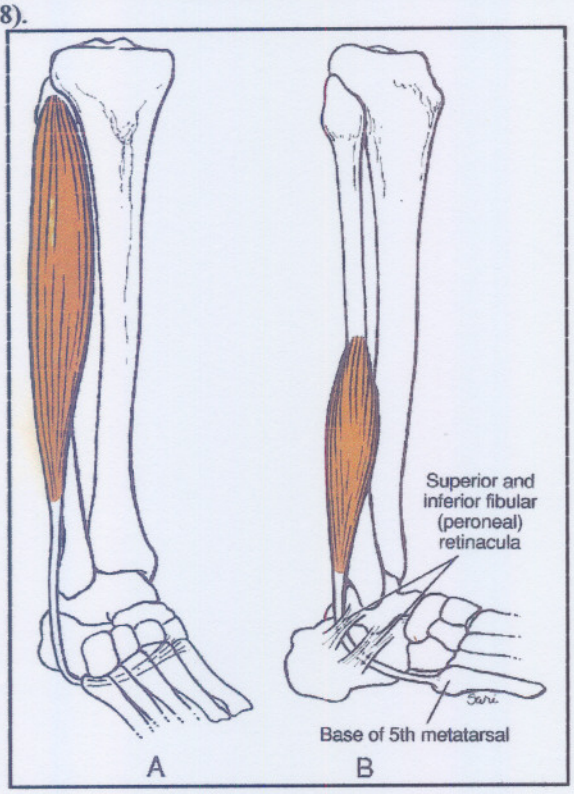


Table 3.2 Muscles of lateral compartment of lower leg (Moore, 1992: 448).

Muscle	Proximal attachment	Distal Attachment	Innervation	Main Action
Peroneus longus	Head and superior two-thirds of lateral surface of fibula	Base of first metatarsal bone and medial cuneiform bone	Superior fibular nerve (L5, S1, S2)	Everts foot and weakly plantarflexes it
Peroneus	Inferior two-thirds	Dorsal surface of tuberosity	Superior	Everts foot and

| fibula | fifth metatarsal bone | (23, 31, 32) | plantar flexes it |

3.2.2.3 Posterior Compartment

This compartment is covered with deep fascia and lies posterior to the tibia, interosseus membrane, fibula and posterior septum. Between the tibia and fibula there is a deep transverse septum, which divides the muscles into two groups. These two groups are the superficial- and deep groups. The superficial group consists of Gastrocnemius, Soleus and Plantaris muscles, while the deep group consists of Tibialis posterior, Flexor digitorum longus, Flexor hallucis longus and Popliteus muscles (Meiring *et al.*, 2000:649).

Figure 3.4 **Deep muscles of posterior compartment of lower leg. A: Popliteus and Flexor** hallucis longus. B: Tibialis posterior. C: Flexor digitorum longus (Moore, 1992: 455).

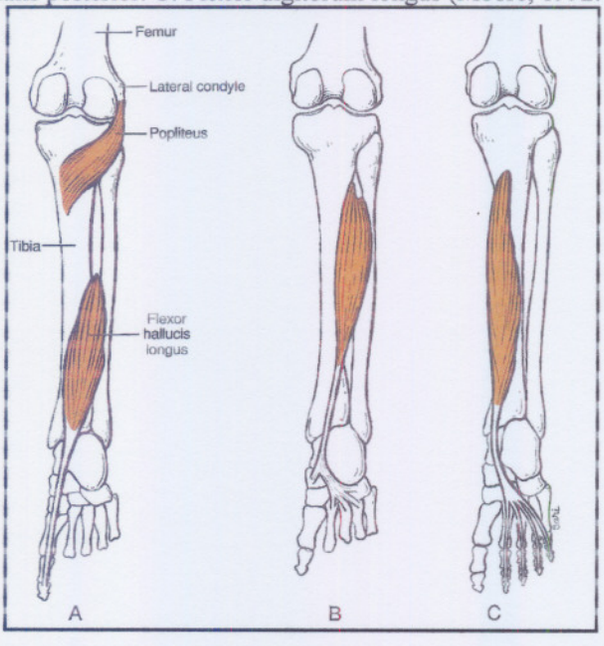


Table 3.3 Deep muscles of posterior compartment of lower leg (Moore, 1992: 455).

Muscle	Proximal attachment	Distal Attachment	Innervation	Main Action
Popliteus	Lateral surface of lateral condyle of femur and lateral meniscus	Posterior surface of tibia, superior to soleal line	Tibial nerve (L4, L5, S1)	Weakly flexes knee and unlocks it
Flexor hallucis longus	Inferior two-thirds of posterior surface of fibula and inferior part of interosseus membrane	Base of distal phalanx of great toe	Tibial nerve (S2, S3)	Flexes great toe at all joints and plantarflexes foot; supports longitudinal arch of foot
Flexor digitorum longus	Medial part of posterior surface of tibia, inferior to soleal line, and by a broad aponeurosis to fibula	Bases of distal phalages of lateral four digits	Tibial nerve (S2, S3)	Flexes lateral four digits and plantarflexes foot; supports longitudinal arch of foot
Tibialis posterior	Interosseus membrane, posterior surface of tibia inferior to soleal line and posterior surface of fibula	Tuberosity of navicular, cuneiform and cuboid bones, bases of second, third and fourth metatarsal bones	Tibial nerve (L4, L5)	Plantarflexes and inverts foot

Figure 3.5 Deep group of muscles of posterior compartment of lower leg. A: Gastrocnemius. B: Soleus and Plantaris (Moore, 1992: 451).

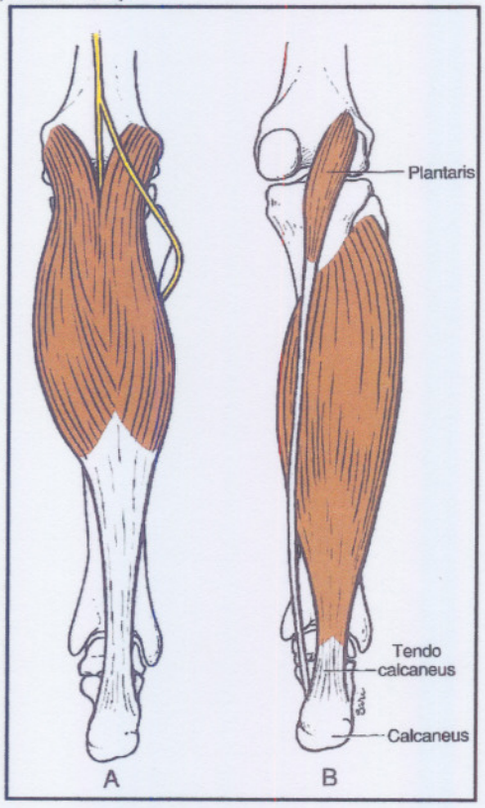


Table 3.4 Superficial muscles of posterior compartment of lower leg (Moore, 1992: 451).

Muscle	Proximal attachment	Distal Attachment	Innervation	Main Action
Gastrocnemius	*Lateral head*: Lateral aspect of lateral condyle of femur *Medial head*: Popliteal surface of femur, superior to medial condyle	Posterior surface of calcaneus via tendo calcaneus	Tibial nerve (S1, S2)	Plantarflexes foot, raises heel during walking, and flexes knee joint.
Soleus	Posterior aspect of head of fibula, superior fourth of posterior surface of fibula, soleal line and medial border of tibia	Posterior surface of calcaneus via tendo calcaneus	Tibial nerve (S1, S2)	Plantarflexes foot and steadies leg on foot
Plantaris	Inferior end of lateral supracondylar line of femur and oblique popliteal ligament	Posterior surface of calcaneus via tendo calcaneus	Tibial nerve (S1, S2)	Weakly assists gastrocnemius in plantarflexing foot and flexing knee joint

3.2.2.4 Muscles of the Foot

The muscles of the foot are divided into four layers. The first layer is formed by three muscles running from the calcaneus posteriorly, to the phalanges. Together, these muscles function like an elastic spring that maintains the foot arches and forms the hollow of the foot. The muscles of the first layer are Abductor hallucis, Abductor digiti minimi and flexor digitorum brevis. The second layer consists of the long flexor tendons of Flexor digitorum longus and Flexor hallucis longus as well as the small muscles attaching to them. The other muscles in the second layer are Quadratus plantae and the Lumbricals. The third layer lies in the anterior part of the foot and contains three short muscles involved with the functioning of the big- and little toes. These muscles are Flexor hallucis brevis, Abductor hallucis and Flexort digiti minimi brevis. The fourth layer consists of the seven Interossei muscles. These consist of

three plantarly located adductors and four dorsally located abductors (Meiring *et al.*, 2000:655).

Figure 3.6 Muscle layers of the sole of the foot. A and B: First layer. C: Second layer. D: Third layer. E and F: Fourth layer (Moore, 1992: 467).

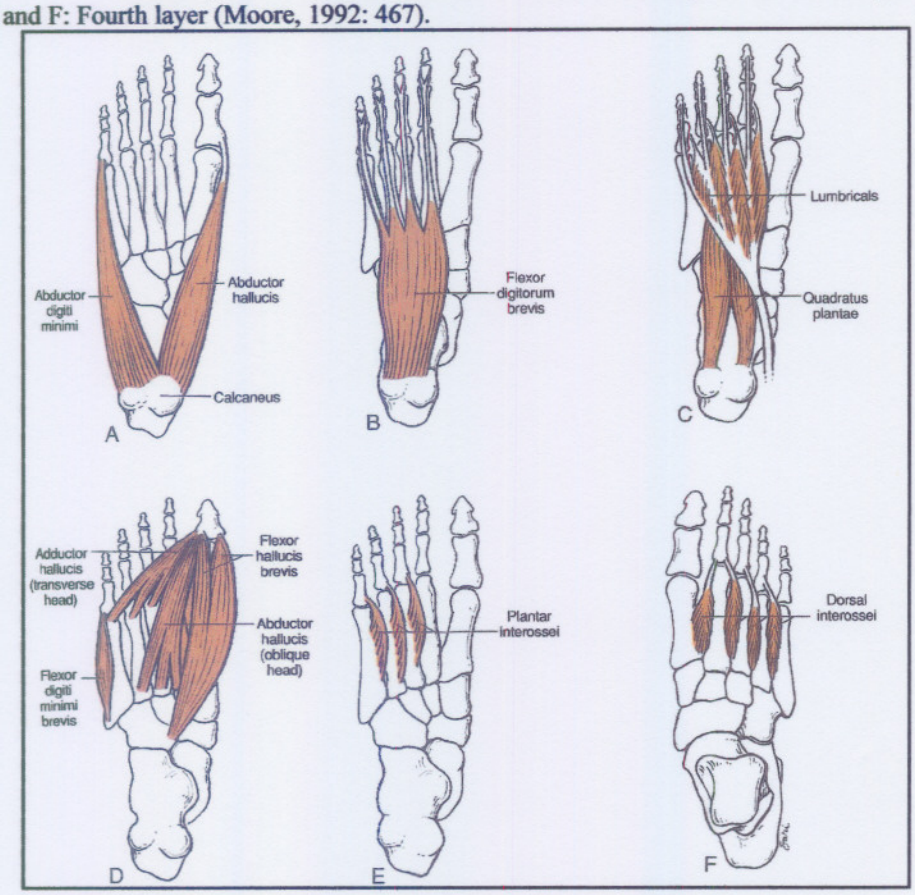


Table 3.5 Muscles of the sole of the foot (Moore, 1992: 466).

Muscle	Proximal attachment	Distal Attachment	Innervation	Main Action
First Layer Abductor hallucis	Medial process of tuber calcanei, flexor retinaculum and plantar aponeurosis	Medial side of base of proximal phalanx of great toe (hallux)	Medial plantar nerve (S2, S3)	Abducts and flexes great toe
Flexor digitorum brevis	Medial process of tuber calcanei, plantar aponeurosis and intermuscular septa	Both sides of middle phalanges of lateral four digits	Medial plantar nerve (S2, S3)	Flexes lateral four digits (toes)
Abductor digiti minimi	Medial and lateral processes of tuber calcanei plantar aponeurosis, and intermuscular septa	Lateral side of base of proximal phalanx of fifth digit (little toe)	Lateral plantar nerve (S2, S3)	Abducts and flexes fifth digit
Second Layer Quadratus plantae	Medial surface and lateral margin of plantar surface of calcaneus	Posterolateral margin of tendon of flexor digitorum longus	Lateral plantar nerve (S2, S3)	Assists flexor digitorum longus in flexing lateral four digits

Lumbricals	Tendons of flexor digitorum longus	Medial sides of bases Of proximal phalanges of lateral four digits and extensor expansions of tendons of flexor digitorum longus	*Medial one:* medial plantar nerve (S2, S3) *Lateral three:* Lateral plantar nerve (S2 and S3)	Flex proximal phalanges and extend middle and distal phalanges of lateral four digits
Third Layer Flexor hallucis brevis	Plantar surfaces of cuboid and lateral cuneiform bones	Both sides of base of proximal phalanx of great toe	Medial plantar nerve (S1, S2)	Flexes proximal phalanx of great toe (hallux)
Adductor hallucis	*Oblique head:* Bases of metatarsals 2-4 *Transverse head:* Plantar ligaments of metatarsophalangeal joints	Tendons of both heads attached to lateral side of base of proximal phalanx of great toe (hallux)	Deep branch of lateral plantar nerve (S2, S3)	Adducts great toe; assists in maintaining transverse arch of foot
Flexor digiti minimi brevis	Base of fifth metatarsal bone	Base of proximal phalanx of fifth digit	Superficial branch of lateral plantar nerve (S2, S3)	Flexes proximal phalanx of fifth digit thereby assisting with its flexion
Fourth Layer Plantar interossei (3 muscles)	Bases and medial sides of metatarsal bone 3-5	Medial sides of bases of proximal phalanges of digits 3-5	Lateral plantar nerve (S2, S3)	Adduct digits (2-4) and flex metatarso-phalangeal joints
Dorsal interossei (4 muscles)	Adjacent sides of metatarsal bones 1-5	*1st:* medial side of proximal phalanx of second digit *2nd-4th:* lateral sides of digits 2-4	Lateral plantar nerve (S2, S3)	Abduct digits (2-4) and flex metatarso-phalangeal joints

3.2.3 Joints of the Lower Leg

3.2.3.1 Proximal Tibiofibular Joint

"The proximal tibiofibular joint is a plane synovial joint formed by the articulation of the head of the fibula with the posterolateral aspect of the tibia. Although the facets are fairly flat and vary in configuration among individuals, a slight convexity to the tibial facet and slight concavity to the fibular facet seem to predominate. The inclination of the facets may vary from nearly vertical to nearly horizontal in

orientation. Each proximal tibiofibular joint is surrounded by a joint capsule that is reinforced by anterior and posterior ligaments and in all but rare instances is anatomically separate from the knee joint. Motion at the proximal tibiofibular joint is variable but consistently small: it has been described as superior and inferior sliding of the fibula and as fibular rotation" (Norkin & Levangie, 1992: 383).

3.2.3.2 Distal Tibiofibular Joint

"The distal tibiofibular joint is a syndesmosis, or fibrous union, between the concave facet of the tibia and the convex facet of the fibula. The tibia and fibula do not actually come into contact with each other at this point but are separated by fibroadipose tissue. Although there is no joint capsule, there are several associated ligaments. These ligaments of the distal tibiofibular joint are primarily responsible for restricting motion at both the proximal and the distal tibiofibular joints and for maintaining a stable mortise. The strongest and most important of the ligaments found at the distal tibiofibular joint is the crural tibiofibular interosseous ligament. Its oblique fibers run for a short distance between the tibia and fibula, maintaining proximity of the bones. The crural interosseous ligament also serves as a fulcrum for fibular motion; as a consequence, small movements of the fibular malleolus result in magnified movements at the proximal tibiofibular joint" (Norkin & Levangie, 1992: 383).

This joint is also additionally strengthened anteriorly and posteriorly by the addition of the anterior and posterior tibiofibular ligaments. These strong ligaments extend between the borders of the fibular notch located on the tibia and the anterior and posterior surfaces of the distal fibula respectively. The transverse tibiofibular ligament

is a strong band which closes the posterior angle between the tibia and fibula. It is actually the inferior, deep part of the posterior tibiofibular ligament. (Moore, 1992: 487).

3.2.3.3 The Ankle Joint (Talocrural Joint)

The talocrural joint, or ankle joint, as it is commonly known, is a hinged type of synovial joint. It consists of the articulation between the ends of the tibia and fibula and the talus inferiorly (Moore, 1992: 487).

According to Norkin & Levangie (1992: 384) "The body of the talus has three articular surfaces: a large lateral facet, a smaller medial facet, and a trochlear or superior facet. The large convex trochlear surface has a central groove that runs at a slight angle to the head and neck of the talus. The body of the talus is also wider anteriorly than posteriorly, giving it a wedge shape. The degree of wedging may vary among individuals, with no wedging at all in some and a 25 percent decrease in width anteriorly to posteriorly in others. The articular cartilage covering the trochlea is continuous with the cartilage covering the more extensive lateral (fibular) facet and the smaller medial (tibial) facet. The ankle joint is the most congruent joint in the human body. The structural integrity is maintained throughout the range of motion (ROM) of the joint by a number of important ligaments."

The bones are connected by a fibrous capsule, and by deltoid, anterior and posterior talofibular, and calcaneofibular ligaments. Warwick and Williams (1973: 460) states "The fibrous capsule surrounds the joint; it is thin in front and behind and attached above to the borders of the articular surfaces of the tibia and malleoli, and below, to

the talus close to the margins of the trochlear surface: except in front where it is attached to the dorsum of the neck of the talus at some distance in front of its superior articular surface. It is supported on each side by strong collateral ligaments. The posterior part of the capsule consists principally of transverse fibres. It blends with the inferior transverse ligament and is somewhat thickened laterally where it reaches as far as the malleolar fossa of the fibula."

The strong, Medial collateral (MCL) or Deltoid ligament, attaches the medial malleolus to the tarsal bones. The apex of the ligament is attached superiorly to the distal end of the medial malleolus. Its broad base fans out and attaches inferiorly to the talar-, navicular-, and calcaneal bones. The four parts of the deltoid ligament are named according to their bony attachments: tibionavicular, anterior and posterior tibiotalar, and tibiocalcanean ligaments. The main function of these ligaments is to strengthen the joint by holding the calcaneus and navicular bones against the talus. In addition, they also support the medial longitudinal arch and medial side of the foot (Moore, 1992: 488).

There are three ligaments on the lateral side of the ankle (anterior talofibular-, posterior talofibular- and calcaneofibular ligaments) that attach the lateral malleolus to the talus and calcaneus. They are much weaker than the medial deltoid ligament. "The anterior talofibular ligament is a flat band that extends anteromedially from the lateral malleolus to the neck of the talus. It is not very strong. The posterior talofibular ligament is thick and fairly strong. It runs horizontally medially and slightly posteriorly from the malleolar fossa to the lateral tubercle of the posterior process of the talus. The calcaneofibular ligament is a round cord that passes posteroinferiorly

from the tip of the lateral malleolus to the lateral surface of the calcaneus" (Moore, 1992: 488).

Norkin & Levangie (1992: 385) continues that "The ability of the Lateral collateral ligament (LCL) to check either dorsiflexion, plantarflexion, talar tilt, or talar rotation is dependent on the position of the ankle joint. The anterior talofibular ligament is the weakest and most commonly torn of the LCL's, followed by tears in the calcaneofibular ligament. Rupture of the anterior talofibular ligament invariably results in anterolateral rotatory instability of the ankle. The posterior talofibular ligament is the strongest of the collaterals and is rarely torn in isolation."

3.2.3.4 The Subtalar Joint

"The subtalar (talocalcanean) joint is distal to the ankle joint where the talus rests on, and articulates with, the calcaneus. This joint is a synovial joint between the inferior surface of the body of the talus and the superior surface of the calcaneus. It is surrounded by an articular capsule, which is attached near the margins of the articular facets" (Moore, 1992: 490).

Norkin & Levangie (1992: 388) express that "The subtalar joint's ligamentous support is ample and strong. The interosseous talocalcaneal ligament lies within the tarsal canal and has both anterior and posterior bands. It is extremely strong, being predominantly composed of collagen with little elastin; this ligament must be severed to fully open the subtalar joint. Occasional reference is also made to a smaller ligament lying lateral to the interosseous talocalcaneal ligament, but still within the tarsal canal. This is the ligamentum cervicis. The MCL and LCL of the ankle also

cross and, presumably, lend some support to the subtalar joint. Additional reinforcement at the subtalar joint is provided by the posterior and lateral talocalcaneal ligaments."

3.2.3.5 Transverse Tarsal Joint

According to Norkin & Levangie (1992: 395), "The transverse tarsal (midtarsal) joint is a compound joint formed by the talonavicular and calcaneocuboid joints. Since the talonavicular joint is classically considered to be part of the transverse tarsal joint, it belongs to two joint complexes: the talocalcaneonavicular joint and the transverse tarsal joint. The other component of the transverse tarsal joint is the calcaneocuboid joint. The two joints together present an S-shaped joint line that transects the foot horizontally, dividing the hindfoot from the midfoot and forefoot. Like the navicular, the cuboid is essentially immobile in the weight-bearing foot. Transverse tarsal joint motion, therefore, is considered to be motion of the talus and of the calcaneus on the relatively fixed naviculocuboid unit."

3.2.3.6 Tarsometatarsal Joints

"The tarsometatarsal (TMT) joints are plane synovial joints formed by the distal tarsal row posteriorly and by the bases of the metatarsals. The first TMT joint is the articulation between the base of the first metatarsal and the medial cuneiform. It has its own articular capsule. The second TMT joint is the articulation of the base of the second metatarsal with a mortise formed by the middle cuneiform and the sides of the medial and lateral cuneiforms. This joint is set back more posteriorly than the other TMT joints; it is stronger and its motion more restricted. The third TMT joint, formed by the third metatarsal and the lateral cuneiform, shares a capsule with the second

TMT joint. The fourth and fifth TMT joints are formed by the bases of the fourth and fifth metatarsals with the cuboid. These two joints also share a joint capsule. There are also small plane articulations between the bases of the metatarsals to permit motion of one metatarsal on the next. Each tarsometatarsal joint is reinforced by numerous dorsal, plantar, and interosseous ligaments" (Norkin & Levangie, 1992: 399).

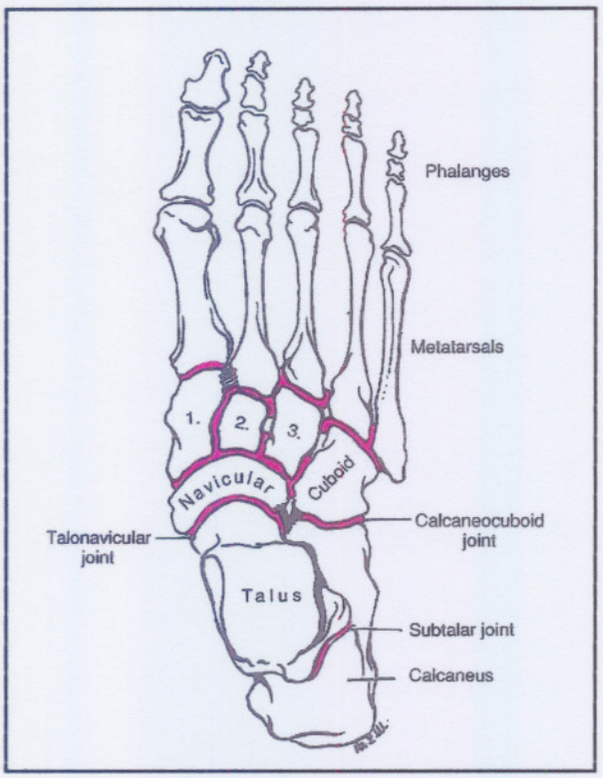
3.2.3.7 Metatarsophalangeal Joints

Moore (1992: 493) states: "These articulations between the heads of the metatarsals and the bases of the proximal phalanges are the knuckle like condyloid type of synovial joint. They permit flexion, extension, and some abduction, adduction and circumduction. The first metatarsophalangeal joint is by far the largest articulation because of the size of the head of the first metatarsal bone and the presence of the sesamoid bones in the two tendons of the flexor hallucis brevis muscle. An articular capsule surrounds each joint and is attached near the margins of the articular surfaces of the involved bones. The articular surfaces pass well onto the dorsal and plantar surfaces of the metatarsal bone. The articular surfaces of the first metatarsophalangeal joint are particularly large and are related to dorsiflexion of the great toe during walking. The fibrous capsules of the metatarsophalangeal joints are strengthened on each side by thick collateral ligaments. The plantar part of the capsule is greatly thickened to form the plantar ligament. This fibrocartilaginous plate is firmly attached to the proximal border of the phalanx and forms part of the socket for the head of the first metatarsal. The margins of the plantar ligament give attachment to the fibrous flexor sheath, to slips of the plantar aponeurosis, and to the deep transverse metatarsal ligaments."

3.2.3.8 Interphalangeal Joints

The interphalangeal joints, or IP joints, of the toes are synovial type of hinge joints which only permit flexion and extension. This is known as one degree of freedom of movement. There are five proximal IP joints in the toes. The lateral four toes each also has a distal IP joint (Norkin & Levangie, 1992: 405).

Figure 3.7 Dorsal aspect of the bones of the right foot, showing six separate joint cavities in red (Moore, 1992: 491).



3.2.4 Nerve Supply of the Lower Leg

3.2.4.1 Tibial Nerve

Meiring *et al.* (2000:673) states "The tibial nerve is the largest branch of the sciatic nerve. It passes through the popliteal fossa, superficial to the popliteal vein and artery and then runs through the posterior compartment of the lower leg to the back of the medial malleolus, where it divides into the medial and lateral plantar nerves." The nerve branches to supply the following muscles: Gatrocnemius, Plantaris, Soleus, Flexor hallucis longus, Flexor digitorum longus, Tibialis posterior and Popliteus. It

also supplies the knee joint articulation of innervation and cutaneously it branches off to form the medial sural cutaneous nerve and a calcaneal branch medially.

3.2.4.2 Common Fibular Nerve

This nerve runs laterally through the popliteal fossa and then divides in to superficial and deep fibular nerves. It has two cutaneous branches namely the sural cutaneous nerve and the sural communicating branch (Meiring *et al.*, 2000:673).

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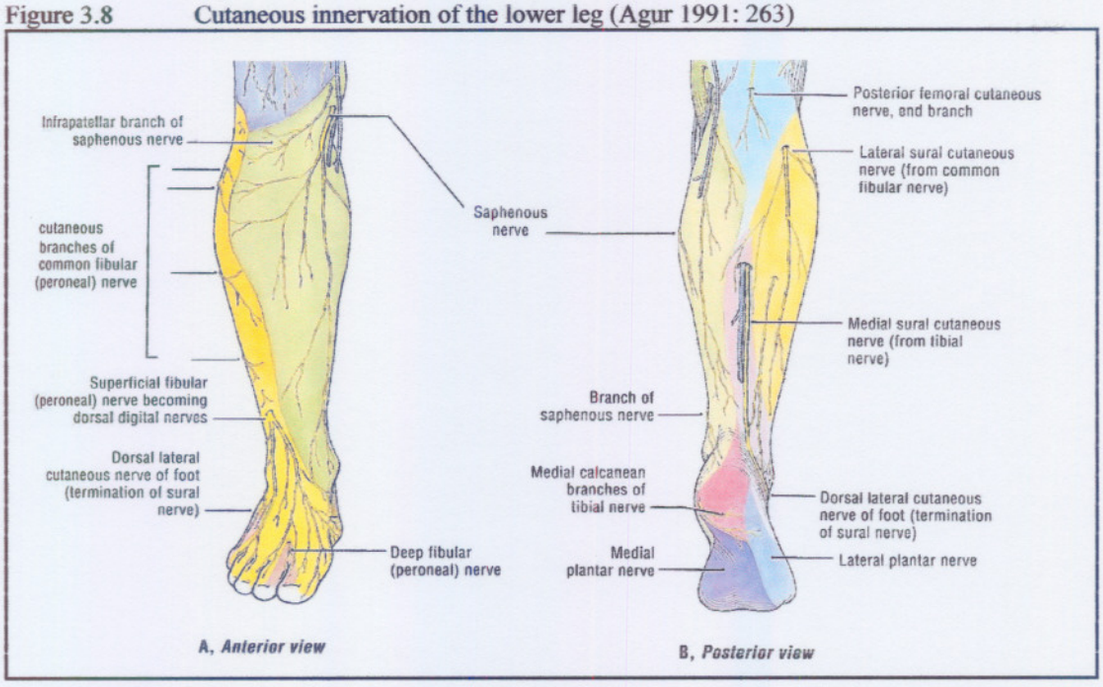
3.2.4.2.1 Superficial Fibular Nerve

This nerve passes to the lateral compartment of the lower leg and extends to the dorsum of the foot. It innervates the Peroneus longus and Peroneus brevis muscles. Cutaneously it supplies the lateral side of the distal third of the leg and the dorsum of the foot, except the space between the first two toes (Meiring *et al.*, 2000:673).

3.2.4.2.2 Deep fibular nerve

"This nerve passes to the anterior compartment of the lower leg, then anterior to the ankle and over the dorsum of the foot next to the dorsalis pedis artery". It innervates the muscles of the anterior compartment, namely: Tibialis anterior, Extensor hallucis longus, Extensor digitorum longus and Peroneus tertius. Cutaneously it supplies the space between the first and second toes (Meiring *et al.*, 2000:674).

Figure 3.8 Cutaneous innervation of the lower leg (Agur 1991: 263)



3.2.5 Blood Supply of the Lower Leg

3.2.5.1 Arterial Supply

3.2.5.1.1 Anterior Tibial Artery

Moore (1992: 447) states "The smaller of the terminal branches of the popliteal artery, the anterior tibial begins opposite the inferior border of the popliteus muscle. It ends at the ankle joint, midway between the malleoli where it becomes the dorsalis pedis artery. It supplies the structures in the anterior compartmentof the lower leg. From its origin, the anterior tibial artery passes anteriorly through the interosseus membrane. It then descends on the anterior surface of this membrane between the extensor hallucis longus and tibialis anterior muscles with the deep fibular nerve. In the distal part of the leg, the anterior tibial artery lies on the tibia. The anterior tibial artery has several branches besides the structures it supplies in the anterior compartment. The anterior and posterior tibial recurrent arteries join the anastomoses around the knee and the medial and lateral anterior malleolar arteries ramify over the medial and lateral malleoli respectively, contributing to the arterial network around the ankle."

The dorsalis pedis artery branches into the medial and lateral tarsal branches at the ankle. It also branches into the first metatarsal artery that supplies the space between the first two toes. The arcuate artery supplies the four dorsal metatarsal branches. It also branches into the deep plantar artery (Meiring *et al.*, 2000:647).

3.2.5.1.2 Posterior tibial artery

"This is the largest branch of the politeal artery. It arises at the lower border of the popliteus and runs downwards in tibialis posterior, deep to the superficial muscles and the transverse septum. Distally, the artery lies 2.5cm in front of the medial border of the calcaneal tendon. Behind the medial malleolus, beneath the flexor retinakulum, it divides into the medial and lateral plantar arteries, which supply the sole of the foot. "It has the following branches: The fibular artery, which is the largest branch and runs laterally, supplying the muscles of the posterior and lateral compartments and the fibular nutrient artery. It has other muscular branches as well as the tibial nutrient artery and the calcaneal branch to the heel" (Meiring *et al.*, 2000:652).

3.2.5.2 Venous Supply

3.2.5.2.1 Deep Veins

Meiring *et al.* (2000:664) states "Two venae comitantes accompany each artery of the lower leg, of which the politeal vein and the femoral vein are examples. The blood flows proximally in the deep veins with the aid of valves, muscular contraction (calf pump), pulsating of the arteries next to these veins and pressure changes in the thorax."

3.2.5.2.2 Superficial Veins

"They arise from the dorsum of the foot and give rise to two main veins, namely the great saphenous vein and the small saphenous vein, which run superficially to the deep fascia. The dorsal venous arch is formed by the plantar veins from the toes by means of numerous veins around the medial and lateral sides of the foot and between the metatarsals. The great saphenous vein arises from the medial arch and the small saphenous vein arises from the lateral side. The small saphenous vein runs along the lateral border of the calcaneal tendon. In the middle of the calf it runs superficial to the calcaneal tendon and gastrocnemius to the popliteal fossa, where it ends in the popliteal vein." It sometimes communicates with the greater saphenous vein and receives several tributaries along its length (Meiring *et al.*, 2000:664).

