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THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

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A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfillment of the requirements for the degree of Master of Science in Physiotherapy

Johannesburg, 2009

DECLARATION

I, Eloize Mellet declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination at this or any other University

_____

6th day of November 2009

ABSTRACT

INTRODUCTION

Rugby is a high impact sport with many injuries reported in the literature. A high rate of ankle injury is reported with resultant recurrence of these injuries. There is however only scarce epidemiological data with minimal detail to highlight clinical findings and prevalence of ankle injuries especially in the club rugby fraternity.

AIMS

This study investigated the prevalence of clinical signs of ankle injuries in rugby players at club rugby level in the South Gauteng region. The data collected was used to identify the clinical signs related to ankle instability for perceived, mechanical and functional parameters and was applied to determine the difference between players with and those without previous injury.

METHODOLOGY

The researcher obtained ethical clearance to do the study from the Human Research Ethics Committee of the University of the Witwatersrand. Permission was obtained from the Golden Lions Gauteng Rugby Union to use players in the South Gauteng region. One hundred and eighty players from nine clubs in the region participated in the study. Informed consent was obtained from all parties concerned and players were asked to complete a battery of tests.

To determine the prevalence of clinical signs of perceived instability each player was asked to complete a data questionnaire and the Olerud and Molander questionnaire. The data questionnaire also included questions pertaining to the exclusion criteria.

Objective testing was done to determine the clinical signs of mechanical instability of both ankles of each player through mechanical tests; the talar tilt and anterior drawer tests.

Balance and proprioception were assessed through the Star Excursion Balance Test (SEBT) and Balance Error Scoring System (BESS) which is used to indicate clinical signs of functional instability and these tests were used to determine the prevalence of clinical signs of functional instability and to relate the clinical signs of functional instability to the other clinical findings.

RESULTS

The prevalence of ankle injuries at club rugby level is discussed for the different parameters of instability. The prevalence of clinical signs of perceived instability based on the Olerud and Molander questionnaire is 47%, as reported by the player and is further described in a sub-analysis of perceived problems. The prevalence of clinical signs of mechanical ankle instability, when laterality is ignored is 38.7%. The prevalence of clinical signs of functional ankle instability depends on the surface and the visual input and is greater as the challenge or protuberance increases in difficulty. The clinical signs of perceived, mechanical and functional ankle instability are further described and related to other clinical findings for two groups, namely those with and those without previous injury to the ankle and as expected clinically significant differences were noted with the players with previous injury recording a higher prevalence for perceived and mechanical parameters. The odds ratios for the presence of certain clinical signs revealed significant p-values for the presence of pain, stiffness and swelling and the need for supports e.g. bracing or taping and the affect on activities of daily living.

DISCUSSION

In this study there is a high prevalence of clinical signs of ankle instability in club rugby players for perceived, mechanical and functional parameters, compared to the prevalence reported in the literature. From the study the clinical findings associated

with the presentation of ankle injuries in club rugby players have been established and related to the perceived, mechanical and functional signs of instability. Differentiation between players with reported ankle injury and those without were also done and significant differences were noted between the two groups for perceived and mechanical parameters but where the functional assessment was done it supported the fact that balance and proprioception tests included the whole kinetic chain and does not view the ankle in isolation. It was evident that previously injured players were more likely to sustain future injury to the ankle and odds-ratios to support this showed an increased risk of the presence of swelling, stiffness and pain for players with previous injury and the greater need for the use of supports and influence on activities of daily life.

The information gathered can be used in the future to set up a management plan for pre-season screening, assessing and addressing individual predisposing biomechanical factors, managing acute injuries successfully and rehabilitation in the post-season phase.

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CHAPTER 1

1. INTRODUCTION

1.1 INTRODUCTION TO THE CONCEPTS

Ankle injuries are sustained regularly in the sporting population (Ergen and Ulkar, 2008; Samuel and Obehi, 2008). Lateral ankle injuries are among the most common injuries sustained, making up 10 – 30 % of all sports injuries (Zoch et al, 2003). Eighty five percent of these injuries involve the lateral ligament complex and in the most part are due to an inversion sprain (Tropp et al, 1985). The anterior talofibular ligament is an extension of the joint capsule and is a long, thin ligament which renders it susceptible to injury (Hunter and Fortune, 2000).