The greater saphenous vein runs upwards in front of the medial malleolus. "It then ascends obliquely upwards over the medial side of the calf in relation to the saphenous nerve. At the knee it lays a hand's breadth posterior to the medial side of the patella" (Meiring *et al.*, 2000:664).

3.3 PHYSIOLOGY OF PLYOMETRICS, PROPRIOCEPTION AND BALANCE

3.3.1 Physiology of Plyometrics

The term "Plyometrics" refers to exercises that enable a muscle to reach maximal strength in as short a time as possible. Such exercises usually involve some form of jumping, but other modes of exercise exist. The elements "ply" and "metric" come from the Latin roots for "increase" and "measure" respectively. The combination thus means "measurable increase" (Allerheiligen, 1994: 319).

The human body is continuously subjected to external forces and impacts, against which muscles contract. Their contractions (or actions) are both negative (eccentric) and positive (concentric). In eccentric contractions, the muscles undergo tension and lengthen or stretch; in concentric contractions they undergo tension and shorten. Any external force a muscle experiences that is greater than its internal tension force allows it to lengthen in an eccentric contraction. This type of contraction enables a muscle to brake skeletal movements or to decelerate the movement. An eccentric contraction allows a muscle to sustain greater tension than it can develop in an isometric position (Radcliffe & Farentinos, 1999: 2).

The goal of plyometric training is to decrease the amount of time required between the yielding eccentric muscle contraction and the initiation of the overcoming concentric contraction. Normal physiological movement rarely begins from a static starting position but rather is preceded by an eccentric pre-stretch that loads the muscle and prepares it for the ensuing concentric contraction. The coupling of this eccentric-concentric muscle contraction is known as the stretch-shortening cycle. The physiology of this stretch-shortening cycle can be broken down into two components: proprioceptive reflexes and the elastic properties of muscle fibres. These components work together to produce a response (Voight & Tippett, 1999: 158).

The muscle has three components that are involved in the mechanical process of force output. They are the contractile component, the series elastic component and the parallel elastic component. When eccentric contraction occurs, the muscle lengthens like a spring. With this lengthening the series elastic component is also stretched and

allowed to contribute to overall force production. The total force is thus equal to the sum of the force of the contractile component and the stretching of the series elastic component. This is similar to the stretching of a rubber band, which can the release the stored energy. Significant increases in concentric muscle force production have been documented when immediately preceded by an eccentric contraction. The concentric contraction can, however, only be magnified if the preceding eccentric contraction is of short range and performed quickly and without delay (Voight & Tippett, 1999: 159).

A good term to describe the time from the eccentric stretch to the concentric contraction is "elastic-reactive". What is important in elastic reactivity is the impulse, or the force that stars a body into motion, and the motion this force produces. Greater impulses relates to better efficiency. When greater stretches precede positive work, they produce increased mechanical efficiency. Called "potentiation", these mechanics explain synergistically augmented energy levels and heightened effectiveness (Radcliffe & Farentinos, 1999: 4).

The rapid eccentric movement evokes the stretch reflex, or stretch shortening cycle, which results in greater concentric contraction of the same muscles. The main mechanism of this stretch reflex is the muscle spindle. Muscle spindles are sensory mechanisms located within the intrafusal muscles that run parallel with extrafusal muscle fibres. Muscle spindles are sensitive to the rate and magnitude of the stretch. A sensory neuron from the muscle spindle innervates with a motor neuron in the spinal cord. The motor neuron then causes a contraction in the muscle (extrafusal

fibres) that was previously stretched. This process protects the muscle from excessive rapid stretching and injury (Allerheiligen, 1994: 320).

Another muscle organ involved in this process is the Golgi tendon organ which lies within the muscle tendon near the point of attachment of the muscle fibre to the tendon. The Golgi tendon organ actually has an inhibiting effect on the muscle by contributing to a tension limiting reflex. Because the Golgi tendon organs are in a series alignment with the contracting muscle fibres, they become activated by tension within the muscle. With activation, sensory impulses are transmitted to the central nervous system. These impulses inhibit the alpha motor neurons in the muscle, limiting the amount of force produced and reducing the excitation of the muscle. The muscle spindle and Golgi tendon organ systems oppose each other, and increasing force is produced. The descending neural pathways from the brain help to balance these forces and ultimately control which reflex will dominate (Voight & Tippett, 1999: 160).

3.3.1.1 Injury Prevention Qualities of Plyometric Training

Sportsmen possess above average conscious appreciation of joint position and motion. Many sports activities subject the lower extremity to plyometric types of activities. These activities may be partially responsible for enhanced proprioception when considering the effects of muscle contraction and chronic neural adaptations on proprioception. The sensitivity of muscle spindles, and thus proprioception, is heightened when muscles are voluntarily contracted. The preparatory muscle contractions needed for plyometric activities serve to protect the joint but also increase sensory feedback to the central nervous system. Long term adaptations that

occur in Golgi-Tendon Organs and muscle spindles may also improve proprioception. This combined effect would be very beneficial during rehabilitation because the sportsman is able to protect against joint positions where he is vulnerable to injury (Swanik & Swanik, 1999).

Moss (2002) states that adequate power is an essential component that is necessary for an injured sportsman to return to activity. The criteria that are used for return to play should go hand in hand with the criteria used to help prevent injury. If a sportsman returns to play without adequate preparation for all the facets, he is being set up for poor performance and injury. A good way to develop power and prevent re-injury or any injury is to use plyometric methods.

In research done by Margison *et al.* (2005), it was found that a prior bout of plyometrics appeared to provide children with some protection from soreness after a subsequent bout of plyometric exercise. Repeated plyometric exercise bouts thus prepare the body and protect it from soreness after subsequent bouts. As sprinting is a form of plyometric exercise, this could have positive results for rugby players protecting them from muscle soreness after repetitive sprinting in matches if plyometrics are included in training.

Plyometric exercise trains the neuromuscular system by teaching it to more readily accept increased strength loads. This goal will help to ensure the body is prepared to accept the stress that will be placed upon it during return to function (Voight & Tippett, 1999:161). This will help to reduce future injuries.

Generally there is a limited amount of literature concerning the influence of plyometric strength on injuries. This study aims to increase the amount of literature available on the subject.

3.3.2 Physiology of Proprioception

Iturri (2003) defines proprioception as "a special type of sensitivity that informs about sensations of the deep organs and the relationship between muscles and joints".

In 1906, Sherrington classically defined proprioception as "the perception of the joint and body movement as well as the position of the body or body segments in space" (Shield, Madhavan, Cole, Brostad, Demeulenaere, Eggers & Otten, 2005)

The proprioceptive system has some functions which are sensory and others which are not. The sensory functions, collectively termed "proprioception", involve awareness of the spatial and mechanical status of the musculoskeletal framework. They include the senses of position, movement and balance. Proprioceptive sensation is integral to develop motor control when learning new skills. The contribution of the proprioceptive system to motor control during learned skills, however, is largely mediated without sensation; as are the roles in reflex protection of joints against potentially harmful forces and protection of the body against falls (balance) (Stillman, 2002).

Individuals can be aware of an impression of the functional state of joints and muscles. This is called "conscious proprioceptive sensation". It includes awareness of active and passive movements and the attitude or position of a somatic part of the

body. If the individual is unaware of the specific proprioceptive stimuli, it is referred to as unconscious proprioceptive sensation. This includes balance, muscle tone and muscular coordination. There is also a special proprioceptive sensation, called labyrinthine. This is located in the inner ear (Iturri, 2003).

Peripheral receptors for proprioception, called mechanoreceptors, are located in articular structures, tendons, muscle and skin. Mechanoreceptors are special nerve endings that depolarize in response to tissue deformation. Therefore, mechanical deformation is transduced into neural signals (Lephart *et al.*, 1998).

Mechanoreceptors vary in shape, location and function and can be classified according to their responses to mechanical stimuli. They are either slow-adapting or quick-adapting and either low threshold or high-threshold. Quick-adapting mechanoreceptors decrease their discharge rate to extinction within milliseconds of the onset of a continuous stimulus, while slow-acting mechanoreceptors continue to discharge. Quick-acting receptors are very sensitive to changes in stimulation and are therefore thought to mediate the sensation of joint motion, while slow acting receptors are maximally stimulated at specific joint angles and are thought to mediate the sensation of joint position (Lephart *et al.*, 1998).

All nerve endings, both superficial-general exteroreceptive (touch, pressure, pain and temperature) and special (sight and hearing); and deep-general proprioceptive (articular and muscular), visceral, general interoceptive and special (taste and smell) are involved in proprioception. The nervous levels used include: the medullar segmentary level, the suprasegmentery level with the brainstem; and the cortical level.

The activity of these levels is conditioned by specific and non-specific sensory afferent nerves. Cutaneous, articular, tendinous and muscular afferent nerves follow the lemniscal path to the somatognostic areas, alert the cerebral cortex and produce proprioceptive sensation. The use of proprioceptive mechanisms helps to correct or perfect motor abilities and conscious proprioceptive perception provides awareness of posture and recognition of the body schema (Iturri, 2003).

3.3.3 Physiology of Balance

According to Guskiewicz (1999) balance is the single most important element dictating movement strategies within the closed kinetic chain. Although balance is often though of as a static process, it is actually a highly integrative dynamic process involving multiple neurological pathways. Balance is the more commonly used term; the broader term postural equilibrium refers to the alignment of joint segments in the effort to maintain the center of gravity within an optimal range.

Balance is the process by which we control the body's center of mass with respect to the base of support, whether it is stationary or moving. Balance could be defined in three ways: the ability to maintain a position, the ability to voluntarily move and the ability to react to a perturbation. All three components of balance are important in the ability to maintain an upright posture. Static balance refers to an individual's ability to maintain a stable antigravity position while at rest by maintaining the center of mass within the available base of support. Dynamic balance involves automatic postural responses to the disruption of the center of mass position (Blackburn & Voight, 2001).

The postural control system operates as a feedback control circuit between the brain and musculoskeletal system. Involvement of the central nervous system in maintaining upright posture can be divided into two components. The first component, sensory organisation, involves those processes that determine the timing, direction and amplitude of corrective postural actions based upon information obtained from the vestibular, visual and proprioceptive inputs. The second component, muscle coordination, is the collection of processes that determine the temporal sequencing and distribution of contractile activity among the muscles of the legs and trunk that generate supportive reactions for maintaining balance (Guskiewicz, 1999).

The body uses three systems to keep itself upright against gravity. The vestibular system centred in the inner ear is the mainstay of the balance mechanism. This mechanism is enhanced by input from vision. It is further assisted by information from the mechanoreceptors. Research has shown that injury damages these mechanoreceptors. This damage will cause a diminished ability to know where the joint is in space and an inability to detect motion. This directly affects skilled movements and indirectly affects balance (Blackburn & Voight, 2001).

3.3.3.1 Injury Prevention Qualities of Proprioceptive and Balance Training

The ability of athletes to control the position of their center of gravity has received attention as a potential risk factor for lower extremity injury because increased variation in postural stability is associated with an altered neuromuscular control strategy; increased intersegmental joint forces and corresponding increased forces

developed about articular, ligamanetous and muscular structures (Murphy *et al.*, 2003).

Several studies have shown that ankle proprioception and balance have an influence on ankle injuries (Stasinopoulos, 2004; Verhagen *et al.*, 2004; Baltaci & Kohl, 2003; Anderson) as well as lower limb injuries (Murphy *et al.*, 2003; Baltaci & Kohl, 2003; Anderson).

Using pre-season testing of high school and collegiate athletes, Trojian and McKeag (2006) demonstrated a significant association between a positive single leg balance test and ankle sprains. In athletes with a positive single leg balance test, not taping the ankle imposed an increased risk of sprain. They proposed that the single leg balance test is a reliable and valid test for predicting ankle sprains. Two hundred and thirty athletes in men's American Football, men's and women's soccer and women's volleyball took part in the study.

Baltaci and Kohl (2003) did a literature review on the influence of proprioceptive and balance training on ankle and knee injuries. Three studies they evaluated showed an improvement in balance following a 6-week, 8-week and 10-week training period. This improvement was greater in patients with previous injury. It was shown that ankle proprioceptive training has decreased functional instability in ankles and decreased the incidence of re-injury. Functional ankle instability is associated with increased risk of injury. Proprioceptive training was shown to decrease postural sway and the risk of injury in sports and everyday activities. It also stated that ankle disk

training can be used as exercise in sports medicine clinics to help protect against ankle sprains and heal ankle sprains as soon as possible.

In a study conducted by Verhagen *et al.* (2004) on 288 teams of volleyball players of the second and third Dutch divisions, it was shown that the intervention group that was put on a proprioceptive balance board programme had a lower incidence of ankle injuries than a control group. This lower incidence was, however, limited to participants with previous ankle injuries. It shows the preventative potential of balance board programmes on ankle injuries. The same programme was used by Verhagen, Bobbert, Inklaar, Van Kalken, Van der Beek and Van Mechelen (2005a) to test whether it had any influence on postural sway in previously injured and non-injured students over a 5 and a half week period. There were no changes in the centre of pressure excursion between any of the groups in this study.

Fifty two Greek volleyball players with previous ankle injuries were used for a study to compare the influence of preventative taping, technical training and proprioceptive training in the reduction of ankle sprains. The study showed that proprioceptive training was effective in decreasing further ankle sprains (Stasinopolous, 2004).

Mattacola and Lloyd (1997) did a 6-week study on three subjects with 1st degree ankle ligament injuries. These subjects were put on a training programme consisting of manual muscle strengthening and proprioception exercises. Dynamic balance was tested three times a week on a single plane balance board. Although the intervention did not produce obvious improvements in balance for all evaluation criteria for all conditions, it was apparent that the strength and proprioception programme positively

influenced all three subjects' ability to balance dynamically on the balance board. Powers, Buckly, Kaminski, Hubbardt and Ortiz (2004) used thirty eight subjects with unilateral functional ankle instability to determine whether the combined effects of 6 weeks of strength and proprioception training had any effect on muscle fatigue and static balance. This study, however, showed that strength training, proprioception training and the combination of the two failed to improve postural stability characteristics.

Rozzi, Lephart, Sterner and Kuligowski (1999) conducted a research study on the effect of a 4-week balance training programme on single leg stance. This study included subject with functionally unstable ankles as well as subjects with non-impaired ankles. Following training, subjects from both groups demonstrated significant improvements in balance ability. Subjects conducted their balance training on a Biodex Stability Training System, training three times a week. This study suggests that balance training is an effective means of improving joint proprioception and single-leg standing ability in subjects with unstable and non-impaired ankles.

A hundred and twenty seven students from ten high schools in Calgary, Canada, took part in a 6-week wobble-board home training programme. Sixty six students formed part of the intervention group, which did daily wobble board exercises for 6 weeks. They then continued with the exercises once a week for 6 months. Self-reported injury data was also collected for 6 months. The control group was only tested along with the intervention group. At 6 weeks, the intervention group showed improvements in static and dynamic balance while the control group did not. There was evidence of a

protective effect of balance training for a period of over 6 months, reducing sports-related injuries amongst the participants (Emery *et al.*, 2005).

Clark and Burden (2005) used nineteen male participants with functionally unstable ankles to investigate the effects of wobble-board training on the onset of muscle activity and perception of stability. Ten participants were placed on a monitored wobble board programme, which was done three times a week for 10 minutes. The other nine participants served as control. Post training, the exercise group showed a significant decrease in muscle onset latency and a significant improvement in perception of their functional stability. This showed that wobble board exercises reduce the likelihood of further sprains in individuals with functionally unstable ankles.

3.4 THE INVOLVEMENT OF PLYOMETRIC STRENGTH, PROPRIOCEPTION AND BALANCE IN IDENTIFYING TALENT IN RUGBY PLAYERS

Various studies have been done on talent identification in rugby players. As a sub-aim, this study will examine whether plyometrics, balance and proprioception could be further integrated as components of the physical motor tests in existing talent identification programmes.

Abbott, Collins, Martindale and Sowerby (2002) stated that the aim of talent identification and detection is to provide an accurate prediction of individuals who have the necessary potential to compete successfully at world class level. In order for

individuals to successfully acquire sporting skills, the underlying fundamental motor skills for the specific sport need to be developed as well.

Hanekom (2000) conducted a study on one hundred and twenty U/17 and one hundred and twenty U/19 rugby players in the North West Province. This study investigated anthropometric, physical and rugby skills related parameters for involvement in performance capabilities of senior secondary players. Physical motor parameters that were used in this study included muscle suppleness; speed, speed endurance and agility tests; grip strength; static back muscle strength; vertical jump test; single leg jump tests and push ups. It was shown in this study that improved speed and acceleration could possibly be attributed to increased vertical plyometric strength and muscle suppleness. Proprioception and balance were not part of the test battery in this study.

Further research was done by Hanekom (2003) to examine which were the best indicators for determining suitable conditioning programmes that would lead to improved performance of U/19, U/21 and senior elite club rugby players. This study showed that improvements in strength (bench press and squat), speed and agility were the best indicators of the success of a conditioning programme for performance improvement.

Van Gent (2003) conducted research to determine the positional requirements for U/13, U/16, U/18 and U/19 rugby players with regard to anthropometric; game specific and physical and motor tests. North West provincial players were used in this study. Physical motor tests included a vertical jump test. In U/19 players, vertical

jump test values were identified as one of the values used to discriminate between tight forwards, loose forwards, scrum- and flyhalf and backline players. The other variables used for discrimination were speed over 30m; ankle girth; ground skills and thigh girth. Once again, balance and proprioception were not included in the test battery.

Pretorius (1997) used anthropometric, game specific and physical motor abilities for talent identification purposes in 10 year old rugby players in the North West Province. This was used to determine positional specific parameters of talent identification. In the top teams, it was found that plyometric performance of wings and centres played a statistically significant part in distinguishing them from their opponents in less successful teams. Proprioception and balance were not included in the test battery of this study.

Van der Merwe (1997) conducted research on two hundred and fifty 11-year old black schoolboys from the Carltonville area in the North West Province. Talent identification was done on these boys to determine levels of talent and a programme was developed to increase these talent levels. The test battery used to determine improvement included seventeen tests. The physical motor tests were suppleness; bent arm hang; pull-ups; vertical jump; speed; agility; dodging runs and speed endurance.

De la Port (2004) conducted research on compiling a physical and game skill profile for elite South African schoolboy rugby players. The players used for this study were the Green squad players identified by the South African Rugby Football Union. This group consisted of the top 100 U/16 and U/18 rugby players in the country.

Anthropometric, game skills, physical and motor tests were used to evaluate the players. The physical and motor tests that were used were: Speed test; Explosive leg power (vertical jump); Agility (Illinois test); strength (1 repetition maximum bench press); underhand pull ups; push ups and speed endurance (multistage shuttle run). The test criteria were used to compile a profile of the elite schoolboy rugby player for future talent identification purposes. Balance and proprioception were absent from the test battery.

Literature shows that plyometric strength is widely included in rugby talent identification test batteries in various forms. It is however, not used in isolation, but combined with a large number of other variables. There is no apparent literature that shows balance or proprioception included in test batteries for rugby talent identification. This study will help to increase the available literature on this aspect to determine whether these variables might be included in future talent identification test batteries.

3.5 SUMMARY

This chapter reviewed the anatomy of the lower leg, which is important background for any study concerned with lower leg injuries. It also examined the physiology and injury prevention qualities of plyometrics, proprioception and balance. These are important as basis for the empirical investigation, which will investigate the influence of these factors on lower leg injuries and also for the creation of a training programme for the prevention of these injuries. The involvement of these three factors in rugby talent identification was also examined.

CHAPTER 4

EMPIRICAL INVESTIGATION

4.1 INTRODUCTION

4.2 STUDY POPULATION

4.3 TEST PROTOCOL

4.3.1 Test Battery

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4.4 INJURY CLINICS AND EXPOSURE RECORDING

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4.6 SUMMARY

CHAPTER 4

EMPIRICAL INVESTIGATION

4.1 INTRODUCTION

With the amount and severity of rugby injuries increasing each year, research into preventative measures is very important. The aim of this study is to investigate the influence of proprioception, balance and plyometric power on the occurrence of lower leg injuries and to compile a preventative training programme. The aim of this chapter is to explain the different components involved in data collection for the empirical investigation.

4.2 STUDY POPULATION

The research population of this study consisted of two hundred and forty adolescent schoolboy rugby players. The players attended two different schools in the Potchefstroom area. Eight teams in each school were selected to take part in the study. These teams were the U/14 A- and B-teams; the U/15 A- and B-teams; the U/16 A- and B-teams and the U/18 A- and B-teams. Dates and times of testing were prearranged with the rugby organisers of each school and took place over a two week period at the beginning of the season, in March 2006. Members of the different age groups taking part in the study were tested separately.

4.3 TEST PROTOCOL

Prior to participation in the study, the parents or legal guardians of the schoolboy rugby players signed an informed consent form (Annexure A) to give approval for

participation in this study. Participants from each school were all tested in the same venue at each school.

Three different tests were used for data collection in this study. These tests were: The Star Excursion Balance Test; a computerised balance board proprioception and balance test and a plyometric test using a timing mat. The test results were recorded on a test result sheet (Annexure C). Participants were tested at the beginning of the season after completing an injury history questionnaire (Annexure B). This questionnaire was used to exclude players with current injuries from the testing procedures.

On the testing dates, players were given an explanation of the different tests and the reason for the conduction of the testing. Participants were instructed to complete an injury history questionnaire prior to commencement of the testing. Tests were conducted in a non-specific order and participants were given more than 5 minutes of rest between the administration of each different test. Each participant was requested to complete all three tests before departing from the test area.

4.3.1 Test Battery

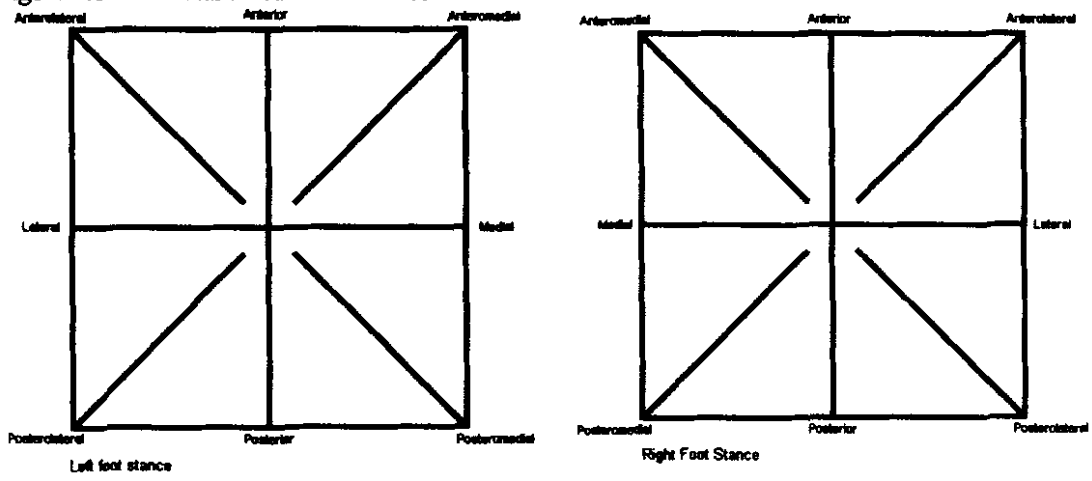
4.3.1.1 Star Excursion Balance Test

Measuring postural control is important for establishing levels of function for the purpose of injury prevention and rehabilitation. Testing dynamic postural control often involves completing a functional task without compromising one's base of support. The Star Excursion Balance Test (SEBT) is a test that significantly challenges an athlete's dynamic postural-control system (Gribble, 2003).

Olmsted *et al.* (2002) showed that the SEBT is an effective means to determine reach deficits within patients with unilateral chronic ankle instability. Distances reached were significantly less when subjects stood on their injured limb as compared to their normal limb.

The SEBT involves that the test subject stands on one foot in the center of an eight line star patterned grid with 45° increments between the lines. The subject then reaches in each of the eight directions with the other foot while maintaining dynamic balance. According to Gribble (2003:46) the test was first introduced by Gray in 1995.

Figure 4.1 Star Excursion Balance Test Grid



Prior to testing an eight lined grid at 45° angles (Figure 1) was measured out on a square vinyl mat. Each line was marked with a cross line 20cm from the center point, to facilitate easier measuring during the testing procedure. The test was explained and demonstrated to the participants. Participants were instructed to practice the procedure 6 times in each direction with each foot, on a separate grid prior to the test commencement. This was done to minimise the learning effect (Hertel, Miller & Denegar, 2000).

Participants started with their left foot on the middle of the grid and reached out with their right foot in each of the eight directions. They started in the middle front (anterior) and then moved around the grid in a clockwise direction. Participants were instructed to reach out and touch the line with their right foot and then return the foot to the middle of the grid. After each reach and touch, the researcher measured the distance from the touch to the 20cm cross line with a standard 1m ruler. The distance was then recorded on the test result sheet, with the 20cm being added before the data was used for statistical analysis. After completion of a full circle with the right foot, a right foot stance was adopted. The left foot was then used to reach out starting with the front (anterior) and moving in a counter clockwise direction. The reach distances were measured and recorded as previously explained.

As was done in most other research using the SEBT (Gribble, 2003; Olmsted, Carcia, Hertel & Schultz, 2002; Hertel *et al.*, 2000) trials were discarded and repeated if a subject did not touch the line with the reach foot while maintaining weight bearing on the stance leg; lifted the stance foot from the center grid; lost balance at any point in the trial; or did not maintain the start and return positions for a second. If a subject was judged by the examiner to have touched down with the reach foot in such a manner that his reach leg considerably supported his weight, the trial was discarded as well and was repeated.

4.3.1.2 Computerised Proprioception and Balance Test

A computerised proprioception and balance test was administered using a Techno Therapy computerised balance test system. The system consists of a balance board

attached to a computer with the necessary software via a serial cable. The balance board has sensors underneath which respond to pressure. If the side of the balance board touches the ground (imbalance) it is recorded by sensors and registered on the computer software. The computer software gives a percentage score for balance based on the percentage of time the sides of the balance board are not in contact with the ground. This test is run for a period of 30 seconds.

As already stated, the body uses three systems to keep itself upright against gravity. The vestibular system centred in the inner ear is the mainstay of the balance mechanism. This mechanism is enhanced by input from vision. It is further assisted by information from the mechanoreceptors (proprioceptors) (Blackburn & Voight, 2001:2). If vision is removed, more focus will be placed on the input from proprioceptors. This test was administered with eyes closed, to focus more on the proprioceptive component of balance.

Participants were instructed to stand on the balance board. They could position their legs as they saw fit and could also use their arms to help keep balance. They were instructed to find their balance and then close their eyes. The test was then commenced. Participants had to keep their balance for 30 seconds with closed eyes. The examiner made certain that the participants kept their eyes closed for the duration of the test. At the end of 30 seconds the computer provided a percentage score. This score was then recorded on the participant's results sheet. According to the Techno Therapy Manual (Techno Therapy, 1992:14) the general test scores for a person with their eyes closed should be between 50% and 60%. Ideally, sportsmen should test

above the average values for the normal population. An average test score for a normal person would thus be a below average score for a sportsman.

4.3.1.3 Plyometric Test

For plyometric testing a vertical jump test, also known as the Sergeant jump test, was used. This test was administered using a Tapeswitch timing mat which was connected to a Psion personal organiser with the correct software installed. This measures the time the feet are off the mat during jumping. From this elapsed time, jump height can be calculated by the Psion computer using the installed software.

Participants were instructed to stand on the edge of the sensory mat with their feet on the sensor strips. Their hands had to be placed on their hips. The first test was conducted while jumping with both feet together, to measure bilateral vertical jump height. The participant was then instructed to jump as high as they could. Hands had to be kept on hips all through the test. They had to land with their legs nearly extended on the sensory mat to measure the height accurately. The height was then recorded on the results sheet of the participant. The test was then repeated in the exactly same manner for the left and right leg respectively for a unilateral jump height to be measured. The unilateral vertical jump tests were also performed with the hands kept on the hips all through the testing procedure. The unilateral vertical jump results were also recorded on the results sheet. If the participant did not land on the sensory mat correctly or an error occurred during the test procedure, the test was repeated.

4.4 INJURY CLINICS AND EXPOSURE RECORDING

Weekly injury clinics with injury and exposure recording formed part of the empirical investigation. Injury clinics were held once a week on Mondays all through the season to monitor injuries occurred by players in the preceding Saturday's matches. The clinics were conducted free of charge by the researcher, a qualified Physiotherapist. Rugby organisers at the different schools were informed of these clinic dates and they conveyed the message to the coaches at each school. At these clinics, players' injuries were evaluated and results were recorded on an injury report form (Annexure D). Players and coaches were given professional advice with regard to the injuries and necessary treatment thereof, as needed. Players with existing injuries were evaluated on a weekly basis to determine whether they were ready to return to practice and play. Additional evaluation of injuries could be arranged with the researcher in case of emergencies during the week.

Injuries were classified according to the grading formulated by McManus (2000) in an article devised to standardise rugby epidemiology research. A minor injury was defined as an injury in a game or practice which did not necessitate the player to stop participating. When a player missed up to one week, it was considered a mild injury. Moderate injuries caused a player to miss between one and two weeks and severe injuries caused more than two weeks worth of time off from practices and games.

Participants' exposure to practice and matches were recorded on an exposure register form. The time of exposure of each player was recorded in hours and if a player was unable to attend a practice or match, was marked as absent. This exposure recording was conducted by the coaches of each team. Using this technique, the exposure of all

the involved players of both schools could be monitored and used for statistical purposes at the end of the season.

The injury report forms and the exposure register forms were used to compile an injury profile of the season and express the injury prevalence as injuries per 1000 hours of play. There were also discerned between match and practice injuries.

4.5 STATISTICAL METHOD

Data analysis was done by means of statistical software. The SAS-computer program of the Potchefstroom campus, North West University (SAS Institute Inc., 2005) was used for this analysis. Descriptive statistics (means, standard deviation, minimum and maximum) were used as well as practical significant differences (d-values) (Cohen, 1988). Practical significant differences were measured using effect size. The standardised differences between the means of two populations, i.e. the differences between the two means divided by the estimate for standard deviation was used. The effect size makes the difference independent of units and sample size, and relates with the spread of the data (Steyn, 1999).

The following formula was used by Cohen (1988) to determine effect sizes of the difference between the means of two groups:

$$d = \frac{|\bar{x}_1 - \bar{x}_2|}{s}$$

x_1 is the mean of group 1 and x_2 is the mean of group 2. S = ½ (S1+S2), where S1 and S2 are the standard deviation of the two groups. Cohen gives the following guidelines for the interpretation of the effect size:

d = 0.2 (Small effect)

d = 0.5 (Medium effect)

d = 0.8 (Large effect).

Data with a large effect is considered to be practically significant. These values are not absolute and only serve as guidelines. A d-value of 0.75 would also be considered practically significant.

4.6 SUMMARY

This chapter gave an overview of the empirical investigation involved in this research project. Test procedures, data collection procedures and the statistical method were discussed.

CHAPTER 5

RESULTS AND DISCUSSION: PROPRIOCEPTION, BALANCE AND PLYOMETRIC TESTING

5.1 INTRODUCTION

5.2 TEST BATTERY RESULTS

5.2.1 Descriptive Statistics

5.2.2 Age Group Comparison

5.2.3 Comparison Between the Two Schools

5.2.4 Talent Identification: A- vs B-Teams

5.2.5 Position Group Comparison

5.3 SUMMARY

5.3.1 Summary of Age Group Test Results

5.3.1.1 U/14 Players

5.3.1.2 U/15 Players

5.3.1.3 U/16 Players

5.3.1.4 U/18 Players

5.3.2 Comparison Between Two Schools

5.3.3 Age Group Comparisons

5.3.4 Positional Group Comparisons

5.3.5 Comparison Between A- and B-Teams

CHAPTER 5

RESULTS AND DISCUSSION: PROPRIOCEPTION, BALANCE AND PLYOMETRIC TESTING

5.1 INTRODUCTION

The aim of this study is to examine the influence of proprioception, balance and plyometric strength in schoolboy rugby players on the occurrence of lower leg injuries in these players. It will also be determined whether proprioception, balance and plyometric strength could be used as talent identification measures.

In this chapter the results of the proprioception, balance and plyometric tests of the empirical investigation are presented and discussed. The Statistica (StatSoft, 2004) and the SAS-computer programme (SAS Institute Inc., 2005) of the North-West University, Potchefstroom campus were used for statistical data analysis.

The chapter presents the descriptive statistics (means and standard deviations) of the test battery, which will be discussed for the different teams. Comparisons were made between the different age groups, player position groups and different schools. A comparison will also be made between the A- and B-teams to determine whether the test battery could be integrated into talent identification test batteries. The results will also be compared to existing literature.

5.2 RESULTS OF PROPRIOCEPTION, BALANCE AND PLYOMETRIC TESTS

5.2.1 Descriptive Statistics

Tables 5.1 to 5.16 show the descriptive statistics of each individual team from the two different schools for balance, plyometric tests and the L+R/Bil, L/Bil and R/Bil ratios and the 8 directions of the Star Excursion Balance Test for left and right legs. The results for Boys High are shown in Tables 5.1 to 5.8. The results of Volkskool are reflected in Tables 5.9 to 5.16.

Tables 5.1 and 5.2 show the descriptive statistics for the U/14A and U/14B-teams of Boys High. The mean scores for Balance for the A- and B-teams are 62.56% and 63.17% respectively. These results are acceptable for sportsmen. According to the Techno Therapy Manual (Techno Therapy, 1992:14) the general test scores for a person with their eyes closed should be between 50% and 60%. Ideally, athletes should test above the average values for the normal population. The bilateral plyometric test mean values were 32.47 cm for the A-team and 23.33 cm for the B-team. Gabbett (2002) conducted anthropometric and physical motor research on sub-elite rugby league players in Australia. Electronic vertical jump testing was also used and reported mean values of 33.1 cm for U/14 forwards and 38.5 cm for U/14 backline players, outperforming the players in this study. Single leg plyometric means for the Boys High U/14 players ranged from 15.84 cm to 21.36 cm. Star Excursion Balance Test mean values ranged from 71.6cm to 92.7cm.

Tables 5.3 and 5.4 show the results for the Boys High U/15A- and U/15B-teams respectively. The mean values for Balance was 64.69% for the A-team and 64.93% for the B-team. These results are acceptable for athletes (Techno Therapy Manual,

1992:14). The bilateral plyometric test mean values were 37.40 cm for the A-team and 34.84 cm for the B-team. This is similar to the U/15 players in the study by Gabbett (2002:336), which showed mean results of 34.7 cm for the forwards and 37.1 cm for the backline. Star Excursion Balance Test mean values ranged from 64.6 cm to 95.4 cm. Single leg plyometric mean values were fairly similar for A- and B-team players and ranged from 20.3 cm to 23.5 cm.

The test values for the U/16A- and U/16B-teams of Boys High School are reported in Tables 5.5 and 5.6. Mean values for Balance were 65.68% for the A-team and 62.76% for the B-team; these are acceptable for athletes (Techno Therapy, 1992:14). Bilateral plyometric mean values were 31.40 cm for U/16A and 29.98 cm for U/16B. This compared poorly to the U/16 players in the study by Gabbett (2002:336), which showed values of 38.0 cm for the forwards and 41.2cm for backline players. Single leg plyometric test mean values ranged between 18.02 cm and 18.36 cm. Star Excursion Balance Test mean values ranged from 63.6 cm to 87.63 cm.

Tables 5.7 and 5.8 shows the test results for the U/18A- and U/18B-teams. The mean value for Balance was 75.88% for the U/18A-team. This is above average for athletes (Techno Therapy, 1992:14). The U/18B-team mean value for Balance was 59.86% which is slightly low as far as sportsmen are concerned. The Bilateral plyometric test mean values were 37.87 cm for the A-team and 39.75 cm for the B-team. This is similar to the findings of Gabbett (2002:336) which showed mean values of 37.9 cm for forwards and 40.0 cm for backline players in the U/19 group. Star Excursion Balance Test mean values ranged from 69.4 cm to 96.07 cm. Piegaro (2003) did research on college students with an age of 21.87 +/- 2.26 years. The Star Excursion

Balance Test was one of the tests used in the study to examine the effect of core stability and balance training programs on semidynamic and dynamic balance. The pre-intervention test mean values for the students in Piegaro (2003) ranged between 66.72 cm and 95.81 cm, which are similar to the Boys High U/18 results of this study.

L+R/Bil for all teams of Boys High were fairly similar and mean values ranged from 1.16 to 1.38. L/Bil and R/Bil mean values ranged from 0.56 to 0.70.

Key to Tables:

Bil:	**Bilateral Plyometric Test**
L:	**Left Leg Plyometric Test**
R:	**Right Leg Plyometric Test**
SEBT L:	**Star Excursion Balance Test Left Leg Stance**
SEBT R:	**Star Excursion Balance Test Right Leg Stance**
A:	**Anterior**
AM:	**Anteromedial**
M:	**Medial**
PM:	**Posteromedial**
P:	**Posterior**
PL:	**Posterolateral**
L:	**Lateral**
AL:	**Anterolateral**
Std. Dev:	**Standard Deviation**
SEB_A_L:	**Left Leg Star Excursion Balance Test- Anterior**
SEB_AM_L:	**Left Leg Star Excursion Balance Test- Anteromedial**
SEB_M_L:	**Left Leg Star Excursion Balance Test- Medial**
SEB_PM_L:	**Left Leg Star Excursion Balance Test- Posteromedial**
SEB_P_L:	**Left Leg Star Excursion Balance Test- Posterior**
SEB_PL_L:	**Left Leg Star Excursion Balance Test- Posterolateral**
SEB_L_L:	**Left Leg Star Excursion Balance Test- Lateral**
SEB_AL_L:	**Left Leg Star Excursion Balance Test- Anterolateral**
SEB_A_R:	**Right Leg Star Excursion Balance Test- Anterior**
SEB_AM_R:	**Right Leg Star Excursion Balance Test- Anteromedial**
SEB_M_R:	**Right Leg Star Excursion Balance Test- Medial**
SEB_PM_R:	**Right Leg Star Excursion Balance Test- Posteromedial**
SEB_P_R:	**Right Leg Star Excursion Balance Test- Posterior**
SEB_PL_R:	**Right Leg Star Excursion Balance Test- Posterolateral**
SEB_L_R:	**Right Leg Star Excursion Balance Test- Lateral**
SEB_AL_R:	**Right Leg Star Excursion Balance Test- Anterolateral**
L+R/Bil:	**Ratio: Left + Right leg Plyometrics divided by Bilateral**
LandR/Bil:	**Ratio: Left + Right leg Plyometrics divided by Bilateral**
L/Bil:	**Ratio: Left leg Plyometrics divided by Bilateral**
R/Bil:	**Ratio: Right leg Plyometrics divided by Bilateral**

Table 5.1 Boys High School U/14A-team

	Descriptive Statistics (BHU14A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	62.55600	62.03000	53.07000	76.5300	8.49236
Bil	15	32.46667	32.00000	22.90000	48.3000	6.73569
L	15	20.82667	21.70000	13.50000	30.4000	4.98132
R	15	21.36667	19.50000	13.40000	38.7000	7.03000
SEB_A_L	15	83.33333	84.00000	72.00000	98.0000	6.99660
SEB_AM_L	15	91.86667	93.00000	80.00000	102.0000	6.40164
SEB_M_L	15	88.46667	90.00000	77.00000	95.0000	5.78010
SEB_PM_L	15	92.73333	95.00000	77.00000	106.0000	8.36205
SEB_P_L	15	88.26667	87.00000	73.00000	105.0000	8.12814
SEB_PL_L	15	78.26667	78.00000	62.00000	100.0000	11.02249
SEB_L_L	15	69.86667	67.00000	55.00000	90.0000	10.14795
SEB_AL_L	15	77.73333	76.00000	67.00000	88.0000	6.63827
SEB_A_R	15	84.80000	85.00000	69.00000	95.0000	6.52687
SEB_AM_R	15	91.13333	93.00000	80.00000	100.0000	6.27770
SEB_M_R	15	89.06667	88.00000	77.00000	100.0000	6.68117
SEB_PM_R	15	91.73333	93.00000	82.00000	103.0000	5.54806
SEB_P_R	15	87.66667	88.00000	74.00000	100.0000	7.06770
SEB_PL_R	15	81.66667	82.00000	69.00000	92.0000	6.85218
SEB_L_R	15	72.40000	73.00000	56.00000	84.0000	8.83823
SEB_AL_R	15	80.73333	82.00000	73.00000	87.0000	5.04928
L+R/Bil	15	1.30787	1.33624	0.94271	1.7072	0.24456
L/Bil	15	0.64791	0.65228	0.42188	0.8786	0.12480
R/Bil	15	0.65996	0.71616	0.37817	0.8972	0.15469

Table 5.2 Boys High School U/14B-team

	Descriptive Statistics (BHU14B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	63.16933	62.60000	46.27000	76.9000	8.88140
Bil	15	23.33333	20.50000	9.70000	38.5000	8.82461
L	15	16.33333	17.10000	3.00000	24.7000	5.69870
R	15	15.84667	16.60000	4.70000	28.1000	6.18326
SEB_A_L	15	82.46667	81.00000	65.00000	93.0000	7.81817
SEB_AM_L	15	88.60000	87.00000	68.00000	103.0000	8.96660
SEB_M_L	15	86.53333	88.00000	60.00000	103.0000	10.12681
SEB_PM_L	15	86.93333	85.00000	70.00000	100.0000	8.89997
SEB_P_L	15	85.53333	83.00000	73.00000	100.0000	7.71702
SEB_PL_L	15	83.06667	84.00000	72.00000	92.0000	6.23889
SEB_L_L	15	71.60000	73.00000	45.00000	89.0000	10.06266
SEB_AL_L	15	81.20000	81.00000	70.00000	92.0000	6.30419
SEB_A_R	15	82.13333	79.00000	71.00000	98.0000	8.55960
SEB_AM_R	15	88.20000	88.00000	75.00000	102.0000	8.35977
SEB_M_R	15	85.00000	85.00000	65.00000	100.0000	8.45999
SEB_PM_R	15	88.46667	90.00000	60.00000	106.0000	11.11541
SEB_P_R	15	83.86667	80.00000	73.00000	100.0000	8.65090
SEB_PL_R	15	79.80000	82.00000	56.00000	97.0000	9.32125
SEB_L_R	15	71.60000	70.00000	40.00000	92.0000	12.85524
SEB_AL_R	15	83.40000	83.00000	72.00000	95.0000	7.36594
L+R/Bil	15	1.38215	1.37952	0.79381	1.7579	0.27345
L/Bil	15	0.70342	0.72103	0.30928	0.9104	0.16150
R/Bil	15	0.67873	0.72165	0.47802	0.9158	0.14493

Table 5.3 Boys High School U/15A-team

	Descriptive Statistics (BHU15A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	64.69333	63.00000	47.00000	83.0000	11.85553
Bil	15	37.40667	38.70000	26.60000	53.2000	6.73281
L	15	21.41333	21.70000	10.90000	32.5000	5.87937
R	15	23.46000	25.30000	13.60000	30.5000	5.31599
SEB_A_L	15	86.06667	90.00000	73.00000	97.0000	6.82921
SEB_AM_L	15	93.20000	91.00000	82.00000	107.0000	7.56118
SEB_M_L	15	90.26667	91.00000	77.00000	104.0000	6.85010
SEB_PM_L	15	95.40000	98.00000	84.00000	105.0000	7.37564
SEB_P_L	15	89.06667	92.00000	67.00000	103.0000	9.09055
SEB_PL_L	15	83.53333	83.00000	68.00000	108.0000	10.25299
SEB_L_L	15	71.86667	75.00000	41.00000	90.0000	13.38905
SEB_AL_L	15	81.66667	86.00000	66.00000	97.0000	9.34013
SEB_A_R	15	89.20000	91.00000	81.00000	93.0000	3.85820
SEB_AM_R	15	92.80000	94.00000	81.00000	107.0000	7.38918
SEB_M_R	15	91.13333	91.00000	82.00000	103.0000	6.59942
SEB_PM_R	15	94.93333	94.00000	82.00000	113.0000	8.85169
SEB_P_R	15	89.86667	92.00000	72.00000	105.0000	9.83337
SEB_PL_R	15	82.00000	86.00000	45.00000	99.0000	13.62246
SEB_L_R	15	70.66667	73.00000	48.00000	90.0000	13.05301
SEB_AL_R	15	81.53333	80.00000	67.00000	92.0000	8.21903
L+R/Bil	15	1.19870	1.21147	0.92105	1.5290	0.17850
L/Bil	15	0.56773	0.58423	0.40977	0.7236	0.09699
R/Bil	15	0.63097	0.60911	0.40052	0.8532	0.12256

Table 5.4 Boys High School U/15B-team

	Descriptive Statistics (BHU15B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	64.93333	66.00000	49.00000	76.0000	7.74105
Bil	15	34.84000	36.10000	20.00000	51.1000	9.00038
L	15	20.30667	21.90000	12.10000	27.9000	5.60733
R	15	22.34667	22.40000	14.10000	29.3000	5.57262
SEB_A_L	15	83.93333	88.00000	67.00000	96.0000	8.55626
SEB_AM_L	15	89.40000	93.00000	74.00000	98.0000	8.13107
SEB_M_L	15	85.40000	85.00000	69.00000	103.0000	9.08531
SEB_PM_L	15	87.86667	87.00000	69.00000	108.0000	10.28776
SEB_P_L	15	82.53333	83.00000	63.00000	103.0000	11.94551
SEB_PL_L	15	76.53333	76.00000	59.00000	94.0000	11.00563
SEB_L_L	15	69.40000	67.00000	49.00000	91.0000	13.65807
SEB_AL_L	15	79.53333	80.00000	58.00000	97.0000	9.17969
SEB_A_R	15	82.40000	84.00000	72.00000	96.0000	6.91582
SEB_AM_R	15	86.46667	85.00000	75.00000	102.0000	7.30818
SEB_M_R	15	85.00000	85.00000	71.00000	97.0000	6.80336
SEB_PM_R	15	87.93333	88.00000	72.00000	113.0000	10.86585
SEB_P_R	15	86.06667	87.00000	50.00000	114.0000	15.79542
SEB_PL_R	15	82.26667	79.00000	61.00000	113.0000	14.08883
SEB_L_R	15	64.60000	61.00000	45.00000	92.0000	15.07505
SEB_AL_R	15	77.33333	78.00000	63.00000	97.0000	8.65750
L+R/Bil	15	1.25349	1.21012	0.82472	1.8150	0.24822
L/Bil	15	0.58778	0.57764	0.43581	0.8141	0.10880
R/Bil	15	0.66571	0.62646	0.31685	1.1600	0.18540

Table 5.5 Boys High School U/16A-team

	Descriptive Statistics (BHU16A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	14	65.68929	66.35000	50.77000	78.1700	8.04715
Bil	15	31.40000	32.10000	20.80000	47.2000	6.87781
L	15	18.20667	17.70000	7.70000	29.6000	5.22828
R	15	18.18667	18.30000	10.70000	24.2000	4.20728
SEB_A_L	8	81.00000	79.00000	74.00000	91.0000	6.02376
SEB_AM_L	8	87.62500	87.50000	80.00000	97.0000	5.47560
SEB_M_L	8	86.37500	87.00000	78.00000	97.0000	6.92691
SEB_PM_L	8	87.62500	88.50000	72.00000	99.0000	9.08590
SEB_P_L	8	85.62500	84.50000	75.00000	94.0000	6.98851
SEB_PL_L	8	78.75000	81.00000	41.00000	94.0000	16.48159
SEB_L_L	8	68.75000	69.00000	42.00000	87.0000	14.26033
SEB_AL_L	8	70.50000	72.00000	61.00000	87.0000	8.58570
SEB_A_R	8	79.37500	78.50000	68.00000	90.0000	8.81456
SEB_AM_R	8	82.50000	83.50000	64.00000	93.0000	8.79935
SEB_M_R	8	81.87500	83.50000	60.00000	94.0000	11.12831
SEB_PM_R	8	84.62500	87.00000	60.00000	101.0000	12.80555
SEB_P_R	8	82.12500	83.00000	55.00000	97.0000	12.35704
SEB_PL_R	8	76.75000	79.50000	41.00000	97.0000	17.33494
SEB_L_R	8	65.62500	71.50000	28.00000	89.0000	22.27707
SEB_AL_R	8	76.87500	75.50000	52.00000	95.0000	12.52925
L+R/Bil	15	1.16237	1.19034	0.93810	1.3413	0.14047
L/Bil	15	0.57421	0.58192	0.36667	0.6763	0.07885
R/Bil	15	0.58816	0.58551	0.37153	0.7754	0.11656

Table 5.6 Boys High School U/16B-team

	Descriptive Statistics (BHU16B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	14	62.76071	63.97000	48.47000	72.8700	6.33579
Bil	15	29.98000	29.90000	20.90000	38.5000	4.12314
L	15	18.02000	18.30000	13.40000	25.3000	3.42036
R	15	18.36000	19.60000	12.80000	26.6000	4.39363
SEB_A_L	7	79.42857	79.00000	72.00000	88.0000	6.24118
SEB_AM_L	7	85.28571	85.00000	79.00000	92.0000	4.68025
SEB_M_L	7	83.14286	83.00000	75.00000	90.0000	5.92814
SEB_PM_L	7	86.00000	86.00000	72.00000	104.0000	10.40833
SEB_P_L	7	76.57143	81.00000	51.00000	92.0000	15.69349
SEB_PL_L	7	82.71429	80.00000	74.00000	93.0000	6.62607
SEB_L_L	7	68.28571	67.00000	51.00000	95.0000	14.11517
SEB_AL_L	7	73.57143	72.00000	61.00000	85.0000	10.96748
SEB_A_R	7	78.57143	79.00000	69.00000	88.0000	6.99660
SEB_AM_R	7	80.14286	82.00000	64.00000	98.0000	11.09698
SEB_M_R	7	78.57143	82.00000	60.00000	98.0000	12.09486
SEB_PM_R	7	85.42857	89.00000	60.00000	102.0000	13.38976
SEB_P_R	7	78.28571	78.00000	55.00000	95.0000	15.55329
SEB_PL_R	7	78.71429	82.00000	58.00000	89.0000	10.79682
SEB_L_R	7	63.57143	63.00000	37.00000	91.0000	16.60178
SEB_AL_R	7	73.85714	72.00000	52.00000	97.0000	13.99320
L+R/Bil	15	1.22775	1.17143	0.96552	2.0048	0.25230
L/Bil	15	0.60504	0.61204	0.45872	0.8900	0.10785
R/Bil	15	0.62272	0.54671	0.44138	1.1148	0.18667

Table 5.7 Boys High School U/18A-team

Variable	Descriptive Statistics (BHU18A)					
	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	75.88533	74.87000	65.53000	86.4500	6.98730
Bil	14	37.87857	35.25000	25.20000	54.5000	8.76946
L	14	20.77857	20.40000	11.70000	29.2000	4.60003
R	14	23.43571	21.20000	14.00000	37.4000	7.58882
SEB_A_L	15	84.53333	85.00000	68.00000	98.0000	8.34837
SEB_AM_L	15	87.80000	87.00000	75.00000	99.0000	7.62702
SEB_M_L	15	86.66667	87.00000	75.00000	100.0000	7.77970
SEB_PM_L	15	96.06667	97.00000	80.00000	113.0000	8.87586
SEB_P_L	15	92.06667	91.00000	73.00000	108.0000	8.93202
SEB_PL_L	15	85.93333	86.00000	64.00000	99.0000	10.04608
SEB_L_L	15	74.80000	75.00000	58.00000	91.0000	10.74510
SEB_AL_L	15	73.66667	72.00000	59.00000	87.0000	8.73962
SEB_A_R	14	82.78571	82.50000	70.00000	93.0000	7.14873
SEB_AM_R	14	85.92857	86.50000	76.00000	96.0000	6.75351
SEB_M_R	14	86.57143	87.50000	75.00000	99.0000	7.77287
SEB_PM_R	14	95.64286	99.50000	72.00000	108.0000	12.36376
SEB_P_R	14	92.35714	95.50000	71.00000	107.0000	11.81659
SEB_PL_R	14	89.57143	90.00000	74.00000	103.0000	7.54182
SEB_L_R	14	82.57143	80.50000	64.00000	108.0000	11.95964
SEB_AL_R	14	77.92857	80.50000	63.00000	89.0000	7.39505
LandR_Bil	14	1.18588	1.14472	0.74719	1.8663	0.25967
L_Bil	14	0.56376	0.54350	0.32865	0.8488	0.13726
R_Bil	14	0.62211	0.61335	0.40115	1.0174	0.16097

Table 5.8 Boys High School U/18B-team

Variable	Descriptive Statistics (BHU18B)					
	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	59.86667	59.00000	43.00000	80.0000	8.94321
Bil	15	39.75333	41.60000	29.40000	54.5000	6.76851
L	15	24.39333	24.30000	18.00000	32.9000	4.27241
R	15	26.14667	26.20000	16.50000	36.1000	5.10404
SEB_A_L	15	81.73333	84.00000	70.00000	94.0000	7.55425
SEB_AM_L	15	88.13333	88.00000	73.00000	99.0000	7.39562
SEB_M_L	15	85.13333	85.00000	66.00000	99.0000	8.33124
SEB_PM_L	15	90.86667	90.00000	73.00000	104.0000	10.17607
SEB_P_L	15	88.26667	90.00000	74.00000	103.0000	10.06029
SEB_PL_L	15	84.06667	86.00000	61.00000	100.0000	10.59964
SEB_L_L	15	69.40000	69.00000	47.00000	90.0000	13.21687
SEB_AL_L	15	77.73333	78.00000	60.00000	94.0000	8.00417
SEB_A_R	15	82.93333	83.00000	64.00000	91.0000	7.11604
SEB_AM_R	15	86.66667	89.00000	70.00000	96.0000	6.38823
SEB_M_R	15	88.66667	90.00000	80.00000	102.0000	6.59726
SEB_PM_R	15	95.00000	96.00000	83.00000	110.0000	8.18535
SEB_P_R	15	90.46667	92.00000	72.00000	107.0000	10.21111
SEB_PL_R	15	85.33333	88.00000	67.00000	104.0000	11.48705
SEB_L_R	15	72.66667	71.00000	48.00000	100.0000	14.51436
SEB_AL_R	15	77.66667	77.00000	58.00000	97.0000	9.07640
L+R/Bil	15	1.28580	1.30625	1.01754	1.6119	0.17521
L/Bil	15	0.62680	0.66053	0.43853	0.9200	0.13461
R/Bil	15	0.65900	0.65625	0.56122	0.8716	0.08525

Tables 5.9 and 5.10 show the results for the U/14 players of Volkskool. The mean values for the Balance test were 79.18% for the A-team and 71.44% for the B-team. These values are above average, even for athletes (Techno Therapy, 1992:14). Mean values for Bilateral plyometrics were 41.75 cm for the A-team and 32.06 cm for the B-team. These are similar to findings by Gabbett (2002:336), who reported mean values of 33.1 cm for U/14 forwards and 38.5 cm for U/14 backline players. The mean values for unilateral plyometric strength ranged from 16.64 cm to 22.88 cm. Star Excursion Balance Test mean values for the U/14 players ranged from 60.73 cm to 95.00 cm.

Test results for the U/15 players of Volkskool are reflected in Tables 5.11 and 5.12. The mean values for Balance were 61.47% for the A-team and 58.47% for the B-team. The A-team shows acceptable values for athletes, while the B-team tested a bit below the accepted norm (Techno Therapy, 1992:14). Bilateral plyometric test mean values for the A-team was 39.28 cm and 37.46 cm for the B-team. This is superior to the U/15 players in the study by Gabbett (2002:336), which showed mean results of 34.7 cm for the forwards and 37.1 cm for the backline. The Star Excursion Balance Test mean values for the players ranged from 72.13 cm to 105.66 cm. Unilateral plyometric strength mean values ranged from 20.60 cm to 21.68 cm, which is not a very big variance.

Results obtained from testing on the U/16 players at Volkskool are shown on Tables 5.13 and 5.14. The mean Balance values for the A-team were 58.46% and 57.23% for the B-team, slightly below the values expected of athletes (Techno Therapy, 1992:14). Bilateral plyometric strength measured mean values of 37.44cm for the A-team and

33.86 cm for the B-team. This compared poorly to the U/16 players in the study by Gabbett (2002:336) which showed values of 38.0 cm for the forwards and 41.2 cm for backline players. Unilateral plyometric testing mean values ranged between 19.69 cm and 25.63 cm. Star Excursion Balance Test mean values ranged between 72.46 cm and 97.13 cm for these U/16 players.

Tables 5.15 and 5.16 show the test values for the U/18 players at Volkskool. The mean values for Balance were 62.82% for the A-team and 64.88% for the B-team. These are acceptable test results for athletes (Techno Therapy, 1992:14). Mean values for bilateral plyometric testing were 37.26 cm for the A-team and 37.39 cm for the B-team. This is slightly lower than the findings of Gabbett (2002:336) which showed mean values of 37.9 cm for forwards and 40.0 cm for backline players in the U/19 group involved in that study. Star Excursion Balance Test mean values ranged from 71.00 cm to 103.18 cm. These values are superior to the results of the slightly older students (aged 21.87 +/- 2.26 years) tested by Piegaro (2003). The pre-intervention test mean values for the students in Piegaro (2003) ranged between 66.72 cm and 95.81 cm.

The R+L/Bil mean values for all the teams at Volkskool ranged from 1.06 to 1.29. R/Bil and L/Bil values ranged between 0.52 and 0.73. The highest values for all these ratios occurred at U/16B level, were only 3 players were tested for Plyometric strength. This could explain these high values in that team.

Table 5.9 Hoër Volkskool U/14A-team

	Descriptive Statistics (VU14A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	79.18933	76.90000	55.07000	95.7000	10.22102
Bil	15	41.75333	41.50000	23.50000	60.9000	10.19964
L	15	21.70667	19.50000	14.50000	37.0000	6.11934
R	15	22.88667	22.60000	15.60000	35.2000	5.55542
SEB_A_L	15	81.80000	84.00000	68.00000	90.0000	6.82642
SEB_AM_L	15	86.66667	88.00000	75.00000	93.0000	5.70296
SEB_M_L	15	90.93333	93.00000	79.00000	105.0000	7.23549
SEB_PM_L	15	95.00000	95.00000	85.00000	106.0000	5.89188
SEB_P_L	15	94.13333	96.00000	81.00000	105.0000	7.85463
SEB_PL_L	15	83.46667	84.00000	76.00000	91.0000	4.30725
SEB_L_L	15	71.73333	73.00000	55.00000	84.0000	7.19590
SEB_AL_L	15	72.60000	71.00000	60.00000	82.0000	6.67404
SEB_A_R	15	74.86667	76.00000	63.00000	87.0000	5.87813
SEB_AM_R	15	77.60000	77.00000	68.00000	87.0000	5.65433
SEB_M_R	15	80.26667	83.00000	62.00000	90.0000	7.70405
SEB_PM_R	15	84.33333	83.00000	72.00000	95.0000	5.88784
SEB_P_R	15	88.46667	87.00000	77.00000	107.0000	8.60952
SEB_PL_R	15	79.60000	80.00000	64.00000	85.0000	5.82850
SEB_L_R	15	68.66667	70.00000	56.00000	77.0000	5.43358
SEB_AL_R	15	66.73333	67.00000	55.00000	75.0000	5.93376
LandR_Bil	15	1.10851	1.10263	0.64368	1.7619	0.30476
L_Bil	15	0.53594	0.53134	0.27258	0.8009	0.14414
R_Bil	15	0.57257	0.55370	0.31801	0.9860	0.17238

Table 5.10 Hoër Volkskool U/14B-team

	Descriptive Statistics (VU14B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	71.44800	69.73000	56.20000	89.5300	10.05266
Bil	15	32.06667	31.30000	16.80000	44.2000	7.92489
L	15	16.64667	16.60000	7.50000	24.5000	4.30048
R	15	17.63333	19.10000	7.80000	23.4000	4.87247
SEB_A_L	15	76.40000	77.00000	65.00000	91.0000	8.18361
SEB_AM_L	15	78.60000	77.00000	68.00000	90.0000	7.88126
SEB_M_L	15	82.66667	83.00000	72.00000	98.0000	8.03267
SEB_PM_L	15	86.13333	85.00000	74.00000	101.0000	8.65915
SEB_P_L	15	87.93333	92.00000	66.00000	97.0000	9.37677
SEB_PL_L	15	73.33333	74.00000	53.00000	85.0000	7.69663
SEB_L_L	15	65.80000	68.00000	49.00000	81.0000	8.70304
SEB_AL_L	15	67.00000	65.00000	54.00000	81.0000	9.97855
SEB_A_R	15	71.00000	70.00000	61.00000	82.0000	6.85565
SEB_AM_R	15	73.73333	74.00000	63.00000	83.0000	5.63746
SEB_M_R	15	77.20000	77.00000	65.00000	88.0000	7.21308
SEB_PM_R	15	80.73333	78.00000	70.00000	93.0000	7.06568
SEB_P_R	15	82.66667	83.00000	69.00000	95.0000	7.03732
SEB_PL_R	15	73.86667	74.00000	55.00000	91.0000	9.65747
SEB_L_R	15	60.73333	59.00000	41.00000	77.0000	9.06695
SEB_AL_R	15	63.53333	65.00000	48.00000	77.0000	7.93605
LandR_Bil	15	1.08335	1.01897	0.81693	1.5933	0.20088
L_Bil	15	0.52603	0.50462	0.37986	0.8167	0.10808
R_Bil	15	0.55732	0.51762	0.40625	0.8417	0.13556

Table 5.11 Hoër Volkskool U/15A-team

	Descriptive Statistics (VU15A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	61.4713	60.7700	45.6000	71.0000	7.68659
Bil	15	39.2800	37.2000	26.9000	55.8000	8.33763
L	15	20.6067	22.2000	10.6000	27.5000	5.72294
R	15	21.6867	20.4000	14.0000	38.7000	6.47234
SEB_A_L	9	89.0000	90.0000	79.0000	97.0000	5.14782
SEB_AM_L	9	95.2222	95.0000	90.0000	100.0000	3.27024
SEB_M_L	9	96.4444	97.0000	90.0000	103.0000	4.71993
SEB_PM_L	9	101.7778	100.0000	96.0000	106.0000	3.34581
SEB_P_L	9	99.2222	98.0000	91.0000	108.0000	5.44926
SEB_PL_L	9	94.4444	94.0000	80.0000	115.0000	9.81212
SEB_L_L	9	85.4444	85.0000	70.0000	105.0000	9.58007
SEB_AL_L	9	88.2222	93.0000	65.0000	102.0000	12.17351
SEB_A_R	9	89.7778	91.0000	79.0000	97.0000	5.40319
SEB_AM_R	9	92.0000	92.0000	87.0000	97.0000	3.87298
SEB_M_R	9	96.6667	97.0000	91.0000	103.0000	4.47214
SEB_PM_R	9	105.6667	105.0000	100.0000	115.0000	5.33854
SEB_P_R	9	99.3333	99.0000	88.0000	110.0000	6.00000
SEB_PL_R	9	96.2222	95.0000	80.0000	109.0000	8.87099
SEB_L_R	9	86.2222	90.0000	56.0000	97.0000	12.24518
SEB_AL_R	9	87.0000	90.0000	73.0000	98.0000	8.67468
LandR_Bil	15	1.0781	1.0457	0.7217	1.3279	0.18519
L_Bil	15	0.5269	0.5376	0.2931	0.7651	0.12111
R_Bil	15	0.5512	0.5095	0.4286	0.7834	0.09800