There are many different sporting codes with different movements and levels of control required at the ankle joint. Both a high prevalence and a high incidence of ankle injuries have been reported in various sporting codes (Trojian and McKeag, 1998; Fong et al, 2007; Hootman et al, 2007).

An 80% recurrence rate of ankle injuries has been reported (Smith and Reischl, 1986; Denegar and Miller, 2002). Twenty percent of patients with acute ligament sprain will complain of residual symptoms after the observation of normal healing time for the mechanical insult to the tissue, which will predispose them to future injury. This can be attributed to continued joint dysfunction, pre-existing anatomical and biomechanical factors or inadequate rehabilitation (Denegar and Miller, 2002; Aiken et al, 2008; Sankey et al, 2008; Liu and Jason, 1994; Mohammadi, 2007)

Pre-season screening is becoming a requirement to managing sporting teams and examinations are performed not only to asses the match fitness of a player,

but also to establish the presence of biomechanical abnormalities which might predispose a player to injury. The use of a standard set of tests to determine ankle stability and then addressing components at risk including range of motion, strength and proprioception may lead to a decrease in the incidence or recurrence of injury (Lui and Jason, 1994). In order to consider what tests can be used the different levels of ankle instability which forms a continuum needs to be considered: mechanical (*disruption of the integrity of the ligamentous supports)*, functional *(increased range of motion of the joint not exceeding the physiological constraints)* and chronic *(the acutely injured ankle that has been poorly managed and where reinjury occurs regularly with the presence of mechanical and/ or functional factors)* ankle instability.

Very little evidence in the literature related to anatomical and biomechanical factors predicting re-injury or predisposing an athlete to injury is available (Morrison and Kaminski, 2007; Denegar and Miller, 2002). Based on the anatomical and biomechanical models, the ankle joint is stabilized by joint orientation, ligamentous restraints and muscular contraction which are controlled by the central nervous system, through the peripheral nerves. Insult to any one of these components can lead to ankle injury. When there are abnormalities in the biomechanics, such as cavovarus, increased foot width and increased calcaneal eversion, it is speculated that the ankle is more susceptible to injury (Morrison and Kaminski, 2007).

Three different kinds of testing of ankle instability are reported in the literature namely: perceived, mechanical and functional tests to determine stability (Denegar and Miller, 2002; Nyska et al, 2003; Susco et al, 2004; Olmsted et al, 2002; Trojian and McKeag, 1998). Perceived ankle instability is the subjective self-evaluation of the player with regards to ankle function and is established by using questionnaires (Olerud and Molander, 1984). Mechanical instability, is the increase in accessory movement (arthrokinematic motion that cannot voluntarily be produced e.g. the glide and roll of the talus in the mortise) which translates into an enlarged neutral zone (Panjabi, 1992). The neutral zone can be defined as the area of minimal internal resistance to joint excursion, supplied by collagen tissue. Mechanical instability is usually the result of a tear or

lengthening of one of the ligamentous structures supporting the joint. Residual mechanical instability suggests a non-optimal healing process, which in turn could lead to functional ankle instability (Denegar and Miller, 2002). Functional ankle instability together with mechanical instability are the precursors to chronic ankle instability which is caused by recurrent disruptions of the ankle integrity with resultant perceived and observed instability or a combination of these (Denegar and Miller, 2002). A recent definition of functional ankle instability is the occurrence of recurrent injuries and the sensation of joint instability due to the contribution of proprioceptive, neuromuscular and postural control deficits (Hertel, 2002). It is suggested that functional instability can be present without any mechanical deficits (Gribble et al, 2004).

With the high incidence, prevalence and recurrence of ankle injuries it has been reported that even though the mechanical integrity of the ligamentous structures are accounted for athletes are vulnerable to re-injury and this is classified as functional ankle instability referring to joint motion beyond voluntary control but within physiological constraints, again referring to larger excursion greater than the neutral zone with or without mechanical deficits (Tropp, 1986). The continuum of stability leads to the intermittent feeling of giving way, difficulty to perform on uneven surfaces with resultant mental and physical distrust of the integrity of the ankle (De Norhona et al, 2008; Denegar and Miller, 2002).