Table 5.12 Hoër Volkskool U/15B-team

	Descriptive Statistics (VU15B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	58.47067	58.00000	51.00000	73.0000	6.29750
Bil	15	37.46667	38.00000	24.20000	44.8000	5.34371
L	15	21.04000	20.10000	14.10000	32.0000	5.39177
R	15	21.37333	21.10000	16.30000	26.2000	2.98627
SEB_A_L	15	83.80000	85.00000	70.00000	95.0000	8.00179
SEB_AM_L	15	87.60000	88.00000	71.00000	100.0000	7.73489
SEB_M_L	15	88.73333	90.00000	66.00000	100.0000	7.66687
SEB_PM_L	15	92.13333	93.00000	75.00000	110.0000	7.86372
SEB_P_L	15	90.13333	90.00000	80.00000	104.0000	7.39562
SEB_PL_L	15	84.93333	84.00000	74.00000	100.0000	6.72380
SEB_L_L	15	72.13333	74.00000	54.00000	87.0000	10.28082
SEB_AL_L	15	78.20000	77.00000	68.00000	85.0000	5.00286
SEB_A_R	15	84.00000	87.00000	72.00000	93.0000	7.19126
SEB_AM_R	15	85.93333	86.00000	68.00000	97.0000	7.36271
SEB_M_R	15	88.33333	90.00000	67.00000	103.0000	7.70590
SEB_PM_R	15	92.13333	93.00000	70.00000	105.0000	8.21033
SEB_P_R	15	88.93333	90.00000	78.00000	107.0000	7.17602
SEB_PL_R	15	83.13333	83.00000	71.00000	97.0000	7.53910
SEB_L_R	15	75.26667	75.00000	63.00000	90.0000	7.43992
SEB_AL_R	15	79.26667	79.00000	70.00000	90.0000	6.25033
LandR_Bil	15	1.13708	1.13564	0.83516	1.3909	0.13854
L_Bil	15	0.55956	0.54918	0.38736	0.7259	0.09854
R_Bil	15	0.57751	0.57289	0.44780	0.7231	0.08537

Table 5.13 Hoër Volkskool U/16A-team

	Descriptive Statistics (VU16A)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	15	58.46667	60.0000	48.00000	70.0000	6.46824
Bil	15	37.44667	35.7000	28.30000	48.3000	5.67977
L	15	20.69333	20.7000	15.30000	31.5000	4.37811
R	15	19.69333	20.2000	11.80000	25.6000	4.10704
SEB_A_L	15	84.00000	84.0000	75.00000	96.0000	5.87975
SEB_AM_L	15	89.00000	88.0000	75.00000	105.0000	8.22018
SEB_M_L	15	92.93333	92.0000	73.00000	110.0000	8.05753
SEB_PM_L	15	99.46667	100.0000	75.00000	121.0000	9.78969
SEB_P_L	15	96.66667	98.0000	78.00000	115.0000	10.18870
SEB_PL_L	15	90.86667	90.0000	72.00000	110.0000	9.54588
SEB_L_L	15	74.86667	78.0000	50.00000	90.0000	11.99325
SEB_AL_L	15	76.93333	77.0000	64.00000	88.0000	7.08587
SEB_A_R	15	88.06667	87.0000	79.00000	95.0000	4.68229
SEB_AM_R	15	91.66667	93.0000	77.00000	100.0000	7.01699
SEB_M_R	15	93.00000	93.0000	81.00000	101.0000	5.26444
SEB_PM_R	15	97.13333	100.0000	75.00000	113.0000	9.70174
SEB_P_R	15	95.80000	96.0000	74.00000	119.0000	11.93554
SEB_PL_R	15	88.66667	90.0000	71.00000	101.0000	9.05276
SEB_L_R	15	77.66667	78.0000	50.00000	95.0000	13.41463
SEB_AL_R	15	80.06667	80.0000	68.00000	97.0000	8.37058
LandR_Bil	15	1.08287	1.0727	0.89426	1.3690	0.10745
L_Bil	15	0.55733	0.5096	0.42857	0.8036	0.11230
R_Bil	15	0.52554	0.5339	0.35224	0.6275	0.07774

Table 5.14 Hoër Volkskool U/16B-team

	Descriptive Statistics (VU16B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	13	57.23077	58.00000	41.00000	77.0000	8.60382
Bil	3	33.86667	31.50000	30.60000	39.5000	4.89932
L	3	19.16667	16.80000	13.20000	27.5000	7.43797
R	3	25.63333	19.50000	19.00000	38.4000	11.05908
SEB_A_L	13	84.30769	88.00000	67.00000	98.0000	9.65561
SEB_AM_L	13	87.07692	86.00000	74.00000	95.0000	6.52510
SEB_M_L	13	86.00000	88.00000	66.00000	107.0000	10.80123
SEB_PM_L	13	88.61538	88.00000	69.00000	110.0000	12.60647
SEB_P_L	13	89.23077	91.00000	66.00000	105.0000	11.64155
SEB_PL_L	13	83.84615	88.00000	68.00000	105.0000	12.71381
SEB_L_L	13	72.46154	75.00000	52.00000	87.0000	11.25918
SEB_AL_L	13	73.84615	74.00000	63.00000	85.0000	5.81444
SEB_A_R	13	84.46154	87.00000	67.00000	96.0000	8.65655
SEB_AM_R	13	87.15385	88.00000	71.00000	98.0000	8.19396
SEB_M_R	13	88.92308	90.00000	69.00000	102.0000	9.45570
SEB_PM_R	13	92.84615	92.00000	66.00000	122.0000	14.59364
SEB_P_R	13	90.69231	92.00000	63.00000	109.0000	13.40637
SEB_PL_R	13	85.76923	85.00000	62.00000	107.0000	13.10314
SEB_L_R	13	74.84615	77.00000	45.00000	95.0000	14.21763
SEB_AL_R	13	78.46154	79.00000	68.00000	88.0000	6.62842
LandR_Bil	3	1.29116	1.13651	1.06863	1.6684	0.32842
L_Bil	3	0.55364	0.53333	0.43137	0.6962	0.13358
R_Bil	3	0.73753	0.63725	0.60317	0.9722	0.20390

Table 5.15 Hoër Volkskool U/18A-team

	Descriptive Statistics (VU18Acsv)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	11	62.8236	63.0000	54.00000	75.8000	6.18784
Bil	11	37.2636	38.7000	29.80000	42.6000	4.38344
L	11	21.5727	22.7000	14.50000	26.1000	3.85152
R	11	23.1182	23.5000	15.30000	29.6000	3.66983
SEB_A_L	11	88.0000	90.0000	80.00000	93.0000	4.21900
SEB_AM_L	11	90.9091	90.0000	85.00000	96.0000	3.61814
SEB_M_L	11	95.0000	96.0000	88.00000	103.0000	4.69042
SEB_PM_L	11	99.1818	101.0000	80.00000	108.0000	7.04014
SEB_P_L	11	103.1818	103.0000	92.00000	114.0000	7.76940
SEB_PL_L	11	95.0909	96.0000	75.00000	107.0000	9.42820
SEB_L_L	11	84.7273	86.0000	62.00000	103.0000	12.11686
SEB_AL_L	11	77.2727	76.0000	67.00000	92.0000	7.97610
SEB_A_R	11	86.3636	87.0000	79.00000	92.0000	4.05642
SEB_AM_R	11	87.0909	88.0000	77.00000	98.0000	6.60991
SEB_M_R	11	93.6364	94.0000	84.00000	106.0000	6.62228
SEB_PM_R	11	99.9091	102.0000	80.00000	118.0000	10.05440
SEB_P_R	11	100.2727	98.0000	88.00000	114.0000	7.65625
SEB_PL_R	11	95.1818	92.0000	79.00000	114.0000	11.32977
SEB_L_R	11	78.6364	81.0000	52.00000	90.0000	12.88622
SEB_AL_R	11	77.6364	80.0000	56.00000	87.0000	10.31768
LandR_Bil	11	1.2135	1.1491	0.86797	1.6551	0.21945
L_Bil	11	0.5850	0.6041	0.35452	0.7184	0.11227
R_Bil	11	0.6285	0.5939	0.51342	0.9367	0.13490

Table 5.16 Hoër Volkskool U/18B-team

	Descriptive Statistics (VU18B)					
Variable	Valid N	Mean	Median	Minimum	Maximum	Std.Dev.
Balance%	10	64.8870	63.7800	57.27000	71.7700	5.55688
Bil	10	37.3900	35.0000	25.60000	49.1000	7.35821
L	10	19.7800	21.0000	10.80000	25.3000	4.27572
R	10	20.2100	21.0000	12.90000	28.8000	5.26148
SEB_A_L	10	86.9000	86.0000	77.00000	96.0000	6.06355
SEB_AM_L	10	90.7000	90.0000	82.00000	105.0000	6.84836
SEB_M_L	10	95.0000	95.0000	90.00000	106.0000	4.59468
SEB_PM_L	10	103.5000	104.5000	98.00000	108.0000	3.65908
SEB_P_L	10	99.7000	101.5000	85.00000	107.0000	7.13442
SEB_PL_L	10	92.8000	96.0000	80.00000	101.0000	7.39068
SEB_L_L	10	80.1000	84.0000	59.00000	92.0000	11.60890
SEB_AL_L	10	80.5000	79.0000	61.00000	107.0000	11.89071
SEB_A_R	10	79.5000	81.5000	64.00000	90.0000	8.11377
SEB_AM_R	10	85.6000	87.5000	73.00000	93.0000	6.05897
SEB_M_R	10	88.1000	89.0000	78.00000	95.0000	4.84080
SEB_PM_R	10	94.4000	96.0000	87.00000	100.0000	4.47710
SEB_P_R	10	93.7000	94.0000	85.00000	103.0000	6.36047
SEB_PL_R	10	87.0000	86.5000	73.00000	98.0000	9.24962
SEB_L_R	10	75.1000	76.0000	60.00000	88.0000	9.49210
SEB_AL_R	10	71.0000	70.0000	57.00000	82.0000	8.49837
LandR_Bil	10	1.0666	1.0315	0.92578	1.2798	0.12165
L_Bil	10	0.5297	0.5099	0.42188	0.6518	0.07435
R_Bil	10	0.5369	0.5511	0.42628	0.6510	0.07192

5.2.2 Age Group Comparison

Table 5.17 shows the values for Star Excursion Balance Tests conducted by Olmsted *et al.* (2002) and Gribble and Hertel (2003) compared to the participants of both schools in this study. It can be seen that the participants in this study mostly outperformed the participants of the other two studies, even though the participants in Olmsted *et al.* (2002) (aged 20.2 +/- 1.4 years) and Gribble and Hertel (2003) (aged 23.2 +/- 3.8 years) were older. The mean test values for the U/14 group ranged between 68.35 cm and 90.2 cm. The U/15 mean values ranged from 72.85 cm to 93.46 cm. The U/16 means ranged between 71.93 cm and 91.78 cm. The U/18 mean test values ranged between 76.39 cm and 96.67 cm. Olmsted *et al.* (2002) recorded test results with mean values ranging from 71.8 cm to 90.4 cm. The U/14, U/15 and U/16 players of this study tested similarly to the participants in the study by Olmsted *et al.* (2002). The U/18 players outperformed the participants in Olmsted *et al.* (2002).

All the age groups in this study, except the U/14 players, outperformed the participants in Gribble and Hertel (2003) which showed mean test values ranging between 71.2 cm and 87.8 cm. This could be due to the fact that participants in Olmsted *et al.* (2002) and Gribble and Hertel (2003) were random students from colleges, and not specifically sportspersons.

Table 5.17 SEBT values for this study compared to Olmsted *et al.* (2002) and Gribble & Hertel (2003)

	U/14		U/15		U/16		U/18		Olmsted *et al.* (20.2 +/- 1.4 years)		Gribble & Hertel (23.2+/- 3.8 years)	
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Means	STD Dev	Means	STD Dev	Means	STD Dev
SEBT L:												
A	81	7.78	85.33	7.5	82.79	7.31	84.92	7.19	81.9	8.6	71.2	7.4
AM	86.43	6.69	90.93	7.64	87.56	6.67	89.14	6.68	83	8.6	76.7	7.7
M	87.15	8.32	89.52	8.15	88.02	9.08	89.65	8.09	86.3	10.7	87.8	8.5
PM	90.2	8.71	93.46	9.08	91.78	11.82	96.67	9.18	90.1	14.1	86	8.1
P	88.97	8.69	89.24	10.41	89.09	12.87	94.84	10.35	87.1	14.8	84.4	9.6
PL	79.52	8.59	83.8	10.99	85.16	12.21	88.71	10.41	80.6	13.2	81.2	11.9
L	69.75	9.2	73.52	12.99	71.93	12.4	76.39	12.97	67.8	14.5	71.9	15.5
AL	74.63	9.13	81.2	9.28	74.26	7.83	76.98	9.14	73	7.8	66.4	8
SEBT R:												
A	78.2	8.82	85.96	6.69	83.81	7.97	82.96	6.97	83.8	8.8		
AM	82.67	9.69	89	7.43	86.72	9.25	86.34	6.3	85.3	9.9		
M	82.88	8.65	89.57	7.62	87.35	10.35	89.06	6.96	84.8	10.1		
PM	86.32	8.62	94	10.43	91.6	13.12	96.14	9.4	90.4	11.4		
P	85.67	8.07	90.13	11.4	88.86	14.3	93.8	9.98	90.1	14.1		
PL	78.73	8.4	84.76	12.46	83.95	12.9	89.02	10.41	83.5	13.4		
L	68.35	10.29	72.85	13.96	72.28	16.53	77.24	12.82	71.8	14.5		
AL	73.6	10.83	80.65	8.37	77.98	9.73	76.4	8.97	75.5	10.3		

Table 5.18 shows an analysis of the practical significant differences between the four age groups for all the test parameters. There are very few differences between the test values of the four age groups that can be classified as practically significant with a high effect. The d-values for the U/15 group were better than those for the U/14 group, with high practically significant values in SEBT Right leg: Anterior (d=0.88) and Medial (d=0.77). A medium effect was noted for the values of SEBT Left leg: Anterior (d=0.56), Anteromedial (d=0.52) and Anterolateral (d=0.71) and SEBT

Right leg: Anteromedial (d=0.65), Posterlateral (d=0.48), Posteromedial (d=0.74) and Anterolateral (d=0.65). There was also a difference with a small to medium effect for Bilateral plyometrics (d=0.46). The U/14 players tested better in Balance with a medium effect (d= -0.58) when compared to U/15s.

When the U/16 group is compared to the U/14 group, a medium effect is noted for SEBT Right leg: Anterior (d=0.64). A small to medium effect is noted for SEBT Left leg: Posterolateral (d=0.46), Anteromedial (d=0.42) and Medial (d=0.43). The U/16 group tested poorer than the U/14s with a medium effect for Balance (d= -0.70). The other test values differed with small effects or even less.

In comparisons between the U/18 and U/14 groups the senior group tested better, with high practically significant differences for SEBT Left leg: Posterolateral (d=0.88) and SEBT Right leg: Posteromedial (d=1.05), Posterior (d=0.81) and Posterolateral (d=0.99). A medium effect was noted for Bilateral Plyometrics (d=0.55); Left leg Plyometrics (d=0.52); Right leg Plyometrics (d=0.62); SEBT Left leg: Anterior (d=0.5), Posteromedial (d=0.7), Posterior (d=0.57) and Lateral (d=0.51) and SEBT Right leg: Anterior (d=0.54), Medial (d=0.71) and Lateral (d=0.69). The rest of the test results showed difference of a small effect or less.

In comparisons between the U/15 and U/16 groups, the U/15 group performed better in most tests. The SEBT Left leg: Anterolateral value (d=0.75) showed a medium to high practically significant difference. The values that had a medium effect were Bilateral Plyometrics (d=0.57) and Right leg Plyometrics (d=0.59). There was a small to medium effect for SEBT Left leg: Anteromedial (d=0.44). These relatively better test results of the U/15s, when compared to the U/16s and U/14s could possibly be a

factor in the lower injury rate in the U/15 group.

When the U/15 Group is compared to the U/18 group, the U/15 group tested better with a small to medium effect in SEBT Left leg: Anterolateral (d= -0.48) and SEBT Right leg Anterior (d=-0.43) and Anterolateral (d= -0.47). The U/18 group tested better with less than small to medium effects for the rest of the tests except SEBT Left leg Anterior, Posterior and SEBT Right leg Anteromedial and Medial. The values for SEBT Left leg Posterior (d=0.54) and Posterolateral (d=0.45) showed effect seizes of medium value.

The U/18 group tested better than the U/16 group for all values except SEBT Right leg: Anterior, Anteromedial and Anterolateral, although this difference has a less than small effect size. The U/18 group tested significantly better with a medium to large effect for Bilateral Plyometrics (d=0.75). They tested better with a medium effect size in Left leg Plyometrics (d=0.62); Right Leg Plyometrics (d=0.74); SEBT Left leg: Posterior (d=0.45) and Balance % (d=0.54). The rest of the differences had small to medium small effects.

Table 5.18 Age group analysis

	U/14		U/15		U/16		U/18		U/14 vs U/15	U/14 vs U/16	U/15 vs U/16	U/15 vs U/18	U/16 vs U/18	U/14 vs U/18
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect Size	Effect size	Effect Size	Effect size	Effect size
Balance	69.09	11.48	62.39	8.84	61.06	7.94	66.2	9.61	-0.58	-0.7	-0.15	0.4	0.54	-0.25
Plyometrics:														
Bil	32.41	10.58	37.25	7.47	33	6.31	38.21	6.96	0.46	0.06	-0.57	0.13	0.75	0.55
L	18.88	5.73	20.84	5.52	18.99	4.6	21.84	4.52	0.34	0.02	-0.34	0.18	0.62	0.52
R	19.43	6.47	22.22	5.17	19.18	4.95	23.52	5.91	0.43	-0.04	-0.59	0.22	0.74	0.62
L+R/Bil	1.22	0.28	1.17	0.2	1.17	0.19	1.2	0.21	-0.19	-0.19	0	0.15	0.15	-0.08
L/Bil	0.6	0.15	0.56	0.11	0.58	0.1	0.58	0.12	-0.28	-0.17	0.16	0.16	0.03	-0.15
R/Bil	0.62	0.16	0.61	0.13	0.59	0.15	0.62	0.12	-0.07	-0.18	-0.12	0.08	0.2	0
SEBT L:														
A	81	7.78	85.33	7.5	82.79	7.31	84.92	7.19	0.56	0.23	-0.34	-0.05	0.29	0.5
AM	86.43	6.69	90.93	7.64	87.56	6.67	89.14	6.68	0.52	0.13	-0.44	-0.23	0.24	0.31
M	87.15	8.32	89.52	8.15	88.02	9.08	89.65	8.09	0.28	0.1	-0.16	0.02	0.18	0.3
PM	90.2	8.71	93.46	9.08	91.78	11.82	96.67	9.18	0.36	0.13	-0.14	0.35	0.41	0.7
P	88.97	8.69	89.24	10.41	89.09	12.87	94.84	10.35	0.03	0.01	-0.01	0.54	0.45	0.57
PL	79.52	8.59	83.8	10.99	85.16	12.21	88.71	10.41	0.39	0.46	0.11	0.45	0.29	0.88
L	69.75	9.2	73.52	12.99	71.93	12.4	76.39	12.97	0.29	0.18	-0.12	0.22	0.34	0.51
AL	74.63	9.13	81.2	9.28	74.26	7.83	76.98	9.14	0.71	-0.04	-0.75	-0.48	0.3	0.26
SEBT R:														
A	78.2	8.82	85.96	6.69	83.81	7.97	82.96	6.97	0.88	0.64	-0.27	-0.43	-0.11	0.54
AM	82.67	9.69	89	7.43	86.72	9.25	86.34	6.3	0.65	0.42	-0.25	-0.36	-0.04	0.38
M	82.88	8.65	89.57	7.62	87.35	10.35	89.06	6.96	0.77	0.43	-0.22	-0.07	0.17	0.71
PM	86.32	8.62	94	10.43	91.6	13.12	96.14	9.4	0.74	0.4	-0.18	0.21	0.35	1.05
P	85.67	8.07	90.13	11.4	88.86	14.3	93.8	9.98	0.39	0.22	-0.09	0.32	0.35	0.81
PL	78.73	8.4	84.76	12.46	83.95	12.9	89.02	10.41	0.48	0.4	-0.06	0.34	0.39	0.99
L	68.35	10.29	72.85	13.96	72.28	16.53	77.24	12.82	0.32	0.24	-0.03	0.31	0.3	0.69
AL	73.6	10.83	80.65	8.37	77.98	9.73	76.4	8.97	0.65	0.4	-0.27	-0.47	-0.16	0.28

Bil = Bilateral; L = Left; R = Right; L+R/Bil = Ratio: Left + Right Plyometrics divided by Bilateral; L/Bil = Ratio: Left Plyometrics divided by Bilateral; R/Bil = Ratio: Right Plyometrics divided by Bilateral; SEBT R = Star Excursion Balance Test Right; SEBT L = Star Excursion Balance Test Left; A = Anterior; AM = Anteromedial; M = Medial; PM = Posteromedial; P = Posterior; PL = Posterolateral; L = Lateral; AL = Anterolateral

5.2.3 Comparison Between the Two Schools

A comparative analysis between the test results for all teams combined in the two schools involved in this study is shown in Table 5.19. There were relatively small differences in test values between the combined values of the two schools involved in this study. Boys High tested higher with medium effect size for L+R/Bil (d=-0.6) and L/Bil (d=-0.51) values. There was a medium to small effect for SEBT Right leg: Anterolateral (d=-0.41). Volkskool showed higher test values of a medium to high practical significant difference for SEBT Left leg: Posterior (d=0.75). There were also differences of small to medium effect for Bilateral Plyometrics (d=0.47) and SEBT Left leg: Medial (d=0.43), Posteromedial (d=0.41) and Posterolateral (d=0.44). The two schools tested similar and only one test value showed a practically significant difference between them.

Table 5.19 School analysis

	Boys High School		Hoër Volkskool		
	Means	STD Dev	Means	STD Dev	Effect size
Balance	64.96	9.46	64.4	10.67	-0.05
Plyometrics:					
Bil	33.34	8.71	37.43	7.62	0.47
L	20.03	5.41	20.23	5.16	0.04
R	21.12	6.45	21.03	5.27	-0.01
L+R/Bil	1.25	0.23	1.11	0.2	-0.6
L/Bil	0.61	0.13	0.55	0.11	-0.51
R/Bil	0.64	0.15	0.57	0.12	-0.5
SEBT L:					
A	83.19	7.48	83.73	7.81	0.07
AM	89.36	7.51	87.61	7.83	-0.22
M	86.76	7.89	90.39	8.53	0.43
PM	90.96	9.55	95	9.81	0.41
P	86.73	10.22	94.35	9.85	0.75
PL	81.71	10.58	86.44	10.85	0.44
L	70.78	12.04	74.87	11.77	0.34
AL	77.64	8.78	76.02	9.74	-0.17
SEBT R:					
A	83.33	7.36	81.75	8.93	-0.18
AM	87.53	8.1	84.55	8.84	-0.34
M	86.54	8.36	87.56	9.24	0.11

PM	91.2	10.62	92.39	11.3	0.11
P	87.18	11.65	91.76	10.37	0.39
PL	82.55	11.64	85.21	11.43	0.23
L	71.2	14.64	73.79	12.46	0.18
AL	79.16	8.8	74.86	10.43	-0.41

Table 5.20 shows the comparison between the two schools when divided into different age groups. In the U/14 groups Volkskool tested better with high practical significance for Balance (d=-1.16) and Bilateral Plyometrics (d=-0.88). Boys High tested better with high practical significance for L+R/Bil (d=0.97); L/Bil (d=1.00); SEBT Left leg: Anteromedial (d=0.96), Anterolateral (d=1.10) and SEBT Right leg: Anterior (d=1.39), Anteromedial (d=1.89), Medial (d=1.07), Posteromedial (d=0.86) and Anterolateral (d=2.39).

In the U/15 groups there were only two test values that showed practically significant differences. Volkskool tested better with large practical significant differences for SEBT Left leg: Posterolateral (d=-0.77) and SEBT Right leg: Lateral (d=-0.83). Volkskool also tested better with medium effect values for SEBT Left leg: Lateral (d= -0.49) and Posterior (d=-0.71) and SEBT Right leg: Posteromedial (d=-0.56). Boys High tested better with medium effect for Balance (d=0.49); L+R/Bil (d=0.55) and R/Bil (d=0.54).

In the U/16 age groups, Boys High tested better with a high practical significant value for Balance (d=0.81). Volkskool tested better with large practical significance for Bilateral Plyometrics (d=-1.06); SEBT Left leg: Posterior (d=-0.96) and SEBT Right leg: Anterior (d=-0.95), Anteromedial (d=-0.85), Medial (d=-0.95), Posteromedial (d=-0.80) and Posterior (d=-0.97). Volkskool also tested better with medium effect

for SEBT Left leg: Anterior (d=-0.50), Medial (d=-0.49), Posterolateral (d=-0.56) and SEBT Right leg: Posterolateral (d=-0.68). These results are interesting when viewed in the light of the fact that the Volkskool tested much better than Boys High and the Volkskool U/16A-team progressed to win the Beeld Trophy final. This could support the fact that these tests could possibly be used a part of a talent identification test battery.

In the U/18 age groups Volkskool tested better than Boys High with practical significance in SEBT Left leg: Medial (d=-1.14), Posteromedial (d=-0.80), Posterior (d=-1.19), Posterolateral (d=-0.88) and Lateral (d=-0.86). Volkskool also tested better with medium effect for SEBT Left leg: Anterior (d=-0.55) and SEBT Right leg: Posterior (d=-0.53).

In total, Boys High tested better than Volkskool at U/14 level with Volkskool testing better at U/15, U/16 and U/18 level.

Table 5.20 Comparison between different age groups of two schools

	U/14					U/15					U/16					U/18				
	BH		VS		Effect size	BH		VS		Effect size	BH		VS		Effect size	BH		VS		Effect size
	Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev	
Balance	62.86	8.54	75.32	10.71	-1.16	64.81	9.84	59.97	7.07	0.49	63.89	7.17	57.89	7.42	0.81	67.88	11.34	63.81	5.84	0.36
Plyometrics:																				
Bil	27.90	9.00	36.91	10.24	-0.88	36.12	7.92	38.37	6.94	-0.28	30.93	5.55	36.85	5.59	-1.06	38.85	7.71	37.32	5.83	0.20
L	18.58	5.73	19.18	5.80	-0.10	20.86	5.67	20.82	5.47	0.01	18.29	4.31	20.44	4.76	-0.45	22.65	4.73	20.72	4.06	0.41
R	18.61	7.08	20.26	5.79	-0.23	22.90	5.38	21.53	4.96	0.26	18.27	4.30	20.68	5.79	-0.42	24.84	6.45	21.73	4.63	0.48
L+R/Bil	1.35	0.26	1.10	0.25	0.97	1.23	0.21	1.11	0.16	0.55	1.19	0.21	1.12	0.17	0.35	1.24	0.22	1.14	0.19	0.42
L/Bil	0.68	0.14	0.53	0.13	1.00	0.58	0.10	0.54	0.11	0.31	0.59	0.10	0.56	0.11	0.31	0.60	0.14	0.56	0.10	0.27
R/Bil	0.67	0.15	0.56	0.15	0.68	0.65	0.16	0.56	0.09	0.54	0.60	0.15	0.56	0.13	0.25	0.64	0.13	0.58	0.12	0.44
SEBT L:																				
A	82.90	7.30	79.10	7.90	0.48	85.00	7.68	85.75	7.40	-0.10	80.27	5.96	84.14	7.71	-0.50	83.13	7.95	87.48	5.08	-0.55
AM	90.23	7.83	82.63	7.91	0.96	91.30	7.95	90.46	7.37	0.11	86.53	5.08	88.11	7.41	-0.21	87.97	7.38	90.81	5.26	-0.39
M	87.50	8.16	86.80	8.61	0.08	87.83	8.28	91.63	7.62	-0.46	84.87	6.47	89.71	9.90	-0.49	85.90	7.96	95.00	4.53	-1.14
PM	89.83	8.98	90.57	8.56	-0.08	91.63	9.59	95.75	8.02	-0.43	86.87	9.40	94.43	12.28	-0.62	93.47	9.75	101.24	5.97	-0.80
P	86.90	7.91	91.03	9.06	-0.46	85.80	10.95	93.54	7.99	-0.71	81.40	12.32	93.21	11.33	-0.96	90.17	9.55	101.52	7.50	-1.19
PL	80.67	9.13	78.40	8.01	0.25	80.03	11.04	88.50	9.12	-0.77	80.60	12.60	87.61	11.48	-0.56	85.00	10.19	94.00	8.39	-0.88
L	70.73	9.97	68.77	8.41	0.20	70.63	13.35	77.13	11.81	-0.49	68.53	13.68	73.75	11.51	-0.38	72.10	12.15	82.52	11.82	-0.86
AL	79.47	6.60	69.80	8.81	1.10	80.60	9.16	81.96	9.56	-0.14	71.93	9.54	75.50	6.60	-0.37	75.70	8.49	78.81	9.91	-0.31
SEBT R:																				
A	83.47	7.60	72.93	6.58	1.39	85.80	6.50	86.17	7.06	-0.05	79.00	7.75	86.39	6.93	-0.95	82.86	7.00	83.10	7.08	-0.03
AM	89.67	7.42	75.67	5.89	1.89	89.63	7.91	88.21	6.87	0.18	81.40	9.64	89.57	7.79	-0.85	86.31	6.46	86.38	6.24	-0.01
M	87.03	7.77	78.73	7.50	1.07	88.07	7.29	91.46	7.75	-0.44	80.33	11.29	91.11	7.64	-0.95	87.66	7.14	91.00	6.36	-0.47
PM	90.10	8.79	82.53	6.65	0.86	91.43	10.37	97.21	9.78	-0.56	85.00	12.61	95.14	12.17	-0.80	95.31	10.23	97.29	8.22	-0.19
P	85.77	8.00	85.57	8.27	0.02	87.97	13.07	92.83	8.39	-0.37	80.33	13.56	93.43	12.67	-0.97	91.38	10.86	97.14	7.67	-0.53
PL	80.73	8.09	76.73	8.36	0.48	82.13	13.62	88.04	10.19	-0.43	77.67	14.19	87.32	11.00	-0.68	87.38	9.85	91.29	10.96	-0.36
L	72.00	10.85	64.70	8.38	0.67	67.63	14.19	79.38	10.73	-0.83	64.67	19.17	76.36	13.61	-0.61	77.45	14.04	76.95	11.26	0.04
AL	82.07	6.35	65.13	7.07	2.39	79.43	8.56	82.17	8.04	-0.32	75.47	12.84	79.32	7.52	-0.30	77.79	8.16	74.48	9.86	0.34

BH = Boys High School **VS = Volkskool**

5.2.4 Talent Identification: A- vs B-Teams

Test result differences between A- and B-teams combined are shown in Table 5.21. A-teams tested better with most tests except L+R/Bil; L/Bil and R/Bil. The differences in test values range between small and medium effect size for these tests and none of the effect size values could be considered to have high practical significance. The largest differences between tests results were found in SEBT Left leg: Medial, Posteromedial and Posterior. These all had a medium effect on practical significance. Although it can thus be seen that plyometrics, balance and proprioception do not have a high practically significant influence on talent in schoolboy players, it shows a small to medium effect for most values.

Table 5.21 Differences between A- and B-teams

	A-teams		B-teams		
	Means	STD Dev	Means	STD Dev	Effect size
Balance	66.48	10.8	62.86	8.89	-0.34
Plyometrics:					
Bil	36.84	7.96	33.37	8.68	-0.4
L	20.7	5.14	19.48	5.39	-0.23
R	21.67	5.81	20.43	6.02	-0.2
L+R/Bil	1.17	0.22	1.21	0.23	0.21
L/Bil	0.57	0.12	0.59	0.13	0.19
R/Bil	0.6	0.14	0.62	0.15	0.17
SEBT L:					
A	84.59	6.77	82.34	8.27	-0.27
AM	90.16	6.84	86.87	8.18	-0.4
M	90.71	7.27	86.45	6.9	-0.48
PM	96	8.38	89.98	10.33	-0.58
P	93.36	9.61	87.7	11.05	-0.51
PL	85.99	11.33	82.15	10.27	-0.34
L	74.74	12.11	70.91	11.75	-0.32
AL	77.16	9.31	76.52	9.29	-0.07
SEBT R:					
A	84.37	7.48	80.76	8.51	-0.42
AM	87.72	8.27	84.43	8.61	-0.38
M	88.91	8.57	85.24	8.68	-0.42
PM	94	10.76	89.65	10.76	-0.4
P	91.9	10.72	87.09	11.28	-0.43
PL	85.88	11.61	81.92	11.28	-0.34
L	75.13	13.53	69.92	13.3	-0.38
AL	78.23	9.57	75.86	10.04	-0.24

Table 5.22 shows the test values for the A and B-teams of the different age groups. In the U/14 group the A-teams tested better with large practically significant effect values for Bilateral plyometrics (d=-0.97); Left leg Plyometrics (d=-0.87); Right leg Plyometrics (d=-0.86) and SEBT Left leg: Posteromedial (d=-0.85). The A-teams also tested better with differences of medium effect size for SEBT Left leg: Anteromedial (d=-0.58), Medial (d=-0.55) and Posterior (d=-0.52) and SEBT Right leg: Posterior (d=-0.62). The A-team tested better with small and small to medium effects for most other test results. The B-team showed higher values for the ratios of L+R/Bil, L/Bil and R/Bil. These differences were of less than small effect though. These findings show that plyometric strength and unilateral plyometric strength could be used at U/14 level as a talent identification method.

In the U/15 player group the A-teams tested better with large practical significant effect values for SEBT Left leg: Posteromedial (d=-0.84) and SEBT Right leg: Anterior (d=-0.89), Anteromedial (d=-0.87), Medial (d=-0.89), Posteromedial (d= -0.92). The A-team also tested better with differences of medium effect for SEBT Left leg: Anteromedial (d=-0.70), Medial (d=-0.65), Posterior (d=-0.62) and Posterolateral (d=-0.61) and SEBT Right leg: Posterior (d=-0.49) and Anterolateral (d=-0.61). The A-team also tested better with small to medium effect values for the rest of the SEBT Left and Right leg values. The B-team showed better ratios for L+R/Bil; L/Bil and R/Bil. These differences were of less than small to small effect size. These findings suggest that the Star Excursion Balance Test could be included in talent identification test batteries at U/15 level.

The U/16 groups did not show any practically significant differences of large effect between A- and B-teams. The A-teams tested better with medium effect size for Bilateral Plyometrics (d=-0.55); SEBT Left leg: Medial (d=-0.61), Posteromedial (d= -0.66) and Posterior (d= -0.57). The B-teams showed better results with small and small to medium effects for L+R/Bil (d=0.45), L/Bil (d=0.28) and R/Bil (d=0.45). There are thus not any test values that could effectively be used for talent identification at U/16 level.

At U/18 level, the A-team tested better with a large practical significant effect for Balance (d=-0.92) and tested better with medium effect values for SEBT Right leg: Posterolateral (d=-0.58) and Lateral (d=-0.57). The A-team also tested better with small to medium effects for SEBT Left leg: Posterior (d=-0.37) and Lateral (d= -0.40) and SEBT Right leg: Anterior (d=-0.37) and Posterior (d=-0.38). From these results it can be seen that balance could be implemented as a part of a talent identification test battery in U/18 players.

Table 5.22 A- and B-team comparison in age groups

	U/14					U/15					U/16					U/18				
	B-team		A-team		Effect size	B-team		A-team		Effect size	B-team		A-team		Effect size	B-team		A-team		Effect size
	Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev		Means	STD Dev	Means	STD Dev	
Balance	67.31	10.23	70.87	12.52	-0.28	61.70	7.67	63.08	9.95	-0.14	60.10	7.88	61.95	8.03	-0.23	61.87	8.03	70.36	9.27	-0.92
Plyometrics:																				
Bil	27.70	9.36	37.11	9.72	-0.97	36.15	7.39	38.34	7.51	-0.29	30.63	4.36	34.42	6.92	-0.55	38.81	6.96	37.61	7.05	0.17
L	16.49	4.96	21.27	5.50	-0.87	20.67	5.42	21.01	5.72	-0.06	18.21	4.04	19.45	4.90	-0.25	22.55	4.78	21.13	4.22	0.30
R	16.74	5.54	22.13	6.27	-0.86	21.86	4.42	22.57	5.89	-0.12	19.57	6.17	18.94	4.16	0.10	23.77	5.86	23.30	6.07	0.08
L+R/Bil	1.23	0.28	1.21	0.29	0.08	1.20	0.21	1.14	0.19	0.28	1.24	0.26	1.12	0.13	0.45	1.20	0.19	1.20	0.24	0.00
L/Bil	0.61	0.16	0.59	0.14	0.14	0.57	0.10	0.55	0.11	0.24	0.60	0.11	0.57	0.10	0.28	0.59	0.12	0.57	0.12	0.12
R/Bil	0.62	0.15	0.62	0.17	0.01	0.62	0.15	0.59	0.12	0.21	0.64	0.19	0.56	0.10	0.45	0.61	0.10	0.62	0.15	-0.10
SEBT L:																				
A	79.43	8.45	82.57	6.84	-0.37	83.87	8.14	87.17	6.30	-0.41	82.60	8.77	82.96	5.97	-0.04	83.80	7.33	86.00	7.01	-0.30
AM	83.60	9.73	89.27	6.52	-0.58	88.50	7.85	93.96	6.29	-0.70	86.45	5.88	88.52	7.28	-0.28	89.16	7.15	89.12	6.35	0.01
M	84.60	9.19	89.70	6.56	-0.55	87.07	8.43	92.58	6.76	-0.65	85.00	9.31	90.65	8.17	-0.61	89.08	8.53	90.19	7.77	-0.13
PM	86.53	8.64	93.87	7.20	-0.85	90.00	9.26	97.79	6.85	-0.84	87.70	11.67	95.35	10.98	-0.66	95.92	10.26	97.38	8.15	-0.14
P	86.73	8.53	91.20	8.40	-0.52	86.33	10.50	92.88	9.27	-0.62	84.80	14.20	92.83	10.51	-0.57	92.84	10.53	96.77	10.01	-0.37
PL	78.20	8.48	80.87	8.64	-0.31	80.73	9.93	87.63	11.25	-0.61	83.45	10.78	86.65	13.39	-0.24	87.56	10.25	89.81	10.65	-0.21
L	68.70	9.70	70.80	8.70	-0.22	70.77	11.96	76.96	13.64	-0.45	71.00	12.13	72.74	12.85	-0.14	73.68	13.46	79.00	12.18	-0.40
AL	74.10	10.93	75.17	7.04	-0.10	78.87	7.30	84.13	10.73	-0.49	73.75	7.70	74.70	8.08	-0.12	78.84	9.61	75.19	8.46	0.38
SEBT R:																				
A	76.57	9.49	79.83	7.92	-0.34	83.20	6.98	89.42	4.39	-0.89	82.40	8.43	85.04	7.52	-0.31	81.56	7.56	84.36	6.15	-0.37
AM	80.97	10.16	84.37	9.05	-0.33	86.20	7.21	92.50	6.21	-0.87	84.70	9.65	88.48	8.71	-0.39	86.24	6.15	86.44	6.58	-0.03
M	81.10	8.68	84.67	8.38	-0.41	86.67	7.34	93.21	6.40	-0.89	85.30	11.33	89.13	9.29	-0.34	88.44	5.85	89.68	7.99	-0.16
PM	84.60	9.96	88.03	6.76	-0.34	90.03	9.70	98.96	9.26	-0.92	90.25	14.29	92.78	12.21	-0.18	94.76	6.83	97.52	11.38	-0.24
P	83.27	7.77	88.07	7.75	-0.62	87.50	12.14	93.42	9.66	-0.49	86.35	15.06	91.04	13.55	-0.31	91.76	8.87	95.84	10.78	-0.38
PL	76.83	9.80	80.63	6.34	-0.39	82.70	11.11	87.33	13.78	-0.34	83.30	12.54	84.52	13.47	-0.09	86.00	10.48	92.04	9.61	-0.58
L	66.17	12.25	70.53	7.45	-0.36	69.93	12.88	76.50	14.66	-0.45	70.90	15.66	73.48	17.52	-0.15	73.64	12.58	80.84	12.27	-0.57
AL	73.47	12.60	73.73	8.94	-0.02	78.30	7.48	83.58	8.64	-0.61	76.85	9.73	78.96	9.85	-0.21	75.00	9.29	77.80	8.60	-0.30

5.2.5 Position Group Comparison

Table 5.23 shows a comparison between the test values for three player position groups for all age groups combined, namely tight forwards (props, hooker, locks); looseforwards (flanks and eight-man) and backline (scrum half, fly half, centres, wings, fullback). Test values for backline and loose forward players were very similar, with only differences of small effect noted for some test values. This shows that backline and loose forward players have very similar abilities when it comes to plyometrics, proprioception and balance. When backline players are compared to tightforwards high practically significant differences can be noted for Left leg Plyometrics (d=-0.85) and Right leg Plyometrics (d=-0.76). There was also a medium effect difference for Bilateral Plyometrics (d=-0.63). This shows that the main difference between tight forwards and backline players can be noted in plyometrics, with backline players testing practically significantly better. When loose forwards and tight forwards are compared the only difference is a medium effect difference with Left leg plyometrics (d=-0.55) and Right leg plyometrics (d=-0.42).

Table 5.23 Comparison between different positional groups for all ages

	Tight forwards		Loose forwards		Backline		BL vs LFWD	BL vs FWD	LFWD vs FWD
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect size	Effect size
Balance %	62.32	8.62	65.96	11.64	65.81	10.04	0.01	-0.35	-0.31
Plyometrics:									
Bil	32.06	7.74	35.62	8.95	37.22	8.16	-0.18	-0.63	-0.4
L	17.52	4.67	20.08	4.68	21.96	5.2	-0.36	-0.85	-0.55
R	18.48	5.47	20.77	4.69	23.03	6.02	-0.38	-0.76	-0.42
L+R/Bil	1.14	0.23	1.18	0.21	1.23	0.22	-0.22	-0.39	-0.18
L/Bil	0.55	0.12	0.58	0.14	0.6	0.12	-0.13	-0.39	-0.21
R/Bil	0.58	0.15	0.6	0.12	0.63	0.14	-0.22	-0.29	-0.09
SEBT L:									
A	84.91	7.39	82.13	8.15	83	7.46	-0.11	0.26	0.34
AM	89.99	7.95	88.4	7.67	87.42	7.43	0.13	0.32	0.2
M	89.27	7.96	88.36	9.66	88.12	8.11	0.02	0.14	0.09
PM	93.4	9.6	93.11	10.99	92.56	9.59	0.05	0.09	0.03
P	89.33	11.52	91.29	11.21	91.01	9.86	0.02	-0.15	-0.17
PL	83.63	10.82	85.22	10.73	83.81	11.23	0.13	-0.02	-0.15
L	72.66	13.35	73.27	12.72	72.7	10.76	0.04	0	-0.05
AL	78.39	10.23	76.11	8.77	76.02	8.71	0.01	0.23	0.22
SEBT R:									
A	83.4	8.47	82.32	7.29	82	8.43	0.04	0.17	0.13
AM	86.93	8.87	86.39	7.47	85.23	8.86	0.13	0.19	0.06
M	86.74	8.85	88.59	8.63	86.55	8.85	0.23	0.02	-0.21
PM	91.59	12.45	93.45	9.72	91.16	10.32	0.22	0.03	-0.15
P	88.74	11.24	91.27	11.59	89.14	11.11	0.18	-0.04	-0.22
PL	84.23	11.41	82.45	12.2	84.28	11.5	-0.15	0	0.15
L	72	14.11	72	15.29	73.09	12.52	-0.07	-0.08	0
AL	77.24	10.41	77.23	9.82	76.76	9.55	0.05	0.05	0

BL = Backline; LFWD = Loose forwards; FWD= Tight forwards

Table 5.24 shows the comparison between the different player groups at U/14 level. In the U/14 age group there were no practically significant differences with large effect when loose forwards and backline players were compared. The backline players tested better than loose forwards with medium effect for Left and Right leg plyometrics (d=0.71 and d=0.63) and small to medium effect for L+R/Bil (d=0.45), L/Bil (d=0.40) and R/Bil (d=0.45). Loose forwards tested better than backline players with medium effect for SEBT Left leg: Medial (d=-0.51) and SEBT Right leg: Anteromedial (d=-0.57). Loose forwards also tested better than backline players with all other SEBT values, although these differences had less than small, small or small to medium effect sizes. Backline players tested better than tight forwards with large effect sizes for Left and Right leg Plyometrics (d=0.89 and d=0.89). Backs also tested better with medium effect sizes for Balance (d=0.53) and Bilateral Plyometrics (d=0.62). Tight forwards tested better than backs with medium effect for SEBT Left leg: Anterior (d=-0.51). When forwards and loose forwards were compared at U/14 age level there were no differences with large or medium effect sizes.

The most significant differences between the player groups at U/14 level is the backline outperforming both tight forwards and loose forwards with Unilateral plyometrics. Backline players also outperformed tight forwards with Bilateral plyometrics and Balance.

Table 5.24 Comparison between different positional groups at U/14 level

	Tight forwards		Loose forwards		Backline		BL vs LFWD	BL vs FWD	LFWD vs FWD
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect size	Effect size
Balance %	65.38	10.24	70.91	14.62	70.97	10.56	0.00	0.53	0.38
Plyometrics:									
Bil	28.51	10.09	33.33	12.84	34.79	9.40	0.11	0.62	0.38
L	16.24	5.48	17.33	2.96	21.43	5.82	0.71	0.89	0.20
R	16.23	5.70	18.01	3.05	22.33	6.89	0.63	0.89	0.31
L+R/Bil	1.16	0.28	1.15	0.31	1.29	0.27	0.45	0.46	-0.03
L/Bil	0.58	0.15	0.57	0.17	0.64	0.15	0.40	0.36	-0.07
R/Bil	0.58	0.15	0.58	0.16	0.66	0.16	0.45	0.46	0.01
SEBT L:									
A	82.45	7.64	81.17	7.95	79.89	7.91	-0.16	-0.32	-0.16
AM	87.95	10.17	88.08	6.56	84.64	8.28	-0.42	-0.33	0.01
M	86.95	8.77	90.42	8.86	85.89	7.68	-0.51	-0.12	0.39
PM	90.90	9.62	91.67	10.70	89.07	7.16	-0.24	-0.19	0.07
P	87.65	10.94	89.75	7.35	89.57	7.54	-0.02	0.18	0.19
PL	77.65	9.86	81.08	7.95	80.21	7.94	-0.11	0.26	0.35
L	68.30	10.73	71.92	7.30	69.86	8.85	-0.23	0.15	0.34
AL	76.30	9.21	76.50	7.78	72.64	9.49	-0.41	-0.39	0.02
SEBT R:									
A	81.30	10.37	78.25	6.45	75.96	8.08	-0.28	-0.51	-0.29
AM	83.80	10.58	85.83	8.60	80.50	9.28	-0.57	-0.31	0.19
M	83.75	10.03	84.83	7.02	81.43	8.26	-0.41	-0.23	0.11
PM	85.30	10.51	88.25	5.85	86.21	8.25	-0.25	0.09	0.28
P	84.90	9.61	87.42	7.84	85.46	7.09	-0.25	0.06	0.26
PL	78.50	8.86	78.67	9.18	78.93	8.04	0.03	0.05	0.02
L	66.70	12.67	69.50	6.53	69.04	9.90	-0.05	0.18	0.22
AL	74.85	11.12	74.00	7.68	72.54	11.96	-0.12	-0.19	-0.08

BL = Backline; LFWD = Loose forwards; FWD= Tight forwards

Table 5.25 shows the positional group comparison for U/15 players. When loose forwards and backline players are compared there are no high practically significant differences. Backline players tested better with medium effect for Balance (d= 0.54) and Bilateral plyometrics (d=0.60). Backline players tested better in most other tests, but only with less than small and small to medium effects. When backline players are compared to tight forwards, backline players tested better with high practically significant effect values for Bilateral plyometrics (d=0.90) and Left leg plyometrics (d=1.23), and also tested better with medium effect values for Balance (d=0.54); Right leg Plyometrics (d=0.77) and L/Bil (d=0.70). In a comparison between loose forwards and tight forwards, loose forwards tested better with medium effect for Left leg plyometrics (d=0.54); L+R/Bil (d=0.58) and L/Bil (d=0.64). Tight forwards tested better with most values of the SEBT Right and Left leg. These differences ranged between less than small and medium effect sizes.

The most significant differences between the player groups among the U/15 players, is that backline players outperformed loose forwards and tight forwards with Bilateral and Unilateral plyometrics. Tight fowards slightly outperformed loose forwards with Star Excursion Balance tests and loose forwards slightly outperformed tight forwards with Plyometrics.

Table 5.25 Comparison between different positional groups at U/15 level

	Tight forwards		Loose forwards		Backline		BL vs LFWD	BL vs FWD	LFWD vs FWD
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect size	Effect size
Balance %	60.12	8.23	60.45	8.63	65.35	9.11	0.54	0.57	0.04
Plyometrics:									
Bil	33.56	7.04	35.04	8.09	39.92	5.57	0.60	0.90	0.18
L	17.54	4.77	20.95	6.25	23.39	4.56	0.39	1.23	0.54
R	20.01	5.75	22.39	5.55	24.44	3.98	0.37	0.77	0.42
L+R/Bil	1.13	0.21	1.25	0.16	1.21	0.18	-0.20	0.40	0.58
L/Bil	0.52	0.08	0.60	0.12	0.59	0.10	-0.10	0.70	0.64
R/Bil	0.60	0.16	0.65	0.11	0.62	0.12	-0.20	0.11	0.26
SEBT L:									
A	86.05	7.86	82.09	9.17	86.26	6.11	0.45	0.03	-0.43
AM	93.25	6.41	87.73	9.33	90.43	7.43	0.29	-0.38	-0.59
M	90.45	7.14	87.55	9.98	89.65	8.23	0.21	-0.10	-0.29
PM	94.00	7.93	91.00	10.49	94.17	9.52	0.30	0.02	-0.29
P	89.35	9.94	89.45	10.88	89.04	11.03	-0.04	-0.03	0.01
PL	84.25	10.72	83.18	12.54	83.70	10.96	0.04	-0.05	-0.09
L	73.05	12.02	70.82	17.75	75.22	11.47	0.25	0.18	-0.13
AL	82.70	10.78	77.64	9.79	81.61	7.40	0.41	-0.10	-0.47
SEBT R:									
A	85.70	6.47	84.27	7.55	87.00	6.56	0.36	0.20	-0.19
AM	89.30	6.74	86.27	8.05	90.04	7.71	0.47	0.10	-0.38
M	89.30	6.39	89.09	8.77	90.04	8.31	0.11	0.09	-0.02
PM	93.90	10.87	92.64	11.07	94.74	10.13	0.19	0.08	-0.11
P	90.10	8.89	89.36	11.83	90.52	13.45	0.09	0.03	-0.06
PL	85.70	10.77	81.55	16.45	85.48	12.02	0.24	-0.02	-0.25
L	72.90	14.89	71.64	16.36	73.39	12.47	0.11	0.03	-0.08
AL	80.45	9.44	80.00	10.75	81.13	6.22	0.11	0.07	-0.04

BL = Backline; LFWD = Loose forwards; FWD= Tight forwards

Table 5.26 shows the player positional group comparison at U/16 level. There were no differences with large effects between backs and loose forwards. Backs tested better than loose forwards with a medium effect for SEBT Left leg: Anterior (d= 0.55). When backline players are compared to tight forwards, backs tested better with medium effect for Bilateral plyometrics (d= 0.64) and Left and Right leg plyometrics (d=0.51 and d=0.48). The tight forwards tested better than the backs with medium effect for SEBT Left leg: Lateral (d= -0.48). Tight forwards tested better than loose forwards with large effect for SEBT Left leg: Anterior (d= -0.87). Tight forwards outperformed loose forwards with medium effect sizes for SEBT Left leg: Anteromedial (d= -0.53) and Lateral (d= -0.67) and SEBT Right leg: Anterior (d= -0.51), Posterolateral (d= -0.53) and Lateral (d= -0.52). Loose forwards tested better than tight forwards with medium effect sizes for Left leg Plyometrics (d= 0.57).

There were very few practically significant differences between players groups at U/16 level. Backline players slightly outperformed loose forwards and tight forwards with Bilateral and Unilateral plyometrics. Loose forwards slightly outperformed tightforwards with plyometrics and tight forwards performed slightly better than loose forwards with Star Excursion Balance Tests.

Table 5.26 Comparison between different positional groups at U/16 level

	Tight forwards		Loose forwards		Backline		BL vs LFWD	BL vs FWD	LFWD vs FWD
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect size	Effect size
Balance %	60.89	6.14	62.44	9.39	61.99	7.78	-0.05	0.14	0.17
Plyometrics:									
Bil	31.44	5.57	33.94	3.81	36.61	8.03	0.33	0.64	0.45
L	17.75	3.18	19.76	3.50	20.58	5.59	0.15	0.51	0.57
R	18.36	4.87	18.44	4.01	21.24	6.04	0.46	0.48	0.02
L+R/Bil	1.18	0.29	1.13	0.11	1.15	0.19	0.16	-0.08	-0.18
L/Bil	0.58	0.14	0.58	0.10	0.57	0.09	-0.19	-0.09	0.05
R/Bil	0.60	0.20	0.54	0.09	0.59	0.14	0.35	-0.05	-0.29
SEBT L:									
A	85.55	6.64	79.78	5.67	84.15	7.99	0.55	-0.17	-0.87
AM	89.64	6.67	86.11	5.64	88.85	7.68	0.36	-0.10	-0.53
M	90.82	6.95	87.11	9.88	90.31	9.47	0.32	-0.05	-0.38
PM	94.91	11.00	94.44	12.74	92.15	12.42	-0.18	-0.22	-0.04
P	88.64	14.76	90.00	16.62	89.92	10.55	0.00	0.09	0.08
PL	88.45	7.41	86.33	11.47	83.85	16.66	-0.15	-0.28	-0.18
L	77.18	13.65	68.00	11.08	70.69	12.93	0.21	-0.48	-0.67
AL	74.82	9.67	75.78	7.03	74.69	9.12	-0.12	-0.01	0.10
SEBT R:									
A	86.55	8.09	81.89	9.12	84.54	7.41	0.29	-0.25	-0.51
AM	89.27	10.95	85.33	8.32	87.23	10.04	0.19	-0.19	-0.36
M	87.73	11.44	86.56	10.45	87.85	11.20	0.12	0.01	-0.10
PM	93.82	15.80	93.56	10.98	89.38	12.81	-0.33	-0.28	-0.02
P	90.00	14.53	89.11	17.14	88.31	14.10	-0.05	-0.12	-0.05
PL	88.64	8.90	81.33	13.67	82.69	15.15	0.09	-0.39	-0.53
L	76.45	14.16	66.33	19.30	73.31	18.56	0.36	-0.17	-0.52
AL	78.82	12.64	79.11	5.71	77.69	12.11	-0.12	-0.09	0.02

BL = Backline; LFWD = Loose forwards; FWD= Tight forwards

Table 5.27 shows the comparison for different positional groups at U/18 age level. In the U/18 age group loose forwards tested better than backline players with practically significant differences for SEBT Left leg: Anteromedial (d=-0.92) and SEBT Right leg: Medial (d=-0.86), Postermedial (d=-0.77) and Posterior (d=-0.81). There were also differences where loose forwards tested better than backline players with medium effect for SEBT Left leg: Anterior (d=-0.49), Posterolateral (d=-0.55) and Lateral (d= -0.66) and SEBT Right leg: Anteromedial (d=-0.61). Backline players tested better than loose forwards with Bilateral and Unilateral plyometrics for both legs, but only with small and small to medium effect sizes. When backline players are compared to tight forwards, backline players outperformed forwards with practically significant large effects for Left and Right Leg plyometrics (d=1.55 and d=1.05) and L+R/Bil (d= 0.83). Backline players also tested better with medium effects for Bilateral plyometrics (d= 0.67); L/Bil (d=0.71) and R/Bil (d=0.70). Tight forwards tested better than backline players with medium effect size for SEBT Left leg: Anterior (d=-0.62) and SEBT Right leg: Posteromedial (d=-0.50). In a comparison between tight forwards and loose forwards, loose forwards outperformed tight forwards with large practical significant effects for Unilateral plyometrics left leg and right leg (d= 0.98 and 1.06 respectively). Loose forwards also tested better with medium effect for Bilateral plyometrics (d=0.64); L+R/Bil (d=0.61); R/Bil (d=0.66); SEBT Left leg: Anteromedial (d=0.49) and SEBT Right leg: Medial (d=0.72) and Posterior (d=0.62).

The most significant differences between the different players in the U/18 age group is that backs and loose forwards markedly outperformed tight forwards with Plyometric tests and loose forwards outperformed backline players with Star Excursion Balance Tests.

Table 5.27 Comparison between different positional groups at U/18 level

	Tight forwards		Loose forwards		Backline		BL vs LFWD	BL vs FWD	LFWD vs FWD
	Means	STD Dev	Means	STD Dev	Means	STD Dev	Effect size	Effect size	Effect size
Balance %	63.86	8.30	67.59	10.75	66.25	9.56	-0.12	0.25	0.35
Plyometrics:									
Bil	34.76	5.89	38.50	4.69	40.03	7.82	0.20	0.67	0.64
L	18.07	3.68	21.98	3.97	23.77	3.55	0.45	1.55	0.98
R	19.21	4.35	23.84	3.14	25.82	6.27	0.32	1.05	1.06
L+R/Bil	1.08	0.18	1.21	0.21	1.26	0.21	0.23	0.83	0.61
L/Bil	0.53	0.11	0.58	0.16	0.61	0.11	0.16	0.71	0.36
R/Bil	0.56	0.10	0.63	0.11	0.65	0.13	0.18	0.70	0.66
SEBT L:									
A	87.33	6.43	87.00	7.59	83.25	6.60	-0.49	-0.62	-0.04
AM	89.73	7.42	93.40	6.38	87.54	5.31	-0.92	-0.30	0.49
M	92.00	6.04	90.10	10.89	88.42	7.96	-0.15	-0.45	-0.17
PM	97.20	7.57	97.10	11.93	96.21	9.53	-0.07	-0.10	-0.01
P	93.80	11.28	97.50	9.35	94.67	10.75	-0.26	0.08	0.33
PL	88.40	11.10	93.40	7.79	87.42	10.88	-0.55	-0.09	0.45
L	77.27	16.93	81.80	10.73	74.71	10.71	-0.66	-0.15	0.27
AL	79.40	10.95	77.40	9.75	75.96	7.21	-0.15	-0.31	-0.18
SEBT R:									
A	82.60	7.68	85.40	3.98	82.17	7.61	-0.42	-0.06	0.36
AM	86.93	6.61	88.70	5.74	84.83	6.29	-0.61	-0.32	0.27
M	88.47	5.97	93.90	7.56	87.38	6.76	-0.86	-0.16	0.72
PM	97.80	9.33	100.30	8.78	93.17	9.24	-0.77	-0.50	0.27
P	93.13	10.57	99.70	6.27	91.42	10.23	-0.81	-0.16	0.62
PL	88.27	12.74	89.30	8.17	88.79	9.84	-0.05	0.04	0.08
L	78.13	12.41	80.40	17.68	75.92	10.95	-0.25	-0.18	0.13
AL	75.73	9.80	76.20	13.62	77.04	6.26	0.06	0.13	0.03

BL = Backline; LFWD = Loose forwards; FWD= Tight forwards

5.3 SUMMARY

5.3.1 Summary of Age Group test results

5.3.1.1 U/14 Players

The mean test score for Balance in the U/14 players in this research study was 69.09%. The mean value for Bilateral plyometrics was 32.41 cm. Left and Right leg plyometric mean values were 18.88 cm and 19.43 cm respectively. The Star Excursion Balance Test mean values for U/14 players ranged between 68.35cm and 88.97 cm. Mean values for L+R/Bil, L/Bil and R/Bil were 1.22, 0.6 and 0.62 respectively.

5.3.1.2 U/15 Players

U/15 players in this study showed a mean test score of 62.39% for Balance. The mean test scores for Bilateral plyometrics, Left- and Right leg plyometrics were 37.25 cm, 20.84 cm and 22.22 cm respectively. L+R/Bil showed a ratio with a mean value of 1.17 with L/Bil and R/Bil presenting with mean values of 0.56 and 0.61 respectively. Star Excursion Balance Test mean values ranged between 72.85 cm and 93.46 cm.

5.3.1.3 U/16 Players

The mean test score for Balance in U/16 players was 61.06%. The Bilateral plyometrics test showed a mean value of 33.0 cm. Left leg plyometrics had a mean value of 18.99 cm and Right leg plyometrics a mean value of 19.18 cm. L+R/Bil, L/Bil and R/Bil showed mean test values of 1.17, 0.58 and 0.59 respectively. Star Excursion Balance Test mean values ranged between 71.93cm and 91.78cm.

5.3.1.4 U/18 Players

U/18 players showed a mean Balance score of 66.2%. The mean scores for Bilateral plyometrics, Left leg plyometrics and Right leg plyometrics were 38.21 cm, 21.84 cm and 23.52 cm respectively. The L+R/Bil mean value was 1.2, with L/Bil and R/Bil mean values being 0.58 and 0.62 respectively. Star Excursion Balance Test mean values for the U/18 players ranged between 76.39 cm and 96.67 cm.

5.3.2 Comparison Between Two Schools

There were no high practically significant differences between the two schools used in this study for any of the test values, when all age groups are combined. In the individual age groups larger differences can be seen. At U/14 level Volkskool outperformed Boys High with Balance and plyometrics while Boys High outperformed Volkskool with Star Excursion Balance Tests. In the U/15 age group, Boys High slightly outperformed Volkskool with balance and plyometric ratios and Volkskool performed slightly better with Star Excursion Balance Tests. At U/16 level, Boys High performed better with Balance testing and Volkskool far outperformed Boys High with Plyometrics and Star Excursion Balance Tests. In light of the fact that Volkskool outperformed Boys High in the league, winning the Beeld Trophy, these better test results suggest that there could be a correlation between superior test results and improved performance. In the U/18 groups Boys High performed slightly better with Balance and Plyometrics while Volkskool performed better with Star Excursion Balance Tests, especially for left leg standing.

5.3.3 Age Group Comparisons

U/15 players generally tested better than U/14 players. U/15 players also generally showed better test results than U/16 players. This could possibly be attributed to increased growth that usually occurs at the age of 15 years. The U/18 players generally had the best test results of all the age groups, outperforming U/14, U/15 and U/16 players with most tests.

5.3.4 Positional Group Comparisons

The only high practically significant differences between the different player positions could be noted in plyometrics when all age groups are combined. Backline players performed better than loose forwards and forwards with plyometric tests in most age groups. Loose forwards also outperformed tight forwards with plyometrics at most age groups. At U/15 and U/16 level, tight forwards slightly outperformed loose forwards with Star Excursion Balance Tests.

5.3.5 Comparison Between A- and B-teams

Generally, A-teams performed better than B-teams with all the tests except L+R/Bil; L/Bil and R/Bil. The difference between the teams, however, only has a small to medium effect and cannot be considered practically significant. At U/14 and U/15 levels, there are more high practically significant differences between the A- and B-teams, with A-teams outperforming B-teams. At U/16 and U/18 levels A-teams outperformed B-teams, but the differences were much smaller than at the younger age groups. Balance tests did, however, show a practically significant difference at U/18 level. There is thus some evidence that these tests could be included in talent identification test batteries at U/14 and U/15 age groups.

CHAPTER 6

RESULTS AND DISCUSSION: RUGBY EPIDEMIOLOGY

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CHAPTER 6

RESULTS AND DISCUSSION: RUGBY EPIDEMIOLOGY

6.1 INTRODUCTION

The aim of this study was to compile a profile of proprioception, balance and plyometric strength in schoolboy rugby players and to establish whether this profile has any influence on the risk of lower leg injuries in these schoolboy rugby players. A secondary aim was to determine whether a profile of proprioception, balance and plyometric strength could be used as a talent identification measure.

In this chapter the results of the weekly rugby injury clinics conducted at the two participating schools are presented and discussed. The chapter consists of a rugby injury epidemiology report as observed at the two schools involved in the study during the 2006 rugby season. Injuries will be described with regard to overall occurrence; play position; age group; site of injury; severity of injuries; mechanism of injury; play situation; phase of play; time of injuries and legality of injuries occurred. Secondly, practical differences between the seven players suffering lower leg injuries during the season and the other players will be examined.