Due to the advent of professionalism in rugby in 1995 a higher incidence of injury than in other team sports has been reported (Brooks and Kemp, 2008). In rugby, the greatest proportion of injuries happen during match play and the most prominent mechanisms of injury are related to the tackle. Sites that are at risk are the shoulder, knee, thigh, ankle and head. The most common injury type is ligamentous sprain (Holtzhausen et al, 2006). Ankle injuries in rugby players have been reported as one of the most common injuries and combined with Achilles tendon injuries account for more than half of the absences due to injury (Sankey et al, 2008). The incidence rate for all injuries in rugby union during a Super 12 rugby season is 55.4 per 1000 game play hours (Holtzhausen et al, 2006). There are no data available on time lost due to ankle injuries in rugby players but in soccer 12% of lost time is secondary to ankle injuries and ankle

sprains account for 10 – 15% of all time lost due to injury in professional, college and high school football (DiGiovanni et al, 2004; Trojian and McKeag, 1998; Garric, 1997). In a collegiate study ankle injuries account for 15% of all injuries sustained across the spectrum of all the sports assessed (Hootman et al, 2007).

Very little is known about the epidemiology of ankle injuries. It has been suggested that studies be done to investigate the risk factors for specific high-risk injuries and to assess the effects of discrete prevention strategies in rugby union (Brooks and Kemp, 2008). Valuable information can be extracted from such studies, because to be successful in the modern sporting arena, peak physical conditioning is required and can only be achieved if there are no mechanical or functional deficits in the kinetic chain, or if these deficits can be compensated for, through rehabilitation (Motram and Comerford, 1998). In contact sports such as rugby, demands on the ankle include rapid acceleration and deceleration and explosive changes in direction, as well as the ballistic impact of jumping and landing (Woods et al, 2003). More contact (69%) than non-contact (31%) injuries have been described in the literature. The tackle causes the most contact injuries explaining 62% of all contact injuries (Woods et al, 2003). Once an injury is sustained the management determine the outcomes (Zoch et al, 2003; Van Dijk, 2002)

Management of ankle injuries should include acute treatment to reduce pain and swelling and the observation of healing time but most importantly correct rehabilitation (Kawaguchi, 1999; De Norhona et al, 2008). Rehabilitation by a physiotherapist has been shown to be effective in reducing the risk of future injury (Arnold and Dogherty, 2004). A holistic approach should include exercises to gain and maintain range of motion and strength retraining as well as enhancement of motor control through the feed forward mechanism of proprioceptive retraining. The “Kinetic Control” model includes four phases, namely motor control including core or local stability and global stability; core strengthening and traditional strengthening with the focus on functionality and performance stability (Motram and Comerford, 1998; Zöch et al, 2003). Lastly

sport specific drills must precede graduated return to sport (Mattacola and Dwyer, 2002).

1.2 SIGNIFICANCE OF THE STUDY

This study sets out to establish a prevalence of ankle injuries in Club Rugby players and to describe clinical factors relating to ankle injuries. The information derived from this study will serve to assist in setting up an assessment protocols and management strategies to effectively manage these injuries in the future. It will also make the rugby fraternity aware of the prevalence of these injuries and what effect it has on the players.

1.3 PROBLEM STATEMENT

There is no specific literature reporting on the prevalence of ankle injuries in Club Rugby players and comparisons between injured and uninjured players. There is also not literature supporting clinical findings related to ankle injuries in this specific group. Even though reports on incidence and prevalence of ankle injuries in sport have been done in the past limited information is available in the South African setting. The other factor that is evident is that injury can lead to recurrence which sets up the continuum for chronic ankle instability. Identifying risk factors for injury and implementing preventative measures is becoming increasingly important for the professional sportsman.

1.3 RESEARCH QUESTIONS

- What is the prevalence of positive clinical signs for perceived, mechanical and functional instability in club rugby players in South Gauteng?

- Is there a difference in prevalence between those with and those without previous injury to the ankle?

- What are the clinical findings related to ankle instability in these players?

1.4 AIMS

The aims of the study are:

- To determine the prevalence of ankle injuries at club rugby level in South Gauteng in terms of positive clinical signs of perceived, mechanical and functional ankle instability and establish the difference in prevalence if there is any between those with previous injury and those with no previous injury.