6.2 RUGBY EPIDEMIOLOGY

This study recorded 54 injuries at the two schools involved during the 2006 season from April to July. Two hundred and forty players were involved in 10 890 hours of play. Eight thousand nine hundred and ten of these player hours were practices and 1 980 were match hours. These injuries occurred at a prevalence rate of 4.96/1000 player hours. This is more than double the rate of 2.34/1000 player hours recorded by

Roux *et al.* (1987), who also did research on South African schoolboy rugby players. A prevalence rate of 2.53/1000 player hours was noted by Nathan *et al.* (1983) at one South African school in the 1982 season. This included 10 to 19 year old players. Upton (1999) also recorded a lower injury prevalence rate of 1.60/1000 player hours for high school players. Jakoet (1993) observed a total injury rate of 13.0/1000 player hours at the 1993 Craven Week for High schools, which is much higher than this study, probably due to the elite nature of Craven Week tournament.

The higher injury rate in this study could possibly be attributed to the fact that both Nathan *et al.* (1983) and Roux *et al.* (1987) only considered an injury if it caused a player to not play rugby for 7 days. If minor injuries in this study are excluded, the injury prevalence rate is 2.29/1000 player hours, which is very similar to the findings published by Roux *et al.* (1987). McManus and Cross (2004) found a much higher prevalence rate of 13.26/1000 hours of play for elite 15 and 16 year old schoolboy players in Australia. The same injury definition was used as in this study.

6.2.1 Age Group Comparisons

Table 6.1 shows the total prevalence rate of injuries as it occurred in the different age groups and compares it to the results of research by Nathan *et al.* (1983) and Upton (1999). It also shows the results for this study if the same injury definition is used as in Nathan *et al.* (1983) and Upton (1999). Except for the U/15 age group, all the age groups show a higher prevalence of injuries. This anomaly could possibly be attributed to under-reporting of injuries by the U/15 player group in this study. If the same injury definition is used a lower prevalence rate than Nathan *et al.* (1983) is noted. A higher rate than Upton (1999) is still noted, except at U/15 level.

Table 6.1 Age Group Comparison: Injuries per 1000 Player Hours

	This Study (2006)	This study with 1983, 1999 injury definition	Nathan *et al.* (1983)	Upton (1999)
U/14	2.73	1.02	1.69	0.73
U/15	0.42	0.42	4.80	1.58
U/16	6.17	1.92	3.35	1.32
U/18	9.79	5.40	7.75	2.27

6.2.2 Match vs Training Injuries

Match injuries accounted for 77.78% of all injuries with training sessions resulting in the remaining 22.22% of injuries. This percentage is fairly similar to Roux *et al.* (1987), who report 71% of injuries in matches and 29% in training. McManus and Cross (2004) found that only 56% of injuries in Elite Australian schoolboy players occurred during match play.

The prevalence of match injuries for the different age groups is shown in Table 6.2. These figures are considerably higher than the overall rate for training and match injuries combined. U/14 players showed an overall match injury rate of 11.11/1000 match hours. U/15 players showed a rate of 2.47/1000 match hours. This low rate could possibly be attributed to under-reporting of injuries by the U/15 players. U/16 players showed a rate of 22.33/1000 hours, while U/18 players showed an exceptionally high rate of 45/1000 match hours, which could be compared prevalence rates of 43/1000 hours reported by Jakoet and Noakes (1998) for the final rounds of the 1995 Rugby World Cup.

Table 6.2 Match injuries for different age groups

Age Group	Number of Match Injuries	Percentage of Total Injuries (n=42)	Rate per 1000 Match Hours
U/14	5	11.90%	11.11
U/15	1	2.38%	2.47
U/16	9	21.43%	22.33
U/18	27	64.29%	45

Match play yielded a total injury prevalence rate of 21.21/1000 match hours for all age groups combined. This rate results in an injury being expected every 3.14 games per individual player. These results are similar to the findings of Jakoet (1993), who did research on U/19 High School Craven Week rugby players at the 1993 South African tournament. A player was considered to be injured in this study if he was forced to leave the field of play as a result of the injury. The overall rate of match injuries at this Craven Week tournament was 21.6/1000 match hours.

The match prevalence rate for the current study is much higher than the 17.6/1000 player hours match injury rate found over 27 years at one private school by Davidson (1987). A four season study spanning 1980-1983 was conducted by Sparks (1985) at one English public school. The injury rate observed in this study by Sparks (1985) was 19.4/1000 player hours. This study correlates well with the findings of the Sparks (1985) study, although it is still slightly higher. It is also almost similar to the findings of Garraway and Macleod (1995), which showed a prevalence of 21.92 injuries/1000 match hours. However, this rate was for the age bracket of 20 to 24 year old club players.

The prevalence rate for training injuries was 1.35/1000 training hours. This is slightly lower than the findings of Nathan *et al.* (1983), which showed a prevalence rate of

1.98/1000 training hours for high school boys. It is higher than the findings of Roux (1992), which showed an injury rate of 0.56/1000 hours during practices.

The similarity of the findings in this study to club prevalence rates in the study by Garraway and Macleod (1995) and the elite players involved in Jakoet (1993), leads to the conclusion that the two schools involved in the study had a fairly injury fraught season.

6.2.3 Incidence of Injuries per Player Position

Table 6.3 shows the incidence of injuries per play position for the different age groups. The playing positions that had the highest total incidence of injuries for all age groups combined, were the loose-head (11.11%) and tight-head (9.26%) props in the forwards and the inside and outside centres (11.11% each) in the backline. The high incidence of injuries in the centres could be ascribed to the intense crash ball strategy used in the game today. Jakoet (1993) also reported a high injury incidence among loose-head props with 47.4% of the total injuries in the Craven week being incurred by this position group. Scrum halves were the only backline players that recorded any injuries in the Jakoet (1993) study. In the study by Nathan *et al.* (1983) hookers and fullbacks were the players that were most injured. McManus and Cross (2004) showed that flanks and wings were the most injured player positions. Upton (1999) recorded that wings and hookers were the most injured players, whereas, Roux (1992) found that eight-men and wings were the most injured.

In research by Hattingh and Spamer (2004) a questionnaire was used to determine injury prevalence in 59 elite South African schoolboy players. In the U/18 group

eight-men were the players with the highest incidence of injury amongst the forwards with 14% of total injuries. Full backs were the backline position with the highest incidence amongst the backline players with 9% of total injuries. Roux (1992) also showed that eight-men (13% of injuries) were the forward players with the most injuries but that wings (12.1% of injuries) were the backline players with the highest risk of injury.

In the U/14 group observed in this study, there were a total of eight injuries. The most injured forward positions were the props (12.5% of total injuries), and the hooker (12.5% of total injuries), with the scrum half (25% of total injuries) being the backline position with the most injuries. In the U/15 group there was only one recorded injury: a prop. This low injury rate is probably due to under reporting of injuries in this age group. In the U/16 group sixteen injuries were recorded. The props were the players with the most reported injuries amongst the forwards (31.25% of total injuries). In the backline the wings (25.00% of total injuries) and the centres (25.00% of total injuries) were the positions with the highest injury incidence. If the injuries for all junior age groups (U/14 to U/16) are combined, loose-head props (16% of total injuries) and inside centres (12% of total injuries) were the positions with the most injuries. Upton (1999) showed that wings (14.3% of total injuries) and hookers (13.9% of total injuries) were the most injured forward and backline positions in players from U/14 to U/16. Roux (1992) recorded that eight-men (12.6% of injuries) and wings (12.5% of injuries) were the most injured players in the U/14 to U/16 age groups.

In the U/18 group a total of 29 injuries were recorded. The hooker was the most injured forward player (10.34% of total injuries) and the outside centre was the most

injured backline player (13.79% of total injuries). Upton (1999) also reported that hookers (13.3% of total injuries) were the most injured forward players in the U/19 age group but wings (16.8% of total injuries) were the most injured backline players. In the study by Roux (1992) full backs (13.6% of injuries) and eight-men (13.2% of injuries) were the most injured players amongst U/19 players.

It is therefore clear that in most teams of most age groups, the front row players in the scrum had the highest incidence of injuries among the forwards, while the centres showed the highest incidence among the backline players of most teams.

Table 6.3 Incidence of injuries per play position in each age group

Position	Number of Total Injuries	Percentage of Injuries (n=54)	U/14 (N=8)	U/15 (n=1)	U/16 (n=16)	U/18 (n=29)
Loosehead Prop	6	11.11%	12.5%		18.75%	6.9%
Hooker	4	7.41%	12.5%			10.34%
Tighthead Prop	5	9.26%	12.5%	100%	12.5%	3.45%
Lock 4	2	3.70%				6.9%
Lock 5	1	1.86%				3.45%
Flank 6	3	5.56%			6.25%	6.9%
Flank 7	2	3.70%				6.9%
Eight-man	3	5.56%			6.25%	6.9%
Scrumhalf	3	5.56%	25.00%			3.45%
Flyhalf	3	5.56%	12.5%		6.25%	3.45%
Left Wing	4	7.41%			12.5%	6.9%
Inside Centre	6	11.11%	12.5%		12.5%	10.34%
Outside Centre	6	11.11%			12.5%	13.79%
Right Wing	4	7.41%	12.5%		12.5%	3.45%
Fullback	2	3.70%				6.9%

6.2.4 Site of Injury

Table 6.4 shows a breakdown of the injuries to different body parts for the various age groups. The lower limb was the site that had the highest percentage of injuries with 57.41% of the 54 injuries recorded in the study for all age groups combined. This is

similar to the findings of Hattingh and Spamer (2004), who reported 55% of injuries in the lower limb in U/15 players and 57% of injuries in the lower limb in U/18 players. These figures are, however, considerably higher than findings by Roux *et al.* (1987) (37% of injuries in lower limb); McManus and Cross (2004) (also 37% of injuries in lower limb); Lee and Garraway (1996) (31% of injuries in lower limb) as well as Upton (1999) (31.6% injuries of lower limb). Orchard (2001) did research on injury occurrence in 11 Schools in the New South Wales area in Australia in the 2001 season, and found that 49.3% of injuries were of the lower limb.

The upper limb was the site with the second highest number of injuries. 20.37% of injuries occurred in this area. This is lower than Upton (1999), who shows 32.3% of injuries to be of the upper limb. Roux (1992) also recorded a slightly higher percentage of upper limb injuries (25.8%). The trunk area accounted for 14.81% of injuries, similar to Roux (1992), who reports 11.3% of injuries to the trunk, but almost double that of Upton (1999), who found that it accounted for 8.4% of total injuries. Head and neck injuries were the remaining 7.41%. The lower leg and ankle, which is the interest area of this study, accounted for 16.67% of the total injuries, with the upper leg and knee showing 40.74% of all injuries.

In the U/14 group, 62.5% of injuries were of the lower limb. Of these, 37.5% were of the lower leg an ankle. 25% of injuries were of the upper limb and 12.5% of injuries were of the head and neck. The U/15 players had one reported injury: of the knee. In U/16 players, 37.5% of recorded injuries were of the lower limb, with 12.5% being of the ankle and lower leg. Injuries of the trunk also amounted to 37.5% of total injuries. 18.75% of injuries were of the upper limb and 6.25% of injuries were of the head and neck. In U/18 players 65.62% of injuries were of the lower limb. 13.79% of these

lower limb injuries were of the lower leg and ankle. 20.69% of injuries were of the upper limb, with 6.9% of injuries were of the trunk. The head and neck area also accounted for 6.9% of injuries.

It can be seen that lower limb injuries are the most common injuries in most age groups. The upper limb was usually the second highest area of injury, except in the U/16 group, where the trunk area was the other site with the highest injury occurrence.

Table 6.4 Area of injury with breakdown into specific body parts

Area	**Total Number of Injuries**	**Combined Injury Percentage (n=54)**	**U/14 (n=8)**	**U/15 (n=1)**	**U/16 (n=16)**	**U/18 (n=29)**
Lower Limb	**31**	**57.41%**	**62.5%**	**100%**	**37.5%**	**65.52%**
Upper Leg	12	22.22%	25.0%		6.25%	31.03%
Knee	10	18.52%		100%	18.75%	20.69%
Lower Leg	3	5.56%	25.0%			3.45%
Ankle	6	11.11%	12.5%		12.5%	10.34%
Upper Limb	**11**	**20.37%**	**25.0%**		**18.75%**	**20.69%**
Shoulder	10	18.52%	12.5%		18.75%	20.69%
Upper Arm	1	1.85%	12.5%			
Trunk	**8**	**14.81%**			**37.5%**	**6.90%**
Pelvis	2	3.70%			12.5%	
Back	4	7.41%			18.75%	3.45%
Chest	2	3.70%			6.25%	3.45%
Head and Neck	**4**	**7.41%**	**12.5%**		**6.25%**	**6.90%**
Head	2	3.70%				6.90%
Neck	2	3.70%	12.5%		6.25%	

Table 6.5 shows the prevalence rate for injuries to the different parts of the body. Lower limb injuries occurred at a rate of 2.85/1000 player hours. Of these, lower leg injuries occurred at a rate of 0.82/1000 player hours. Rotem and Davidson (2001)

found an acute match injury rate of 4.72/1000 match hours for lower limb injuries and 2.03/1000 match hours for lower leg injuries. These findings of Rotem and Davidson (2001) were higher than this study, but only reflected match hours and did not take training hours or injuries into considerations.

Upper limb injuries occurred at a prevalence rate of 1.01/1000 hours. Trunk injuries occurred at a rate of 0.73/1000 hours of play and head and neck injuries at a rate of 0.37/1000 hours.

Table 6.5 Prevalence rate for injuries to different body parts

Area	Total Number of Injuries	Prevalence Rate per 1000 Player Hours
Lower Limb	**31**	**2.85**
Upper Leg	12	1.10
Knee	10	0.92
Lower Leg	3	0.27
Ankle	6	0.55
Upper Limb	**11**	**1.01**
Shoulder	10	0.92
Upper Arm	1	0.09
Trunk	**8**	**0.73**
Pelvis	2	0.18
Back	4	0.37
Chest	2	0.18
Head and Neck	**4**	**0.37**
Head	2	0.18
Neck	2	0.18

6.2.5 Severity of Injuries

According to the injury definition of McManus (2000) used for this study, 53.7% of the injuries could be considered minor, and did not cause players to lose any match or practice hours. This is higher than the findings of McManus and Cross (2004), which showed 40% of injuries to be minor. 27.78% of the injuries were mild, keeping players out of play for up to a week; 5.56% of injuries were moderate and kept players out of play for up to 2 weeks; and 12.96% of injuries were severe, keeping the injured

player out of play and practices for more than 2 weeks. This shows that if a player did not return to play within the first week after injury, it was more likely that he would be out of play for more than 2 weeks instead of returning to action in the second week.

6.2.6 Situation of Injury

57.14% of injuries recorded during the season occurred during the tackle situation. This is similar to the 55% reported by Roux *et al.* (1987) and also 56.9% reported by Upton (1999), but 10% higher than the findings of Nathan *et al.* (1983). McManus and Cross (2004) found that 52% of injuries in their study were due to the tackle situation.

Open play accounted for 23.81% of injuries during this season. Nathan *et al.* (1983) and Roux *et al.* (1987) reported that 11% and 8% of injuries occurred in open play respectively. Upton (1999) reported 9.2% of injuries in open play. Scrums and the ruck/maul situation amounted to 9.52% of injuries each. Nathan *et al.* (1983) reported 18% of injuries in the scrum and 6% of injuries in the ruck/maul situation. Upton (1999), however, showed 20% of injuries in the ruck/maul situation and 7.2% in scrums. Roux *et al.* (1987) also showed a similar pattern, with 18% of injuries in the ruck/maul situation, and 8% of injuries in the scrum. All these different values point out that the only definitive finding is that the tackle situation amounts, by far, to the most injuries in a game.

6.2.7 Time of Injury in Match

54.76% of the injuries occurred in the 1st half of play, while 45.24% of injuries took place in the 2nd half of games. McManus and Cross (2004) show similar findings with 60% of injuries in the 1st half of the game and 40% in the 2nd half.

6.2.8 Legality of Injury Causes

88.10% of injuries were part of legal play, with 11.9% of injuries occurring as a result of illegal play. This is similar to findings by Nathan *et al.* (1983), which showed that 8% of injuries were the result of foul play. Similarly, Upton (1999) also showed 10.1% of injuries were the result of foul play.

6.2.9 Comparison Between Two Schools

The players at Volkskool had 42.6% of the injuries in this study at an injury rate of 4.29/1000 player hours. Boys High presented with 57.4% of the injuries at a prevalence rate of 5.60/1000 player hours. These results possibly due to a certain amount of underreporting of injuries at Volkskool.

6.2.10 Positional Group Comparisons

The injury prevalence rate was highest among backline players with a rate of 5.5/1000 hours and 51.85% of the total injuries. Backline players only represent 46.7% of the total amount of players, which means that backline players are more likely to be injured than forwards. Similarly, Roux (1992) found that 50.2% of injuries occurred in backline players. Tightforwards incurred 33.34% of injuries and had an injury prevalence rate of 4.95/1000 player hours. Looseforwards had 14.81% of the total injuries at a rate of 3.67/1000 hours. In research by McManus and Cross (2004)

forwards presented with 57% of injuries and backline players with 43% of the injuries.

6.2.11 Comparison Between A- and B-Teams

A-team players had 66.6% of the injuries with an injury prevalence rate of 6.37/1000 player hours. A-team players constituted 50% of the population. B-team players had 33.3% of injuries at a much lower rate of 3.43/1000 player hours. In the study by Upton (1999), A-team players constituted 32% of the total number of players and accounted for 46% of all injuries. In Roux (1992), A-team players made up 30.2% of all players and accounted for 44.2% of all injuries. This greater percentage of A-team players involved in this study could be another reason why the injury rate in the current study is higher than that of Roux (1992) and Upton (1999), since it is clear that A-team players have a higher injury prevalence than lower ranked teams.

6.3 CASE STUDIES: LOWER LEG INJURIES

The relationship between pre-season testing and lower leg injuries will now be examined to determine if there is any correlation between the test values and the occurrence of lower leg injuries. During the season, there were eight players that suffered nine lower leg injuries. Of these players, one also had a re-injury. One player was not tested in the pre-season test battery. Table 6.6 shows a comparison between test battery values obtained by the seven injured players and their respective positional groups and age groups. The side of the injured lower limb is placed in brackets behind the player description on the tables.

The first injured player (VS U/16B Centre) with a left ankle injury, showed weakness with a large effect on practical significance for L+R/Bil (d=-0.96) when compared to backline players in his age group and when compared to his entire age group (d= -0.86.). He also showed a large effects for L/Bil when compared to his age group (d= -0.98) and backline players (d=-0.92). These findings are practically significant. There was also a medium effect for R/Bil (d=-0.64 vs backline and d=-0.53 vs group).

(BH U/14A Prop) had a peroneus tendonitis of his right ankle, which was an extrinsic injury. This player showed high practically significant weakness for Balance (d = -0.90 vs forwards and d=-1.12 vs group); Right Leg plyometrics (d=-0.93); SEBT Left leg: Posterior (d=-1.34 vs forwards and d=-1.84 vs group) and SEBT Right leg: Posterior (d=-1.13 vs forwards and d=-1.45 vs group), findings which have high practically significant implications. There were also some findings with medium effect values. These were Bilateral plyometrics (d=-0.67 vs group); Left leg plyometrics (d=-0.59 vs group); Right leg plyometrics (d=-0.5 vs forwards); R/Bil (d= -0.55 vs group); SEBT Left leg Anterior (d=-0.58 vs forwards) and Posterolateral (d= -0.64 vs group) and SEBT Right leg: Posteromedial (d=-0.50 vs group).

(BH U/14B Hooker) suffered an achilles bursitis of his right ankle. He showed high practically significant weakness for L+R/Bil (d=-1.54 vs forwards and d=-1.51 vs group); R/Bil (d=-1.71 vs forwards and d=-0.84 vs group); L/Bil (d=-3.58 vs forwards and d=-1.93 vs group); Bilateral plyometrics (d=-2.15 vs group); Left leg plyometrics (d=-2.77 vs group); Right leg plyometrics (d=-2.28 vs group); SEBT Left leg: Posterior (d=-1.84 vs group), Posterolateral (d=-0.88 vs group) and SEBT Right leg: Anteromedial (d=-0.79 vs group), Medial (d=-2.07 vs group) and Posteromedial (d=

-3.05 vs group). He showed medium effects for Left leg plyometrics (d=-0.52 vs forwards); Right leg plyometrics (d=-0.54 vs forwards); SEBT Left leg: Anteromedial (d=-0.51 vs group), Posteromedial (d=-0.60 vs group) and SEBT Right leg: Posterior (d=-0.54 vs group).

(BH U/16A Centre) injured the lateral ligaments of his left ankle. He showed high practically significant weakness for Bilateral plyometrics (d=-1.94 vs backline and d= -2.02 vs group); Left leg plyometrics (d=-2.30 vs backline and d=-2.65 vs group); Right leg plyometrics (d=-1.53 vs backline and d=-1.44 vs group); L+R/Bil (d= -1.16 vs backline and d= -1.04 vs group) and L/Bil (d=-2.17 vs backline and d=-1.92 vs group). Star Excursion Balance Tests were not conducted on this player due to a prior engagement by the player.

(BH U/18A Centre) sustained a Grade II anterior talofibular ligament injury of his left ankle. He re-injured his ankle in his first match after returning to play. This player showed high practically significant weakness for most test values except Balance; Bilateral plyometrics; L/Bil and Left leg Plyometrics vs group. Weakness with large effects were noted for Left leg plyometrics (d=-0.78 vs backline); Right leg plyometrics (d=-1.88 vs backline and d=-1.60 vs group); L+R/Bil (d=-1.20 vs backline and d=-0.90 vs group) and R/Bil (d=-1.85 vs backline and d=-1.71 vs group). SEBT test values were practically significant weaker with large effects for all eight directions in both legs. These values ranged from d=-0.97 to d=-2.29 vs backline players and d=-1.05 to d=-2.54 vs group. The mean test values for U/18 players for Left leg plyometrics was 21.84 cm and Right leg plyometrics 23.52 cm. The comparatively good results achieved for L/Bil (d=-0.05 vs backs and 0.19 vs group)

and Left leg Plyometrics (d=-0.15 vs group) could be ascribed to the fact that he is left leg dominant while most other players are right leg dominant. These results would not be so favourable if compared to the dominant legs of the other players.

(BH U/18A Prop) developed shin splints of both legs. He tested weaker by a high practically significant margin for Left leg plyometrics (d=-1.73 vs forwards and d= -2.27 vs group); Right leg plyometrics (d=-0.99 vs forwards and d=-1.44 vs group); L+R/Bil (d= -1.83 vs forwards and d=-2.10 vs group); L/Bil (d=-1.77 vs forwards and d=-2.03 vs group) and R/Bil (d=-1.33 vs forwards and d=-1.58 vs group). He also tested weaker with a medium effect in SEBT Left leg: Anteromedial (d=-0.50 vs forwards and d=-0.52 vs group) and Posterior (d=-0.57 vs group).

(BH U/18B Prop) injured the Anterior Talofibular ligament in his right ankle. This injury was the result of extrinsic causes. Practically significant weakness of large effect was only noted for L/Bil (d=-0.84 vs group). Weakness of medium effect value was recorded for Balance (d=-0.59 vs forwards and d=-0.73 vs group) and L+R/Bil (d=-0.69 vs group).

It can be seen from these results that all players with intrinsic lower leg injuries tested weaker with high practical significance for the L+R/Bil plyometric ratio. The plyometric ratio for (Injured leg)/Bil also showed high practical significant weakness for all but one players with intrinsic injuries. This exception could be attributed to the fact that (BH U/18A Centre) is left leg dominant, where most other players are right leg dominant. This left leg dominance explains the relatively good test results the player obtained with testing of this leg. Table 6.18 shows that there are very small,

practically insignificant differences for the ratios of R+L/Bil; L/Bil and R/Bil between different age groups ($d<0.29$). These values are thus fairly similar for players of all age groups. Weak results for L+R/Bil, L/Bil or R/Bil could thus be described as risk factors for the occurrence of intrinsic lower leg injuries with a large effect on practical significance for all age groups. Weaker test scores for unilateral plyometrics of the injured leg occurred in four of the six intrinsic lower leg injuries. Weak test results for unilateral plyometrics could thus be said to have a medium effect practical significance of the occurrence of lower leg injuries.

When the individual test results of the players that sustained lower leg injuries during the season (Table 6.7) are compared to the percentile values for the combined descriptive statistics of the two schools involved in this study (Table 6.8); it becomes clear that the injured players all fall within the 20^{th} percentile for L+R/Bil and (Injured leg)/Bil. These 20^{th} percentile values could thus be used as a testing standard to determine increased risk of intrinsic lower leg injuries in schoolboy rugby players. The values which could be used for injury prediction is 1.012 for L+R/Bil values; 0.483 for L/Bil values and 0.492 for R/Bil values.

Table 6.6 Comparison between injured players and uninjured players

	VS U/16B Centre (L)		BH U/18A Prop (Both)		BH U/14B Hooker (R)		BH U/16A Centre (L)		BH U/18A Centre (L)		BH U/14A Prop (R)		BH U/18B Prop (R)	
	Effect size		Effect size		Effect size		Effect size		Effect size		Effect size		Effect size	
	Backs	Group	Fwds	Group	Fwds	Group	Backs	Group	Backs	Group	Fwds	Group	Fwds	Group
Balance	**0.52**	**0.56**	**1.62**	**1.23**	**-0.16**	**1.09**	**-0.16**	**-0.13**	**0.08**	**0.13**	**-0.90**	**-1.12**	**-0.59**	**-0.73**
Plyometrics:														
Bil	**0.47**	**0.96**	**0.14**	**0.30**	**-0.45**	**-2.15**	**-1.94**	**-2.02**	**-0.66**	**0.24**	**-0.32**	**-0.67**	**1.28**	**0.93**
L	**-0.25**	**-0.05**	**-1.73**	**-2.27**	-0.52	-2.77	**-2.30**	**-2.65**	**-0.78**	**-0.15**	-0.13	-0.59	0.55	-0.36
R	-0.17	0.13	**-0.99**	**-1.44**	**-0.54**	**-2.28**	-1.53	-1.44	-1.88	-1.60	**-0.50**	**-0.93**	**1.15**	**0.14**
L+R/Bil	**-0.96**	**-0.86**	**-1.83**	**-2.10**	**-1.54**	**-1.51**	**-1.16**	**-1.04**	**-1.20**	**-0.90**	**-0.07**	**-0.28**	**-0.19**	**-0.69**
L/Bil	**-0.98**	**-0.92**	**-1.77**	**-2.03**	-3.58	-1.93	**-2.17**	**-1.92**	**-0.05**	**0.19**	0.21	0.06	-0.46	-0.84
R/Bil	-0.64	-0.53	**-1.33**	**-1.58**	**-1.71**	**-0.84**	-0.13	-0.05	-1.85	-1.71	**-0.34**	**-0.55**	**0.17**	**-0.35**
SEBT L:														
A	**0.23**	**0.36**	**0.41**	**0.69**	-0.10	-0.13			**-1.86**	**-2.07**	-0.58	-0.39	-0.36	-0.04
AM	**0.80**	**0.98**	**-0.50**	**-0.52**	-0.10	-0.51			**-1.42**	**-1.45**	1.38	1.79	0.84	1.01
M	**1.23**	**1.43**	**-0.33**	**0.02**	-0.10	-0.26			**-1.06**	**-1.22**	0.69	0.70	0.50	0.63
PM	**1.28**	**1.22**	**0.63**	**0.57**	-0.10	-0.60			**-0.97**	**-1.04**	-0.41	-0.37	0.50	0.46
P	**1.90**	**1.53**	**-0.43**	**-0.57**	-0.12	-1.84			**-2.02**	**-2.09**	-1.34	-1.84	0.82	0.76
PL	**1.09**	**1.27**	**0.14**	**0.10**	-0.12	-0.88			**-1.51**	**-1.71**	-0.37	-0.64	0.32	0.29
L	**0.87**	**0.77**	**-0.19**	**-0.23**	-0.13	0.03			**-1.56**	**-1.46**	0.25	0.14	0.40	0.55
AL	**-0.30**	**-0.35**	**0.51**	**0.86**	-0.12	-0.18			**-2.07**	**-1.82**	-0.03	0.15	0.51	0.86
SEBT R:														
A	0.06	0.06	**0.96**	**1.00**	**-0.11**	**0.09**			-1.60	-1.84	**0.84**	**1.34**	**0.70**	**0.72**
AM	0.57	0.58	**0.92**	**1.06**	**-0.13**	**-0.79**			-1.09	-1.30	**0.30**	**0.45**	**1.37**	**1.53**
M	0.73	0.79	**0.42**	**0.28**	**-0.13**	**-2.07**			-1.83	-2.00	**-0.37**	**-0.33**	**1.43**	**1.13**
PM	1.22	0.98	**0.56**	**0.74**	**-0.14**	**-3.05**			-2.29	-2.54	**-0.31**	**-0.50**	**0.56**	**0.74**
P	1.75	1.63	**1.31**	**1.33**	**-0.10**	**-0.70**			-2.00	-2.26	**-1.13**	**-1.45**	**0.84**	**0.84**
PL	1.14	1.21	**0.29**	**0.32**	**-0.09**	**0.98**			-1.50	-1.43	**-0.06**	**-0.09**	**-0.02**	**-0.07**
L	1.01	1.13	**1.52**	**1.52**	**-0.12**	**2.01**			-1.09	-1.05	**-0.13**	**-0.33**	**0.31**	**0.35**
AL	0.19	0.15	**1.05**	**1.05**	**-0.13**	**0.87**			-2.08	-1.38	**-0.08**	**0.04**	**0.54**	**0.50**

Values in bold type indicate values for tests that involve the injured limb

Table 6.7 Individual results of injured players

	Balance	Pliometrics			SEBT (L)								SEBT (R)							
Name	%	Bil	L	R	A	AM	M	PM	P	PL	L	AL	A	AM	M	PM	P	PL	L	AL
BH U/18B Prop(Ext)	59.00	42.3	20.1	24.2	85	96	95	101	103	92	84	85	88	96	97	103	102	88	82	81
BH U/18A Prop	77.27	35.6	11.7	14.9	90	86	90	102	89	90	74	85	90	93	91	103	107	92	97	86
BH U/18A Centre	67.00	34.9	21.0	14.0	71	80	80	87	73	71	58	61	70	78	75	72	71	74	64	69
BH U/16A Centre	60.77	21.0	7.7	12.0																
BH U/14B Hooker	76.53	9.7	3.0	4.7	80	82	85	85	73	72	70	73	79	75	65	60	80	87	89	83
BH U/14A Prop (Ext)	56.20	25.3	15.5	13.4	78	102	93	87	73	74	71	76	90	87	80	82	74	78	65	74
VS U/16B Centre	66.00	40.4	19.2	20.2	86	95	102	108	110	102	82	72	85	93	96	105	113	100	92	80

	L+R/Bil	L/Bil	R/Bil
BH U/18B Prop (Ext)	1.047	0.475	0.572
BH U/18A Prop	0.747	0.329	0.419
BH U/18A Centre	1.003	0.602	0.401
BH U/16A Centre	0.938	0.367	0.571
BH U/14B Hooker	0.794	0.309	0.485
BH U/14A Prop (Ext)	1.142	0.613	0.530
VS U/16B Centre	0.975	0.475	0.500

Table 6.8 Descriptive statistics for both schools combined

	Descriptive Statistics (skole.sta)									
Variable	Valid N	Mean	Median	Minimum	Maximum	Lower Quartile	Upper Quartile	Percentile 20.00000	Percentile 80.00000	Std.Dev.
Balance%	227	64.66934	63.87000	41.00000	95.70000	57.00000	71.03000	56.00000	73.40000	10.04377
Bil	218	35.20000	35.05000	9.70000	60.90000	29.80000	40.40000	28.30000	41.60000	6.46610
L	218	20.12110	20.10000	3.00000	37.00000	16.40000	23.60000	15.70000	24.70000	5.28457
R	218	21.08349	20.75000	4.70000	38.70000	16.60000	24.50000	15.60000	25.70000	5.92893
L+R/Bil	218	1.18858	1.15373	0.64368	2.00478	1.03819	1.31980	1.01282	1.35958	0.22645
L/Bil	218	0.58058	0.56393	0.27258	0.92000	0.50151	0.65714	0.48359	0.67632	0.12363
R/Bil	218	0.60801	0.59214	0.31685	1.16000	0.50896	0.68624	0.49201	0.71850	0.14068

6.4 SUMMARY

6.4.1 Rugby Epidemiology

During the season centres and props were the positions that presented with the highest injury rate amongst the forward and backline players. An increase in injuries was noted from U/14 to U/18 levels. U/15 players were the group for whom the smallest number of injuries were recorded; this could be attributed to under-reporting of injuries by U/15 players. The lower limb was the site with the highest number of injuries in this study (57.41%). Match injuries accounted for 77.78% of the recorded injuries, with a match injury rate of 1 injury per individual player every 3.14 matches. The tackle situation was responsible for the highest percentage of injuries (57.14%). The majority of injuries (53.7%) could be classified as minor, according the definition used (McManus, 2000). 54.76% of injuries occurred during the first half of play in matches. When the two schools used in this study are compared, Boys High presented with more injuries (57.4%) at a higher prevalence rate (5.60/1000 player hours). In a positional group comparison, backline players presented with 51.85% of injuries. Since backline players are only 46.7% of players in a team, this shows that backline players have a higher risk of injury. A-team players presented with 66.6% of injuries at a prevalence rate of 6.37/1000 player hours. B-team players had an injury rate of 3.43/1000 player hours.