- To describe findings relating to the clinical presentation of ankle instability of these players

1.5 OBJECTIVES

To establish:

- The prevalence of clinical signs of perceived ankle instability and perceived functional limitations in club rugby players.

- The prevalence of positive clinical signs of mechanical instability of the ankle in club rugby players.

- The prevalence of positive clinical signs of functional instability in club rugby players

- The prevalence of concurrent positive clinical signs of mechanical and functional instability in club rugby players

- To compare positive clinical signs of mechanical and functional ankle instability in players with and those without previous injury

- To describe the clinical findings for club rugby players with positive clinical signs and symptoms of ankle instability

(Perceived parameters are those that the subject subjectively observes and interprets. Objective parameters are those measured by the researcher and based on objective tests for mechanical and functional instability)

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

This review encompasses literature found in the fields of physiotherapy, orthopaedics, podiatry, biokinetics and general sports medicine. This discussion will include an array of definitions used throughout the text relating to ankle injury and stability; a summary of injury frequency including prevalence and incidence of injury reported in a sedentary population, sporting population and specifically in rugby; a summary of the functional anatomy of the ankle including the joints and surrounding structures referring to normal and abnormal biomechanics, injuries, outcome measures used to evaluate the ankle and the latest research done on sporting injuries focussing on rugby and concentrating on ankle injuries.

2.2 INJURY FREQUENCY - DEFINITION

Injury frequency is a measurement used in statistics and describes the epidemiology of injury or disease occurrence. It describes the total number of affected subjects within a group of which the total population number is known, e.g. all the club rugby players in the South Gauteng region. This number reflects the risk of 'disease' or injury for the specific group. This is used to compare results with other groups with similar features e.g. players from different regions or in different sporting codes. The two depictions for injury frequency are prevalence and incidence (Portney and Watkins, 2000).

Supporting the use of prevalence rather than incidence stems from the definitions used in the literature:

Prevalence is defined as the proportion reflecting the number of existing cases of a disorder relative to the total population at a given point in time. This indicates the probability that the particular disorder is present in an individual at a specific moment in time. A simple calculation is:
The number of existing cases of a disease at a given point in time / the total population at risk. In this study it will refer to the total number of rugby players with ankle injury at the specific time (point) of testing (Portney and Watkins, 2000).

Incidence on the other hand refers to the number of new case of a disorder in a population during a specified time period. If used this would refer to all the new cases of ankle injury sustained during a time period e.g. a rugby season (Portney and Watkins, 2000).

2.2.1 ANKLE INJURY FREQUENCY IN DIFFERENT POPULATIONS

2.2.1.1 SPORTING POPULATION

Ankle injuries are commonly sustained whether in a normal sedentary population but even more so in sporting populations. Ankle injuries in the non-sporting population are not very well researched and a search of the literature did not reveal any isolated studies on the topic, only referring to patients presenting to an accident and emergency unit with ankle injury. In most cases these were still related to sport or activity and did not identify the level at which the sport is played (Aiken et al, 2008; Fong et al, 2008). It has been reported that 10 – 30% of all sporting injuries are ankle injuries (Zöch et al, 2003; Garric 1997).. In a recent study on ankle injuries sustained in sport, 81.3% of these injuries were ligamentous and 10.4% were more serious including fractures (Fong et al, 2008).

The lateral ankle ligament complex is more vulnerable and 85% - 95% of all injuries to the ankle occur at the lateral ligament complex (Tropp et al, 1985;

Geiringer, 1997). The reason for the vulnerable nature of the lateral ligament complex can be found in the fact that the anterior talo-fibular ligament which is only a continuation of the anterior joint capsule is actually a very long and thin ligament which renders it susceptible to injury (Hunter and Fortune, 2000). Ankle sprain is the major injury to the ankle in 33 sporting codes out of a total of 43 investigated and the ankle is only second to the knee as the most common site of injury (irrespective of the nature of the injury) sustained in 24 out of 70 sports assessed (Fong et al, 2007). Fifteen percent of all injuries in collegiate sports were ankle ligament injuries and this was the most common injury over all sports (Hootman et al, 2007). The incidence of ankle injury is particularly high in court games and team sports such as rugby, soccer and volleyball (Fong et al, 2007). A study on high school athletes in different sporting codes relating to ankle injuries reported ankle injuries at 22.6% of all high school sport injuries sustained (Nelson et al, 2007). There was no mention made of the mechanical tests implemented in these studies to determine ankle injury.