6.4.2 Comparison Between Players with Lower Leg Injuries and Uninjured Players

There were eight players with nine lower leg injuries; one player had injuries of both legs. Six of the players had intrinsic injuries and two had extrinsic injuries. Test values for all five tested players with intrinsic injuries were weaker by a high

practically significant margin for the L+R/Bil ratio. This proved to be the test result with the most influence on the occurrence of intrinsic lower leg injuries. Five out of the six intrinsic lower leg injuries of the five players tested weaker by a high practically significant margin for R/Bil and L/Bil for the respective injured legs. The remaining player tested slightly better with L/Bil, but he was left dominant, which could explain this anomaly. When the individual test results for the players with intrinsic injuries are compared to the percentiles for all players, it can be seen that the injured players fall in the 20th percentile for both L+R/Bil and (Injured leg)/Bil ratios. These 20th percentile values could thus be used as a standard for determining the possible occurrence of intrinsic lower leg injuries. These 20th percentile values are 1.012 for R+L/Bil ratios; 0.483 for L/Bil ratios and 0.492 for R/Bil ratios.

CHAPTER 7

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CHAPTER 7

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

7.1 INTRODUCTION

This study was aimed at examining the influence of proprioception, balance and plyometric strength on the occurrence of lower leg injuries in schoolboy rugby players. The influence of these variables on rugby talent identification was also investigated. Furthermore, the design of a preventative training programme for improvement of these motor skills with resulting reduction of lower leg injuries is also included. A summary of the research material, conclusions drawn from the empirical study and a preventative training programme are presented in this chapter.

7.2 SUMMARY OF LITERATURE REVIEW

Rugby injuries are a major cause of morbidity among young men. Junge *et al.* (2004) explain that: "it is commonly accepted that sport is beneficial for physical and mental health, but it is also associated with a certain risk of injury." Babic *et al.* (2001) also argue that sports injuries are an important source of health care costs in developed countries. Upton (1999) estimated that there were 91 276 injuries in the South African rugby playing population in 1999. The average cost of a single injury was estimated at R1 318. The total estimated cost of these 1999 rugby injuries accumulated to R126 633 344. When inflationary correction is done, these injuries accumulate to a staggering estimated cost of R214 502 480 in 2006.

Various studies have been done on schoolboy rugby injuries, both in South Africa (Erasmus, 2006; Hattingh & Spamer, 2004; Upton, 1999; Jakoet, 1993; Roux, 1992; Roux *et al.*, 1987; Nathan *et al.*, 1983) and abroad (McManus & Cross, 2004; Junge *et al.*, 2004; Rotem & Davidson, 2001; Orchard, 2001; Lee & Garraway, 1996; Davidson, 1987; Sparks, 1985; Sugarman, 1983). The prevalence rate for injuries in South African epidemiological studies range from 1.60/1000 player hours (Roux *et al.*, 1987) to 13.0/1000 player hours (Jakoet, 1993). Match injury prevalence rates ranged between 7.04/1000 match hours (Roux *et al.*, 1987) and 21.6/1000 match hours (Jakoet, 1993).

Various rugby epidemiological studies have shown the lower limb to be the area of the body that sustains the most injuries during rugby (Babić *et al.*, 2001; Bottini *et al.*, 2000; Upton, 1999; Bird *et al.*, 1998; Jakoet & Noakes, 1998; Garraway & Macleod, 1995; Jakoet, 1993; Roux *et al.*, 1987). The percentage of injuries that occurred in the lower limb area in South African studies ranged from 31.6% (Upton, 1999) to 57% (Hattingh & Spamer, 2004). Some studies have shown the upper limb (Lee & Garraway, 1996; Davison, 1987; Nathan *et al.*, 1983;) and the head and neck area (Myers, 1980) to be the body area that is most injured.

Bathgate *et al.* (2002) found that 19.6% of all injuries in Australian elite rugby players were of the lower leg. Sugarman (1983) reported that 17.5% of the injuries occurring during the 1981 season he surveyed were of the lower leg. Sparks (1985) also reported a 15.1% incidence of lower leg injures.

Emery *et al.* (2005) found that the impact of sport-related lower limb injuries may be lifelong, as there is evidence that that knee and ankle injuries may result in an increased risk of osteoarthritis in later life. Gabbett (2004) stressed that the implementation and evaluation of effective injury prevention strategies are dependent on the identification of injury risk factors. Junge *et al.* (2004) also recommend the development and implementation of preventative interventions to reduce the severity and rate of injury.

Moss (2002) indicates that adequate power is an essential requirement for an injured sportsman to return to activity, and he further explains that a good way to develop power and prevent re-injury or any injury is to use plyometric methods. Margison *et al.* (2005) found that a prior bout of plyometrics appeared to provide children with some protection from soreness after a subsequent bout of plyometric exercise. As sprinting is a form of plyometric exercise, this could have positive results for rugby players protecting them from muscle soreness after repetitive sprinting in matches if plyometrics are included in training. Plyometric exercise trains the neuromuscular system by teaching it to more readily accept increased strength loads. This goal will help to ensure the body is prepared to accept the stress that will be placed upon it during return to function (Voight & Tippett, 1999). This will help to reduce future injuries. Generally there is a limited amount of literature concerning the influence of plyometric strength on injuries. This study aims to increase the amount of literature available on the subject.

Several studies have shown that ankle proprioception and balance have an influence on ankle injuries (Stasinopoulos, 2004; Verhagen *et al.*, 2004; Baltaci & Kohl, 2003;

Anderson) as well as lower limb injuries (Murphy *et al.*, 2003; Baltaci & Kohl, 2003; Anderson). Using pre-season testing of high school and collegiate athletes, Trojian and McKeag (2006) demonstrated a significant association between a positive single leg balance test and ankle sprains. Emery *et al.* (2005) found evidence of a protective effect of balance training for a period of over 6 months, reducing sports-related injuries among the participants of a 6 week wobble board training programme.

Literature indicates that rugby injuries are a tangible problem in South Africa with large financial implications. Lower leg injuries account for between 15% and 20% of these injuries. Literature also suggests that improved proprioception, balance and plyometric strength could reduce the occurrence of these injuries.

7.3 SUMMARY OF THE RESULTS OF THE STUDY

7.3.1 Profile of U/14 Players

The mean test score for Balance in the U/14 players in this research study was 69.09%. The mean value for Bilateral plyometrics was 32.41 cm. Left and Right leg plyometric mean values were 18.88 cm and 19.43 cm respectively. The Star Excursion Balance Test mean values for U/14 players ranged between 68.35 cm and 88.97 cm. Mean values for L+R/Bil, L/Bil and R/Bil were 1.22, 0.6 and 0.62 respectively. The most significant differences between the player groups at U/14 level was the backline outperforming both tightforwards and looseforwards with Unilateral plyometrics. Backline players also outperformed tightforwards with Bilateral plyometrics and Balance. The match injury prevalence rate for U/14 players was 11.11/1000 match hours. The total injury prevalence rate was 2.73/1000 player hours. The lower limb was the site with the most injuries (62.5%) with the highest

percentage of injuries occurring in props (12.5%), hookers (12.5%) and scrum halves (25%).

7.3.2 Profile of U/15 Players

U/15 players in this study showed a mean test score of 62.39% for Balance. The mean test scores for Bilateral plyometrics, Left- and Right leg plyometrics were 37.25cm, 20.84cm and 22.22cm respectively. L+R/Bil showed a ratio with a mean value of 1.17 with L/Bil and R/Bil presenting with mean values of 0.56 and 0.61 respectively. Star Excursion Balance Test mean values ranged between 72.85cm and 93.46cm. In U/15 players the most significant differences between the player groups is that backline players outperformed loose forwards and tight forwards with bilateral and unilateral plyometrics. Tight fowards slightly outperformed loose forwards with Star Excursion Balance tests and loose forwards slightly outperformed tight forwards with Plyometrics. The U/15 players showed a total injury rate of 0.42/1000 player hours and a match prevalence rate of 2.47/1000 match hours. This low rate could be attributed to underreporting of inured players in this age group. There was only one injured player in this age group, with a lower limb injury. The injured player was a prop.

7.3.3 Profile of U/16 Players

The mean test score for Balance in U/16 players was 61.06%. The Bilateral plyometrics test showed a mean value of 33.0 cm. Left leg plyometrics had a mean value of 18.99 cm and Right leg plyometrics a mean value of 19.18 cm. L+R/Bil, L/Bil and R/Bil showed mean test values of 1.17, 0.58 and 0.59 respectively. Star Excursion Balance Test mean values ranged between 71.93 cm and 91.78 cm. There

were very few practically significant differences between players groups at U/16 level. Backline players slightly outperformed loose forwards and tight forwards with bilateral and unilateral plyometrics. Loose forwards slightly outperformed tight forwards with plyometrics and tight forwards performed slightly better than loose forwards with Star Excursion Balance Tests. The total injury prevalence rate for U/16 players was 6.17/1000 player hours. The match injury prevalence rate was 22.33/1000 match hours. Loosehead props (18.75%), inside and outside centres and wings (12.5% each) were the playing positions with the highest injury incidence. Lower limb and trunk injuries each accounted for 37.5% of the total injuries.

7.3.4 Profile of U/18 Players

U/18 players showed a mean Balance score of 66.2%. The mean scores for Bilateral plyometrics, Left leg plyometrics and Right leg plyometrics were 38.21 cm, 21.84 cm and 23.52 cm respectively. The L+R/Bil mean value was 1.2, with L/Bil and R/Bil mean values being 0.58 and 0.62 respectively. Star Excursion Balance Test mean values for the U/18 players ranged between 76.39 cm and 96.67 cm. The most significant differences between the different players in the U/18 age group is that backs and loose forwards markedly outperformed tight forwards with Plyometric tests and loose forwards outperformed backline players with Star Excursion Balance Tests. U/18 players showed a match injury prevalence rate of 45/1000 match hours with a total injury prevalence rate of 9.79/1000 player hours. Hookers (10.34% of total injuries) and outside centres (13.79% of total injuries) were the playing positions at the highest risk of injury.

7.3.5 Profile of Players with Lower Leg Injuries

During the season, eight players suffered nine lower leg injuries. Of these players, one also had a re-injury. One player was not assessed in the pre-season test battery. Of the five players with intrinsic lower leg injuries, all five showed values which were practically significantly weaker than the players in their player group for L+R/Bil. The d-values for these tests compared to their different age groups were d=0.86, d= 2.10, d=1.51, d=1.04 and d=0.90. L+R/Bil ratios could thus be said to have a large effect on lower leg injuries. The d-values for (Injured leg)/Bil plyometric ratios were d=0.92, d=2.03 and d=1.58 (bilateral injury), d=0.84, d=1.92 and d=-0.19. All these values have large effects on practical significance, except the last one. The last player, was however, left leg dominant and his injured left leg would have also shown substantial weakness if tested against the dominant leg of the other players in the same age group. (Injured leg)/Bil ratios could thus also be said to have a large effect on lower leg injuries.

Weaker test scores for unilateral plyometrics of the injured leg occurred in four of the six intrinsic lower leg injuries. These values had practically significant values for injured leg plyometric score. The d-values for these scores were d=2.27 and d=1.44 (bilateral injury), d=2.28 and d=2.65. Unilateral plyometric strength could thus be said to have a medium effect on injury occurrence. One player tested weaker with practically significant values for all directions of the Star Excursion Balance Test. Balance performance in the Star Excursion Balance Test could thus be said to have a small effect on lower leg injuries.

7.4 CONCLUSIONS OF THE STUDY

The total injury prevalence rates in this study (4.96/1000 player hours and 21.21/1000 match hours) are higher than all previous South African epidemiological studies on non-elite schoolboy rugby players (Nathan *et al.*, 1983; Roux, 1992; Upton, 1999). If minor injuries are excluded from the current study, the prevalence rate of 2.29/1000 player hours is very similar to the findings of Roux (1992) which showed a prevalence rate of 2.34/1000 player hours. However, it is still higher than the results of Upton (1999), which showed a rate of 1.60/1000 player hours. Upton (1999), however, used correspondence to monitor injuries and Roux *et al.* (1987) reported that this leads to under-reporting of injuries. The higher rate in the current study could thus possibly be attributed to the use of a different injury definition.

7.4.1 Influence of Proprioception, Balance and Plyometric Strength on the Occurrence of Lower Leg Injuries

Aim 1: To determine the influence of proprioception, balance and plyometric strength on the incidence of lower leg injuries in schoolboy rugby players.

The L+R/Bil ratio showed a practically significant effect of large size on the occurrence of lower leg injuries. The (Injured leg)/Bil ratio also showed a practically significant effect of large size on the occurrence of lower leg injuries. As no literature is available to this effect, this study is creating literature to enrich scientific knowledge. Unilateral plyometric test results showed to have a medium effect on the occurrence of lower leg injuries. This supports the findings of Swanik and Swanik (1999) namely that the preparatory muscle contractions needed for plyometric activities serve to protect the joint but also increase sensory feedback to the central

nervous system and that this effect would be very beneficial during rehabilitation because the athlete is able to protect against joint positions where he is vulnerable to injury

The balance results for the Star Excursion Balance Test had a small effect on the occurrence of lower leg injuries. Proprioception, as measured by the Balance board test with closed eyes, did not show to have an effect on the occurrence of lower leg injuries. This is contrary to the research by Trojian and McKeag (2006) and Wang *et al.* (2006), who found that pre-season testing of proprioception and balance could be used to determine the risk for ankle injuries during a season.

All the players with intrinsic lower leg injuries fell in the 20th percentile of all players involved in this study for L+R/Bil and (Injured leg)/Bil, when leg dominance is taken into account. The 20th percentile values could thus be used to determine an increased risk of lower leg injuries in schoolboy rugby players after pre-season testing. The values to be used are 1.012 for R+L/Bil ratios; 0.483 for L/Bil ratios and 0.492 for R/Bil ratios.

Aim 2: To create a suitable training programme to address these parameters if they prove to have an influence on lower leg injuries.

As a result of these findings, a preventative training programme was compiled, using a large number of different literature sources. The aim of this programme is firstly to improve plyometric strength in schoolboy rugby players and consequently reduce the risk of lower leg injuries. Proprioceptive and balance exercises are also included in the programme, based on the weight of existing literature on the injury preventative

qualities of proprioception and balance training (Stasinopoulos, 2004; Verhagen *et al.*, 2004; Powers *et al.*, 2004; Baltaci & Kohl, 2003; Rozzi *et al.*, 1999; Mattacola & Lloyd, 1997). The complete programme with illustrations may be found in Annexure E.

7.4.1.1 Compiling of the Injury Prevention Programme

7.4.1.1.1 General Programme Considerations

The exercise programme is designed not to interfere with the training schedule of teams and can be used as part of any warm-up programme that is followed. Players should be divided into three groups for the exercises. The players are divided according to similarities of build and function in the team. This division of players will result in the first group consisting of the two props, the hooker and the two locks. The second group will consist of the loose forwards the scrum half and the fly half. The third group will consist of the two centres, the wings and the fullback.

Each group will do only one set of either plyometric, balance board or combined exercises (includes balance, proprioception and plyometric exercise components) at each practice session. The groups will switch exercises at each practice so that each group does one set of all exercises each week. The exercises will thus be done at three practice sessions in a week. The exercises are designed not to take longer than seven minutes, to minimise interference with other training activities, while still providing effective exercise. This programme remains untested and research should be conducted in the future to determine its efficacy in improving plyometric strength, balance and proprioception and also its influence on injuries. See Annexure E for the complete exercise programme with illustrations.

The plyometric part of the programme should also be followed four weeks pre-season by players with tested weakness. In the pre-season period, these plyometric exercises should be done twice a week. During the season, the exercises should be done once a week, as prescribed in the previous paragraph.

7.4.1.1.2 Plyometric Programme

Voight and Tippett (1999) suggest that plyometric training has a variety of training variables which need to be manipulated to create and ideal programme. These variables were all taken into consideration during the compilation of this training programme and include: direction of body movement, weight of the athlete, speed of execution of the exercise, external load, intensity, volume, frequency and recovery period.

1) Direction of body movement: Athletes require speed and power not only in the vertical plane, but also in the horizontal, lateral and diagonal directions. Sports that require horizontal and lateral execution include football, baseball and sprinting (Allerheiligen, 1994).
2) Weight of athlete: Large athletes (>90kg) should avoid high-volume, high-intensity plyometric exercises. Athletes over 100kg should be limited to in-depth jumps ranging from 0.5 m to 0.75 m (Allerheiligen, 1994).
3) Speed of execution: Increased speed of execution on exercises like single-leg hops or alternate-leg bounding raises the demand on the individual (Voight & Tippett, 1999).
4) External load: External load can be added to further raise the training load of the athlete (Voight & Tippett, 1999). External loads will not be added in this

programme, as it is designed for training with minimal equipment. Allerheiligen (1994) stresses that only very experienced athletes should use external weights.

5) Intensity: Plyometric exercise intensity is controlled by the type of exercise. Single leg jumping has a higher intensity than double leg jumping (Voight & Tippett, 1999:158). Generally, as the intensity increases, the volume should decrease. In the early phases of training, both intensity and volume may increase, but once high intensity drills form the base of the programme, volume should decrease (Allerheiligen, 1994).

6) Volume: If intensity is high, volume should be low or medium. Volume for beginners should be 80 - 100 foot contacts per session, intermediate athletes should have 100 - 120 foot contacts per training session and advanced athletes should have 120 - 140 contacts per session (Allerheiligen, 1994). Voight and Tippett (1999:159) indicate that between 200 and 250 foot contacts of low to moderate intensity could be done by beginners as their ability increases.

7) Frequency: Frequency implies the number of training sessions per week. The usual range is one to three sessions per week, with two being the norm in the off season. In season, one session is usually sufficient for football players (Allerheiligen, 1994). Voight and Tippet (1999:159) advises that 48 – 72 hours of rest is necessary between sessions for optimal recovery, although research on this area is limited.

8) Recovery period: According to Voight and Tippet (1999:159) the rest time between sets should be adjusted according to whether the training goal is strength or endurance. With strength training a work rest ratio of 1:4 should be

used and with endurance training rest period can be shortened to a 1:1 or 1:2 ratio.

Week 1

Consists of four low intensity exercises (Allerheiligen, 1994).

1) Pogo Jump 2 x 10 (Radcliffe & Farentinos, 1999:46)

2) Squat Jump 2 x 10 (Radcliffe & Farentinos, 1999:46; Allerheiligen, 1994:328)

3) Vertical Jump 2 x 10 (Radcliffe & Farentinos, 1999:47; Allerheiligen, 1994:330; Chu, 1996:133; Brown, Ferrigno & Santana, 2000: 212)

4) Hip-twist ankle jump 2 x 20 (Brown *et al.*, 2000:208)

Week 2 and 3

Consists of two low and two medium intensity exercises (Allerheiligen, 1994:323)

1) Lateral skaters 2 x 10 L + R (Brown *et al.*, 2000: 210)

2) Skipping 2 x 15m (Brown *et al.*, 2000: 74)

3) Split squat jump 2 x 10 L + R (Allerheiligen, 1994:328)

4) Star jump 2 x 10 (Radcliffe & Farentinos, 1999:50)

Week 4 and 5

Consists of four medium intensity exercises (Allerheiligen, 1994:323)

1) Lateral line jump 2 x 10 (Allerheiligen, 1994:333; Shepard, 2004:128)

2) Cycle squat jump 2 x 10 (Allerheiligen, 1994:328; Brown *et al.*, 2000: 75)

3) Pike jump 2 x 10 (Allerheiligen, 1994:330; Radcliffe & Farentinos, 1999:211)

4) Double leg hop 2 x 15m (Allerheiligen, 1994:333; Radcliffe & Farentinos, 1999:82)

Week 6 and 7

Consists of two medium and two high intensity exercises (Allerheiligen, 1994:323)

1) Double leg tuck jump 2 x 10 (Radcliffe & Farentinos, 1999:52; Allerheiligen, 1994:330; Brown et al, 2000: 211)
2) Standing triple jump 2 x 10 (Allerheiligen, 1994:332; Brown *et al.*, 2000: 215)
3) Alternate leg bound 2 x 10 (Allerheiligen, 1994:336)
4) Hop and turn 180 degrees 2 x 10 (Chu, 1996:82)

Week 8 and 9

Consists of 4 high intensity exercises (Allerheiligen, 1994:323)

1) Lateral bound 2 x 10 (Radcliffe & Farentinos, 1999:71)
2) Scissor Jumps 2 x 10 (Brown *et al.*, 2000:75; Radcliffe & Farentinos, 1999:54)
3) Single leg vertical power jump 2 x 10 L + R (Allerheiligen, 1994:331)
4) Single leg lateral hop 2 x 10 L + R (Radcliffe & Farentinos, 1999:93)

Week 10

Consists of 4 high intensity exercises (Allerheiligen, 1994:323)

1) Single leg lateral hop 2 x 10 L + R (Radcliffe & Farentinos, 1999:93)
2) Single leg hop 2 x 15m L + R (Radcliffe & Farentinos, 1999:91; Brown *et al.*, 2000:77)
3) Single leg diagonal hop 2 x 15m L + R (Radcliffe & Farentinos, 1999:92)
4) Single leg diagonal bound 4 x 15m (Radcliffe & Farentinos, 1999:79)

7.4.1.1.3 Balance Board Programme

The balance board programme trains both balance and proprioception, as these components do not often function individually.

Many balance-orientated programmes are poorly defined; require substantial and frequent time commitments from participants and often last several months. Likewise, many balance training programmes use expensive clinical equipment, professional staff and a clinical environment. The need for a simplistic, concise, short term balance training programme that addresses dynamic balance and can be performed independently without expensive clinical equipment is evident (Bellew, Fenter, Chelette, Moore & Loreno, 2005).

Verhagen, Van Tulder, Van der Beek, Bouter and Van Mechelen (2005b) stated that the positive effects of a balance board programme were only achieved at a certain cost. These costs can be limited if taken into account that balance boards could be used for more than one season of training. A broader implementation of balance board training could be recommended if the long term health burden of ankle sprains and the clinical effectiveness of a proprioceptive balance board training programme are considered. The balance boards provided for this study were easy to construct and could be given as a project in any school woodwork class. A diagram of the balance board design can be seen in Annexure F. At a cost of about R40 a unit for materials, they are not very expensive, compared to commercially available units that retail for over R200.

A good general guideline for progression of a sensorimotor (balance) training programme is given by Page (2005): Participants should progress through three stages

of training namely static, dynamic and functional exercises. Within each stage, participants progress through exercises in different postures, bases of support and challenges to their centre of gravity. Each exercise should elicit automatic and reflexive muscular stabilization, challenging the participant to maintain postural control under a variety of conditions.

For complete balance board programme with illustrations and instructions, see Annexure E.

Week 1

1) Wide-legged stance 4 x 1minute (Guskiewitz, 1999:119)

Week 2 and 3

1) Wide-legged stance 2 x 1minute (Guskiewitz, 1999:119)

2) Narrow stance 2 x 1 minute (Page, 2005:3)

7.5.3.3 Week 4 and 5

1) Stand with eyes closed 2 x 1minute (Emery *et al.*, 2005; Clark & Burden, 2005)

2) Step over 2 x 20 Left + Right (Verhagen *et al.*, 2005a:1096)

Week 6 and 7

1) Heel to toe standing 2 x 1minute

2) Stand with ball catching 2 x 30 (Verhagen *et al.*, 2005a:1096)

Week 8 and 9

1) Zig-zag ball passing 2 x 10

2) Stand in line and pass ball 2 x 10

3) Lunge on board 2 x 20 (Page, 2005:2)

Week 10

1) 2-Legged squats 3 x 15 (Verhagen *et al.*, 2005a:1096)

2) One-legged standing 45 seconds Left + Right (Guskiewitz, 1999:121)

3) Lengthwise one-legged standing 45 seconds Left + Right

7.4.1.1.4 Combination of Plyometrics, Balance and Proprioception

Exercises without equipment

A combination of plyometric, balance and proprioceptive exercises were added to the programme to be performed without any equipment except rugby balls, which are readily available at rugby practices. These exercises supplement the effect of the other exercises and further help to improve static and dynamic balance, proprioception and plyometric strength. The illustrated programme may be seen in Annexure E.

Week 1

1) Tandem stance 4 x 45 seconds (Guskiewitz, 1999:121)

2) Lunges Left + Right 2 x 10 (Page, 2005; Guskiewitz, 1999:123)

Week 2 and 3

1) One-legged standing Left + Right 2 x 45 seconds (Page, 2005)

2) One-legged squats 2 x 10 Left + Right (Verhagen *et al.*, 2005a:1096)

Week 4 and 5

1) One-legged standing in running positions 2 x 45 seconds Left + Right (Brown *et al.*, 2000: 26)

2) One-legged stand with ball catch 2 x 15 Left + Right (Verhagen *et al.*, 2005a:1096)

Week 6 and 7

1) One legged stand with reaching 3 x Left + Right (Chaiwanichsiri, Lorprayoon & Noomanoch, 2005:91)

2) One legged stand with overhead throw 2 x 15 Left + Right (Verhagen *et al.*, 2005a:1096)

Week 8 and 9

1) Toe walking 4 x 15m

2) Heel walking 4 x 15m

3) Carioca 4x15m (Brown *et al.*, 2000: 84)

Week 10

1) Carioca 4x15m (Brown *et al.*, 2000: 84)

2) Pliometrics to sprint (4 x 10m) x 4 (Brown *et al.*, 2000: 216)

7.4.2 Influence of Proprioception, Balance and Plyometric Strength on Rugby Talent Identification

Aim 3: To determine whether proprioception, balance and plyometric testing could be integrated into existing test protocols as a rugby talent identification measure.

Generally, A-teams performed better than B-teams in all the tests except L+R/Bil, L/Bil and R/Bil, when all age groups are combined. The difference between the teams, however, only has a small to medium effect and cannot be considered practically significant. At U/14 and U/15 levels, there are more high practically significant differences between the A- and B-teams, with A-teams outperforming B-teams. At U/16 and U/18 levels A-teams outperformed B-teams, but the differences were much smaller than at the younger age groups. Balance tests did, however, show a high practically significant difference at U/18 level.

The U/16A team from Volkskool won the Beeld Trophy competition in 2006, identifying them as the best U/16 rugby team in the Northern Provinces (Gauteng, Limpopo, Mpumalanga and the North West). At U/16 age level, Volkskool markedly outperformed Boys High with most tests. This is further evidence that proprioception, balance and plyometric strength could be included in talent identification test batteries. There is thus some evidence that these tests could be included in talent identification test batteries at U/14, U/15 and U/16 age groups. Research by Hanekom (2000), Van Gent (2003), Pretorius (1997), Van der Merwe (1997) and De la Port (2004) shows that plyometric strength testing is usually included in talent identification test batteries, but is generally one of the test that carry less weight in the end determination. None of these studies include balance or proprioceptive testing as

possible predictors of rugby talent. Further research is needed in this field and the results in Table 5.22 could be used as a norm for comparative purposes with future studies.

7.5 RECOMMENDATIONS

Plyometric testing should be done by rugby coaches at all schools 4 weeks prior to the start of the rugby season. Since ratios for L+R/Bil, L/Bil and R/Bil are not influenced by the manner of testing (as long as bilateral and individual leg plyometrics are all tested in the same manner), testing can be done by electronic or wall-mark methods.

Players who present with test values below 1.012 for R+L/Bil ratios; 0.483 for L/Bil ratios; and 0.492 for R/Bil ratios should start following the plyometric part of the programme 4 weeks prior to the start of the rugby season. The rest of the players can start the entire programme at the beginning of the rugby season with the exercises for week 1 and 2, as prescribed. The players who presented with pre-season test weakness should restart with the week 1 and 2 programme along with the rest of the players at this stage.

7.5.1 Shortcomings of this Study

1) Post-season testing of many players failed due to unforeseen circumstances, making inclusion of the post-season proprioception, balance and plyometric test results in the study unfeasible. These results would have been valuable for comparative purposes. More attention should be paid to communication between researchers, rugby organisers, individual coaches and players with regards to the organisation of test dates and venues in future.

2) Implementation of the proprioceptive, balance and plyometric strength intervention programme during the season was not possible due to a number of reasons. Further research should be done on implementation of the programme in the next season to monitor its effectiveness.

3) The use of electronic equipment for the tests made result comparisons with earlier research studies using manual testing impossible. Plyometric tests should have been done using wall-mark methods. The complexity and time-consuming nature of the Star Excursion Balance Test make it a difficult test to administer effectively on large groups of people in limited time, especially if coaches without professional training were to administer it. It should be replaced in future research of this nature with a single limb stance test, which gives a simple positive or negative result; is less time consuming and has been proven to be effective as proprioceptive measure and predictor for ankle injuries.

7.5.2 Recommendations for Further Research

1) Research should be conducted to determine whether L+R/Bil, L/Bil and R/Bil plyometric ratios fall in similar ranges for club and provincial rugby players and whether the influence of these ratios on lower leg injuries could be expanded to senior rugby players.

2) Research should also be conducted on other sport codes to determine whether L+R/Bil, L/Bil and R/Bil plyometric ratios could be used *universally* for determining an increased risk of the occurrence of lower leg injuries.

3) Research in the past has proven that proprioception and balance have an influence on lower leg and ankle injuries. This study should be repeated using different tests, such as a simple single limb stance test to determine beyond any doubt whether these variables have any influence on the occurrence of lower leg injuries in schoolboy rugby players.

4) Further research needs to be conducted into the possible inclusion of proprioception and balance testing in talent identification test batteries.

5) The preventative training programme remains untested and research should be conducted in the future to determine its efficacy in improving proprioception, balance and plyometric strength and also its influence on injury occurrence.

To summarise, this study succeeded in proving that proprioception, balance and plyometric strength have an influence on the occurrence of lower leg injuries in schoolboy rugby players. It also expanded the literature with regard to the influence of plyometric strength on lower leg injuries.

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ANNEXURE A
INFORMED CONSENT

I will be commencing a Master's degree study in Movement Education at the North-West University in 2006. I hereby request your consent for the participation of your son in this study. It should cause minimal interference with players and staff and will benefit the school, the scientific- and rugby playing communities alike.

My research project will be conducted on the influence of a balance, proprioception and plyometric strength on the incidence of lower leg injuries in schoolboy rugby players. The project will entail the following:

1. Teams participating in the study will be the U/14 A + B teams, U/15 A + B teams, U/16 A + B teams and U/18 A + B teams.
2. At the beginning of the season players will be given a proprioception and balance tests as well as an evaluation of explosive jumping power. A questionnaire regarding any previous and current injuries sustained will also be completed.
3. During the season a register will be kept by the coach of each team to indicate the amount of hours each player was involved in match play or training.
4. All injuries sustained by players will be assessed on an ongoing basis by a qualified Physiotherapist at free clinics throughout the season, and these injuries will be documented.
5. Balance, proprioception and explosive jumping power tests will be repeated again at the end of the rugby season.

No player will be negatively affected by any part of the study. A full briefing and explanation will be given to all coaches and players involved in the study.