Table 2.1 below include figures that indicate the frequency rate of lateral ankle injuries in the different sporting codes.

Table 2.1 ANKLE INJURY FREQUENCIES IN DIFFERENT SPORTING CODES

SPORTING CODE	INJURY FREQUENCY	LEVEL PLAYED	REFERENCE
Basketball	37.4% - *incidence*	Not specified	Fong et al, 200
Soccer	31.7% - *incidence*	Not specified	Fong et al, 200
Hiking	5.8% - *incidence*	Not specified	Fong et al, 200
Soccer	18.75 per 1000 athletic exposure – *rate of injury*	Collegiate level	Agel et al, 200
Spring football	1.34 per 1000 athletic exposures – *rate of injury*	Collegiate level	Hootman et al,
Basketball – men	1.30 per 1000 athletic exposures – *rate of injury*	Collegiate level	Hootman et al,
Football	24.1% - *incidence*	High school	Nelson et al, 2
Soccer	33.6% - *incidence*	High school	Nelson et al, 2
Volleyball	10.6% *incidence*	High school	Nelson et al, 2
Basketball	23.8% *incidence*	High school	Nelson et al, 2
	25% - *rate of injury*	Collegiate	Hootman et al,
Boys basketball	7.74/ 10000 athletic exposures – *rate of injury*	High school	Nelson et al, 2
Boys football	6.52 /10000 athletic exposures – *rate of injury*	High school	Nelson et al, 2
Basketball	45% - *rate of injury*	Not specified	Trojian and McKe
Soccer	31% - *rate of injury*	Not specified	Trojian and McKe
Fencing	13% – *rate of injury per athletic exposures*	National	Harmer, 2008
Rugby	13.3% - *rate of injury*	High school	Collins et al , 2008
Basketball – female	1.12 per 1000 athletic exposures – *rate of injury*	Professional	Kofotolis and Kell

2.2.1.2 RUGBY UNION INJURIES

Ankle injuries have been reported on in a spectrum of sports and have been one of the most commonly injured body sites (Nelson et al, 2007; Fong et al, 2007; Mashawari et al, 2003; Dietzen and Topping, 1999). Many sports have the components of the strain imposed on the ankle by the game of rugby, for example basketball has explosive jumps and controlled landing, as with rugby when a player leaps in the line-out or takes a high ball. There is rapid acceleration and deceleration in rugby and the impact of tackles is similar to soccer and American football. Netball and basketball demand rapid acceleration to be able to elude an opponent, leaping into the air for high balls, intercepts or rebounds off the posts after an attempted goal as well as explosive directional changes (Steele and Milburn, 1987). All the above can be compared to the strain imposed on the ankle structures in the rugby player. In rugby explosive power is needed for jumping or initializing a dart, change of direction, and with changing pace during running. Tackles and ground reaction forces impact on landing from jumping or in contact situations. Ankle injuries are especially common where the ankle is exposed to jumping and sidestepping activities (Zöch et al, 2003).

The previous literature on rugby union injuries is made up of epidemiological studies and case reports. Prospective epidemiological studies suggested that ankle injuries account for between eight percent and 20% of all injuries in rugby (Sankey et al, 2008; Brooks et al, 2005; Bathgate et al, 2002). The information from the Super 12 on New Zealand players showed 10% of injuries as ankle injuries (Targett, 1998) and international Australian players at 11% (Bathgate et al, 2002), international players at the 2003 World Cup at 14% (Best et al, 2005) and Scottish district players at 20% (Garraway et al, 2000). It has been suggested that prospective epidemiological studies would be useful to identify injuries, and to subsequently set up management and prevention strategies (Brook and Kemp, 2008). Most of the evidence based literature is focussed on elite professional sportsmen and little is known about the game and its injuries at an amateur level. The comparison from professional international rugby to

club rugby union as an injury per 1000 hours is a ratio of 60 to 40 (Brooks and Kemp, 2008).