Testing of players will be conducted at the beginning and end of the rugby season. Each player will be needed for approximately 10 minutes to conduct the physical testing. Tests will be conducted at the school.

The aim of this study is to evaluate lower leg injuries in school rugby players and to identify the extent to which these injuries are influenced by balance, proprioception and explosive jumping strength.

JH Serfontein

I, _____ parent/legal guardian of _____
_____ hereby give consent that my son may participate in this study.
Signature: _____ Date: _____

ANNEXURE B

INJURY HISTORY QUESTIONNAIRE

RUGBY EPIDEMIOLOGY QUESTIONNAIRE

DATE _____ **TEAM** _____

FULL NAMES _____ **AGE** _____

DATE OF BIRTH _____ **PLAY POSITION** _____

HEIGHT _____ **WEIGHT** _____

POSTAL ADDRESS _____

CONTACT NUMBERS _____

CURRENT AND PREVIOUS INJURIES

INJURY	CURRENT	PREVIOUS	REMARKS
Total concussions			
Total skull fractures			
Neck			
Shoulder			
Arm/wrist/hand			
Rib/sternum			
Back hip/groin			
Upper leg			
Knee			
Lower leg/shins			
Ankle			
Feet			
Muscle torn/strain			
Abdominal			
Dental			
Other			

Adapted from: Hattingh, 2003

ANNEXURE C
TEST RESULT SHEET

HOëR VOLKSKOOL POTCHEFSTROOM

Name: _____

Team: _____

BALANCE

Star excursion balance test

	Left Leg stance	**Right Leg stance**
Anterior	cm	cm
Anteromedial	cm	cm
Medial	cm	cm
Posteromedial	cm	cm
Posterior	cm	cm
Posterolateral	cm	cm
Lateral	cm	cm
Anteromedial	cm	cm
	+20cm	+20cm

PROPRIOCEPTION

Percentage %

PLYOMETRIC TESTING

Bilateral **cm**

Left **cm**

Right **cm**

ANNEXURE D
INJURY REPORT FORM
CLINIC DATE_____

NAME_____

_____

POSITION_____**AGE GROUP**_____

_____

SITE OF INJURY (Circle) Head, Face, Neck, Shoulder, UArm, LArm, Wrist, Hand, Fingers, Thumb, Chest, Abdomen, Spine, Back, Pelvis, ULeg, LLeg, Knee, Ankle, Foot, Toes, Other_____

SEVERITY OF INJURY Minor, Mild, Moderate, Severe

MECHANISM: Intrinsic / Extrinsic

WHERE: Match / Training

PHASE OR ASPECT OF PLAY: Scrum, Line-out, Ruck, Maul, Tackle, Kicking, Pile-up, Collision, Other_____

IF MATCH INJURY:

Time of game: 1st Half / 2nd Half

Relationship of ball and Injured player: near ball / behind ball

Play: Legal / Illegal

CLASSIFICATION OF INJURY

Assessment:_____

_____

_____

Treatment:_____

_____

_____

Instructions to Coach/ Player_____

_____

_____

_____

Special Tests/ Referrals_____

_____

_____

Adapted from: Hattingh (2003), McManus (2000)

ANNEXURE E

TRAINING PROGRAMME

General:

Players will be divided into 3 groups for the exercises. Group number one will consist of the 2 props, the hooker and the 2 locks. Group number two will consist of the loose forwards the scrum half and the fly half. Group number three will consist of the 2 centres, the wings and the fullback.

Each group will do only one set of either plyometric, balance board or combined exercises at each practice session. The groups will switch exercises at each practice so that each group does one set of all exercises each week. The exercises will thus be done at 3 practice sessions in a week.

WEEK 1

Plyometrics

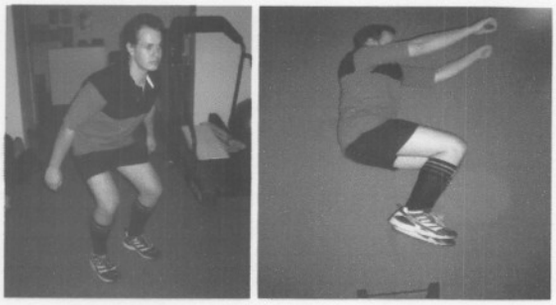
Pogo Jump 2 x 10

Starting Position:

Arms next to sides, knees slightly bent.

Action:

Using only lower legs, project body upwards. Using arms to help with upwards motion. Land with slightly bent legs to absorb impact. Rest 15 seconds between sets.



Squat Jump 2 x 10

Starting Position:

Stand with legs straight and hands interlocked behind head.

Action:

Bend knees to a half squat position and explode into jump extending hips, knees and ankles. Land with legs bent to absorb impact. Rest 15 seconds between sets.

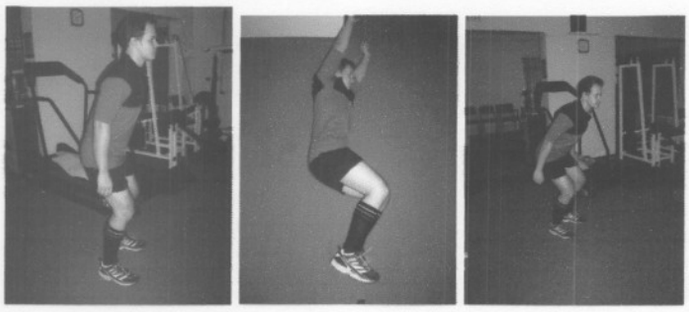
Vertical Jump 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides.

Action:

Bend knees to half squat position and explode into jump extending hips, knees and ankles. Also extend arms above head and try to reach up to maximum height. Land in half squat position with arms bent next to sides and immediately explode into next jump. Rest 15 seconds between sets.



Hip-twist ankle jump 2 x 20

Starting Position:

Stand with arms slightly away from sides.

Action:

Jump using only ankles and rotate slightly bent legs to left. Land with slightly bent legs and jump again, rotating legs to right. Repeat motion. Rest 15 seconds between sets.



Balance Board Exercises

Wide legged stance 4 x 1minute

Starting Position:

Stand with legs spaced widely apart on balance board.

Action:

Keep board horizontal by balancing. Arms can be extended to sides. Do for 1 minute and then rest 30 seconds between sets.



Combined Exercises

Tandem stance 4 x 45s

Starting Position:

Stand with feet heel to toe.

Action:

Keep balance in this position for 45 seconds. Rest 15 seconds and then change feet. Do 2 sets with each foot in front. Rest 15 seconds between sets.



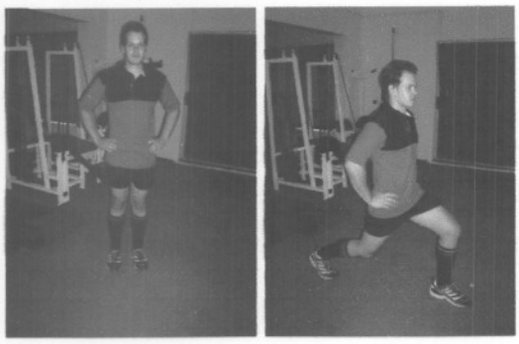
Lunges L + R 2 x 10

Starting Position:

Stand with hands on hips.

Action:

Lunge forward with left leg as far as possible. Return to starting position. Repeat 10 times with left leg and then switch to right leg. Rest 30 seconds after one set of left and right.



WEEK 2 + 3

Plyometrics

Lateral skaters 2 x 10 L + R

Starting Position:

Stand with both legs together.

Action:

Push off laterally with one leg. Upon landing immediately push off with other leg into the opposite direction. Do 10 repetitions to each side . Rest 15 seconds between sets.



Skipping 2 x 15 m

Starting Position:

Stand with arms next to sides.

Action:

Go into skipping motion bringing opposite arm and leg up together. Try to attain maximum height. Rest 15 seconds between sets.



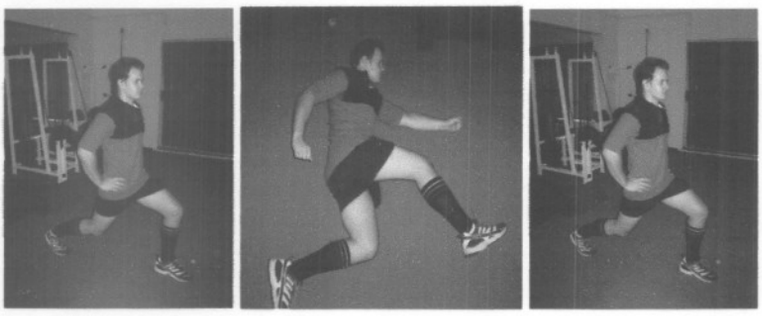
Split squat jump 2 x 10 L + R

Starting Position:

Stand in lunge position with hands on hips.

Action:

Jump vertically upwards and land in the starting position. Back knee should not touch ground. Do 2 sets with left and right leg. Rest 15 seconds between sets.



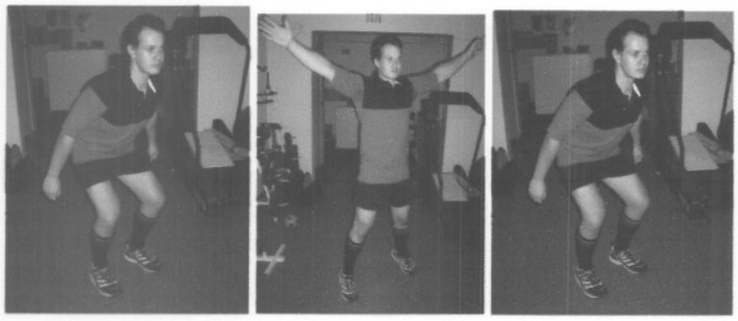
Star jump 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides

Action:

Bend knees to half squat position and explode into jump extending hips, knees and ankles outwards. Also extend arms outwards as far as possible. Land in half squat position with arms bent next to sides and immediately explode into next jump. Rest 15 seconds between sets.



Balance Board Exercises

Wide legged stance 2 x 1minute

Starting Position:

Stand with legs spaced widely apart on balance board

Action:

Keep board horizontal by balancing. Keep hands on hips. Do for 1 minute and then rest 30 seconds between sets.



Narrow stance 2 x 1 minute

Starting Position:

Stand with feet directly next to each other in middle of balance board

Action:

Keep board horizontal by balancing. Arms may be extended to sides. Do for 1 minute and then rest 30 seconds between sets.



Combined Exercises

One legged standing L + R 2 x 45s

Starting Position:

Stand on one leg.

Action:

Keep balance for 45 seconds. Switch legs and repeat with other leg. Rest 30 seconds between sets.



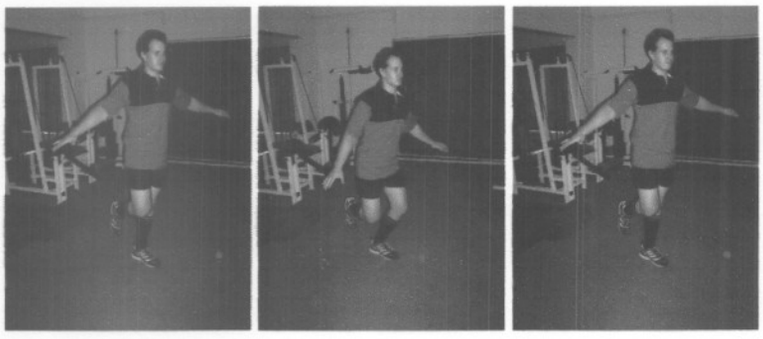
One legged squats 2 x 10 L + R

Starting Position:

Stand on one leg

Action:

Bend knee 45 degrees and straighten up again. Repeat 10 times with each leg. Rest 15 seconds between sets.



WEEK 4 + 5

Plyometrics

Lateral line jump 2 x 10

Starting Position:

Stand with both legs together and arms next to sides, next to line.

Action:

Jump with both legs over the line and land on other side. Immediately jump back to other side upon landing. Jump 10 times to each side. Rest 15 seconds and repeat.



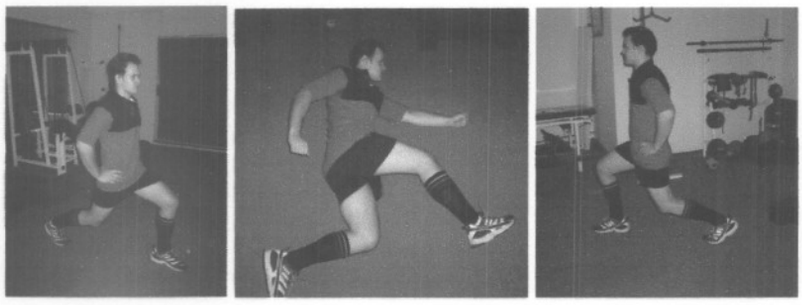
Cycle squat jump 2 x 10

Starting Position:

Stand in lunge position with hands on hips.

Action:

Jump vertically upwards. Switch legs while in the air and land in the starting position, with the back leg now in front. Back knee should not touch ground upon landing. Repeat 10 times. Do 2 sets. Rest 15 seconds between sets.



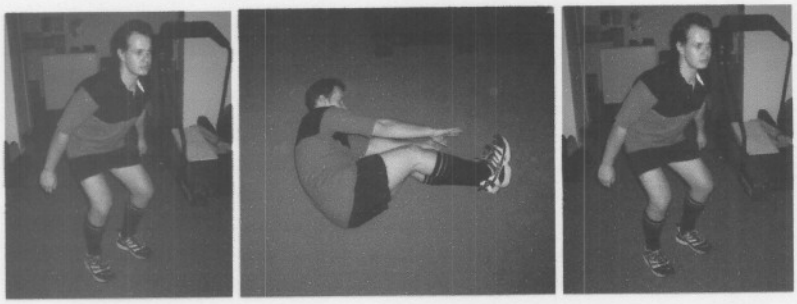
Pike Jump 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides.

Action:

Bend knees to half squat position and explode into jump extending hips, knees and ankles. Kick legs out straight to front. Also use hands to try to touch toes. Land in half squat position with arms bent next to sides. Take a moment and then explode into next jump. Do 2 sets. Rest 15 seconds between sets.



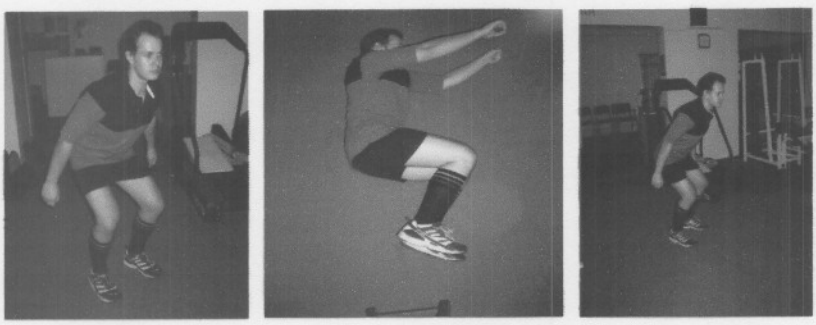
Double leg hop 2 x 15 m

Starting Position:

Stand with legs straight and hands next to sides.

Action:

Bend knees to a half squat position and explode into jump extending hips, knees and ankles, moving body forwards. Land with legs bent to absorb impact and immediately explode into next jump. Try to attain maximum horizontal distance. Rest 15 seconds after 15 metres and repeat.



Balance Board Exercises

Stand with eyes closed 2 x 1min

Starting Position:

Stand with legs spaced widely apart on balance board. Close eyes.

Action:

Keep board horizontal by balancing. Arms may be extended to sides. Keep eyes closed. Do for 1 minute and then rest 30 seconds between sets.



Step over 2 x 20 L + R

Starting Position:

Stand on right hand side next to one end of balance board.

Action:

Take step forward with left leg onto balance board and step over landing on right leg again. Keep balance in during the process. Turn around and repeat with right leg onto board. Do 20 repetitions with each leg and then rest for 30 seconds. Repeat another 20 repetitions with each leg.



Combined Exercises

One legged standing in running positions 2 x 45 seconds L + R

Starting Position:

Stand in a running position with only one leg on the ground.

Action:

Keep balance in this position for 45 seconds minute. Switch legs. Rest 15 seconds between sets.



One legged stand with ball catch 2 x 15 L + R

Starting Position:

Stand on 1 leg.

Action:

Keep balance while catching a ball and passing it back 15 times. Switch legs and repeat with other leg. Rest 15 seconds between sets. Do 2 sets on each leg.



WEEK 6 + 7

Plyometrics

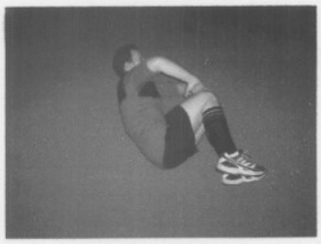
Double leg tuck jump 2 x 10

Starting Position:

Stand with arms slightly flexed with hands in front of chest.

Action:

Bend knees to half squat position and explode into jump extending hips, knees and ankles. Tuck in legs close to body and touch hands with knees. Land in half squat position with arms bent next to sides. Explode into next jump immediately. Do 2 sets. Rest 15 seconds between sets.



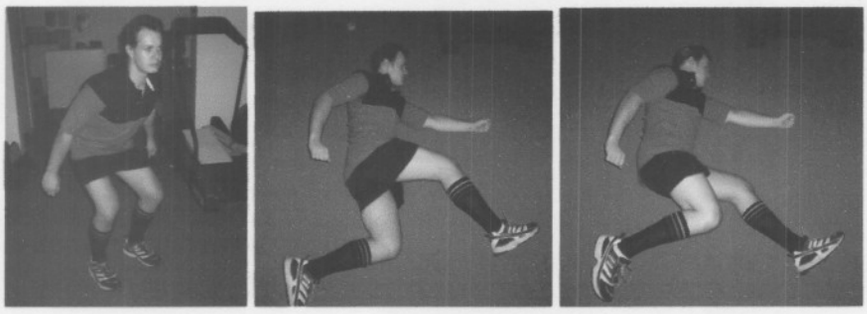
Standing Triple jump 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides.

Action:

Perform a long jump and land on left leg. Immediately jump and land on right leg. Then immediately jump and land on both legs. Take a moment and repeat. Do 10 repetitions and rest 30 seconds. Then do 10 repetitions landing on right leg first.



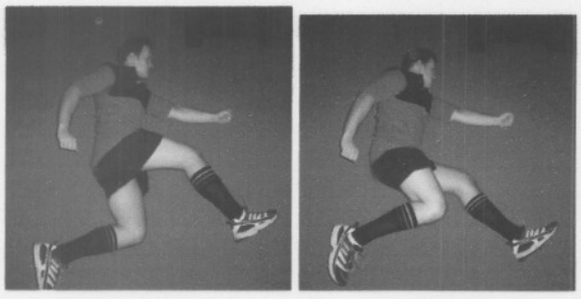
Alternate leg bound 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides.

Action:

Perform a bound with left leg and land on right leg. Upon landing, immediately bound with right leg and land on left leg. Do 10 repetitions and rest 15 seconds. Then do 10 repetitions landing on left leg first. Try to attain maximum distance with each bound.



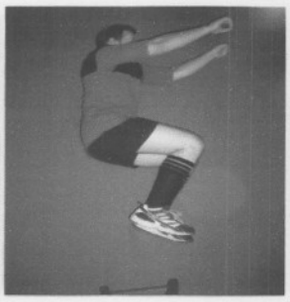
Hop and turn 180 degrees 2 x 10

Starting Position:

Stand with arms slightly flexed next to sides.

Action:

Jump forwards and turn 180 while in the air. Land facing the direction you came from. Jump backwards from this position and turn 180 degrees in the air again, landing facing forward. Continue jumping and turning in the air 10 times. Rest 15 seconds and then repeat another 10 jumps, all the while turning in the air while jumping.


Balance Board Exercises

Heel to toe standing 2 x 1min

Starting Position:

Stand heel to toe in the length of the balance board.

Action:

Keep balance in this position for 1 minute. Rest 30 seconds. Change legs and do another set of 1 minute.



Stand with ball catching 2 x 30

Starting Position:

Stand with legs spaced widely apart on balance board.

Action:

Keep balance and catch a ball that is being passed to you from the front. Do 30 catches and rest 15 seconds between sets.



Combined Exercises

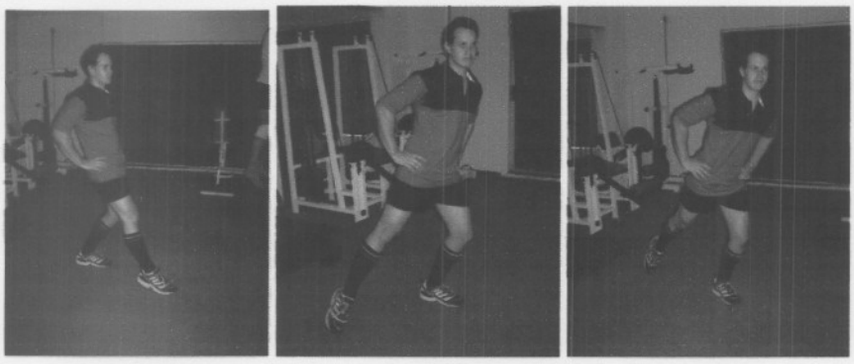
One legged stand with reaching 3 x L + R

Starting Position:

Stand on one leg.

Action:

Reach out with other leg in 8 different directions moving around while keeping balance and not putting down the leg reaching out. Do 3 circumventions with each leg. Rest 10 seconds between sets. Similar to star balance excursion test.



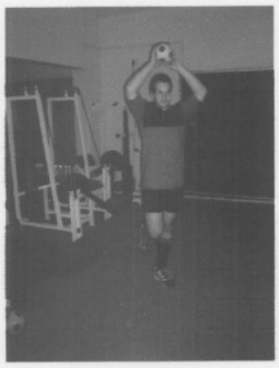
One legged stand with overhead throw 2 x 15 L + R

Starting Position:

Stand on one leg.

Action:

Throw and catch a ball above the head while maintaining balance on one leg. Do 2 sets of 15 throws on each leg. Rest 15 seconds between sets.



WEEK 8 + 9

Plyometrics

Lateral Bound 2 x 10

Starting Position:

Stand with both legs together in a semi-squat position and hands hanging down in front, next to line.

Action:

Jump sideways with both legs over the line and land as far as possible on the other side on the outside leg, with the other leg following afterwards. Upon landing, reset to starting position and jump back to other side. Jump 10 times to each side. Rest 15 seconds and repeat.





Scissor Jumps 2 x 10

Starting Position:

Stand in lunge position with hands on hips.

Action:

Jump vertically upwards. Straighten legs while in the middle of the jump. Switch legs at this stage while in the air and land in the starting position, with the back leg now in

front. Back knee should not touch ground upon landing. Repeat 10 times. Do 2 sets. Rest 15 seconds between sets.



Single leg vertical power jump 2 x 10 L + R

Starting Position:

Stand with arms slightly flexed next to sides on one leg, with other leg bent at hip.

Action:

Bend knee to half squat position and explode into jump extending hip, knee and ankle. Also extend arms above head and try to reach up to maximum height. Land in half squat position on one leg with arms bent next to sides and immediately explode into next jump. Rest 15 seconds between sets.



Single leg lateral hop 2 x 10 L + R

Starting Position:

Stand on one leg with arms next to sides, next to line.

Action:

Jump over the line and land on same leg on other side. Immediately jump back to original side upon landing. Jump 10 times to each side. Rest 15 seconds and repeat with other leg. Do 2 sets with each leg.



Balance Board Exercises

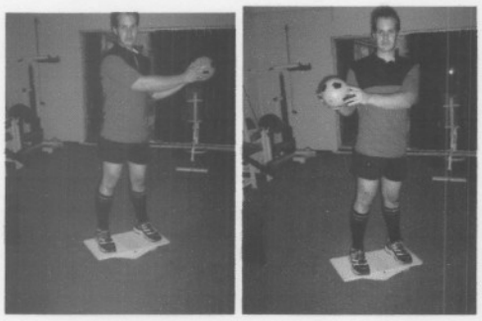
Zig-zag ball passing 2 x 10

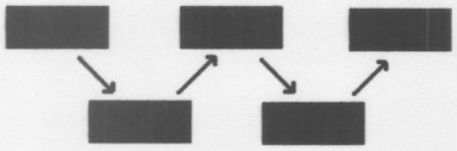
Starting position:

Position boards in a zig-zag fashion with 2 boards facing 3 boards in 2 parallel rows. Players face the opposite boards with legs spread apart.

Action:

Players pass rugby ball in zig-zag fashion down line while keeping dynamic balance on board. Repeat 10 lines in each direction. Rest 30 seconds. Repeat 10 more lines.





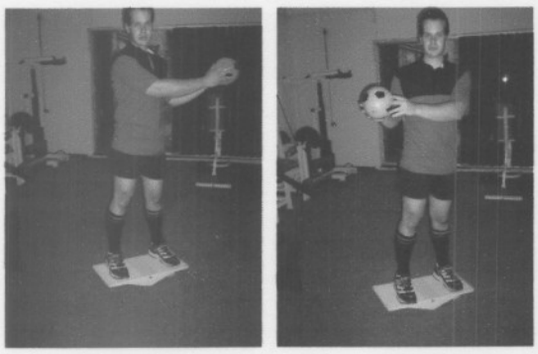
Stand in line and pass ball 2 x 10

Starting Position:

Position all balance boards in straight line with players facing same direction, standing with legs spread apart on board.

Action:

Players pass rugby ball down line while keeping dynamic balance on board. Repeat 10 lines in each direction. Rest 30 seconds. Repeat 10 more lines.





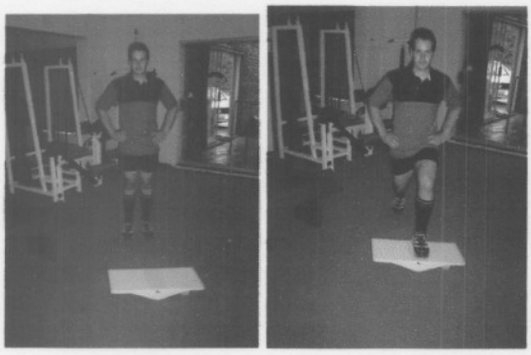
Lunge on board 2 x 20

Starting Position:

Players stand on ground with board at 90 degree angle approximately half a metre in front of them.

Action:

Players lunge forward landing with front foot on balance board. They then return to starting position and lunge with other foot. Do 20 repetitions with each foot. Rest 30 seconds and then repeat.



Combined Exercises

Toe walking 4 x 15 m

Starting Position:

Stand on toes behind line

Action:

Walk 15 metres on toes to opposite line. Turn around and walk back to beginning on toes. Rest 15 seconds and repeat 4 times. Rest 15 seconds between every 2 lengths.



Heel walking 4 x 15 m

Starting Position:

Stand on heels behind line

Action:

Walk 15 metres on heels to opposite line. Turn around and walk back to beginning. Rest 15 seconds and repeat 4 times. Rest 15 seconds between every 2 lengths.



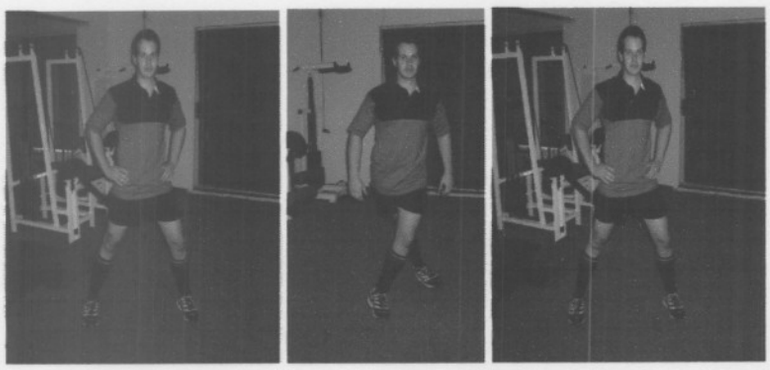
Carioca 4x15 m

Starting position:

Turned sideways behind line.

Action:

Step out sideways with right leg. Step in front of right leg with left leg. Then step out with right leg again. Now step behind right leg with left leg. Repeat this pattern for 15 metres. Turn back and repeat pattern, now stepping out with left leg first. Repeat 2 lengths 4 times and rest 15 seconds between each set.





WEEK 10

Plyometrics

Single leg lateral hop 2 x 10 L + R

Starting Position:

Stand on one leg with arms next to sides, next to line.

Action:

Jump over the line and land on same leg on other side. Immediately jump back to original side upon landing. Jump 10 times to each side. Rest 15 seconds and repeat with other leg. Do 2 sets with each leg.



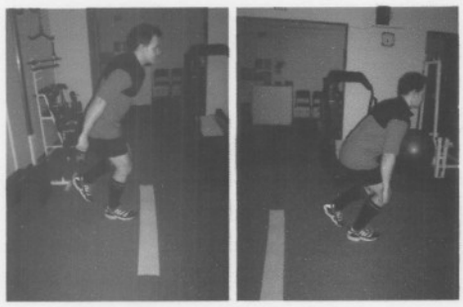
Single leg hop 2 x 15 m L + R

Starting Position:

Stand on one leg with arms next to sides, behind line.

Action:

Jump over the line and land on same leg. Immediately jump again upon landing. Jump 15m on one leg. Switch legs and jump back to starting position. Rest 15 seconds and repeat. Do 2 lengths with each leg. Attempt for maximal horizontal distance with each jump.



Single leg diagonal hop 2 x 15 m L + R

Starting Position:

Stand on one leg with arms next to sides, next to line.

Action:

Jump over the line diagonally and land on same leg on other side. Immediately jump diagonally back to other side again upon landing. Jump 15 m on one leg. Switch legs and jump back to starting position. Rest 15 seconds and repeat. Do 2 lengths with each leg. Attempt for maximal distance with each jump.



Single leg diagonal bound 4 x 15 m

Starting Position:

Stand on left leg with arms next to sides, next to line.

Action:

Jump over the line diagonally and land on right leg on other side of the line. Upon landing immediately jump diagonally back to other side again, landing on left leg.

Continue bounding diagonally across line, landing on different foot each time. Jump a distance of 15 m. Rest 15 seconds and repeat. Do 4 lengths.




Balance Board Exercises

Lengthwise one legged standing 45 seconds L + R

Starting Position:

Stand on one leg on balance board, lengthwise.

Action:

Keep balance for 45 seconds. Rest 15 seconds and switch legs.



One legged standing 45 seconds L + R

Starting Position:

Stand on one leg on balance board.

Action:

Keep balance for 45 seconds. Rest 15 seconds and switch legs.



2 Legged squats 3 x 15

Starting Position:

Stand on balance board with legs spaced apart.

Action:

Do 15 quarter squats in this position while keeping balance. Rest 15 seconds between sets. Do 3 sets.



Combined Exercises

Carioca 4x15 m

Starting position:

Turned sideways behind line.

Action:

Step out sideways with right leg. Step in front of right leg with left leg. Then step out with right leg again. Now step behind right leg with left leg. Repeat this pattern for 15 metres. Turn back and repeat pattern, now stepping out with left leg first. Rest 15 seconds. Repeat 4 times.

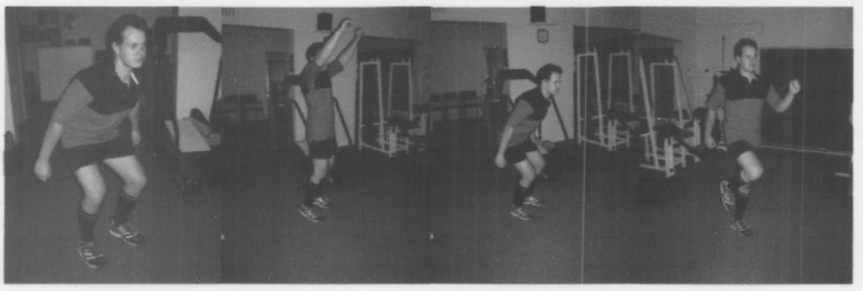
Plyometrics to sprint (4 x 10m) x 4

Starting position:

Stand with arms slightly flexed next to sides

Action:

Bend knees to half squat position and explode into jump extending hips, knees and ankles. Land in half squat position and then sprint 10metres to opposite line. When reaching other line repeat jump and sprint procedure. Do 4 lengths and the rest 30 seconds. Do 4 sets of 4 lengths. Rest 30 seconds between sets.



ANNEXURE F
BALANCE BOARD DESIGN