Injury profiles have determined that the lower limb is the site most commonly injured with the knee, thigh and ankle being named as the 'hot spots' for injury. In the ankle, lateral ligament injuries are the most common injury sustained followed by Achilles tendon strain. The study by Hume and Gerard, 1998 underlines the importance of investigating and identifying the relationship between risk factors either intrinsic or extrinsic that might contribute to injury. The ankle has been investigated in the past (Hume and Gerard, 1998) but it is suggested that more detailed information be gathered. There have also recently been advances made by the International Rugby Board suggesting a consensus statement to determine injury definitions and suggested procedures for data collection for future studies in rugby union (Fuller et al, 2007).

More contact than non-contact injuries have been described in the literature for rugby players at, 69% versus 31% and that tackling whether being tackled or enforcing the tackle explains 62% of ankle injuries (Woods et al, 2003). Tackles are the game event responsible for the highest number of injuries and most time lost, but collisions and scrums present the highest risk of injury per event (Fuller et al, 2007). The most causative events for injury is suggested by Sankey et al, 2008 as contact injuries at 52%, non-contact at 35% and unknown mechanisms at 12%. The ankle made up 40% of all injuries sustained during lineouts and 71% of these injuries were related to being stamped on and 29% to being taken out at the lineout (Sankey et al, 2008). In rugby league the incidence of injury at junior and senior level has been investigated and it was concluded that injury prevention strategies should be implemented to reduce the incidence, severity and cost of injuries (Dietzen and Topping, 1999). Suggested strategies included coaching on defensive skills, correct tackling and falling techniques and methods to minimise absorption of impact forces in tackles. Practising attacking and defensive drills when fatigued may also lead to players making appropriate decisions under pressure in a match situation (Gibbet, 2004). With the introduction of rugby in the United States a study to determine injury and plan prevention strategies was done and again adequate pre-season training,

conditioning and coaching were mentioned as requirements for injury prevention. It was suggested that protective gear should be used, e.g. wraps, tape, joint sleeves, scrum caps and facial grease (Dietzen and Topping, 1999). Coaches should be trained to handle medical emergencies. It was also suggested that players needed proper pre-season training and to be taught techniques to manage tackles and falls to avoid injury. The study advised medical surveillance not only at games but also during training. (Dietzen and Topping, 1999) This underlines the importance of the coach, sports physician and player working together to achieve a common goal (Brukner and Khan, 2007).

Various authors have urged that injury registers of different sporting codes be compiled (Sankey et al, 2008; Brooks and Kemp 2008; Edgar et al, 1995). Recently in South Africa a national register of rugby injuries has been called for and it has been suggested that proper epidemiological studies are required to compile such a register (Holtzhauzen et al, 2006), past studies have included studies on schools rugby (Upton, 1996; Nathan et al 1982). This is based on a recent study done in England by Brooks and Kemp (2008) who determined that investigations into high risk injuries are required and that assessing the effects of injury prevention strategies is important. A suggested set of criteria include the following: stage of the game when the injury was sustained, the phase of play, when the injury was sustained on a seasonal timeline, the level at which the game was played and weather conditions on match day. The nature of the injury and resultant complications should be accurately established for this to be effective (Edgar et al, 1995; Clark et al, 1990). This is particularly relevant to ankle injuries because it has been established that a considerable proportion of injuries to professional rugby union players occur at the ankle joint (Brooks and Kemp, 2008).

Based on the suggested criteria the study by Sankey et al, 2008 revealed that most injuries were diagnosed clinically and that radiological investigations were mostly required for more severe cases. Time of injury during matches was confirmed at 12% in the first quarter and 23% in the third quarter, 30% in the second quarter and 35% in the fourth quarter.

Epidemiological studies have only recently been undertaken and the injuries sustained by a cohort of players have been described. Lateral ankle injuries were most commonly reported for both matches and training sessions (Sankey et al, 2008). Forwards, especially second row forwards were at greater risk for injury and it is speculated that it is possibly the combination of speed and power required as a loose forward in the modern day game that might be the causative factor. Players reported that in more than a quarter of cases injuries were recurrent (Sankey et al, 2008).

Rugby is the sport with the highest risk per player-hour of injury. (Sankey et al, 2008). As early as 1970 concerns were raised about the high number of rugby injuries and rugby rules were changed which subsequently lead to less serious spinal injuries. However it is evident that tackling and being tackled are related to modern day rugby injuries, especially ankle injuries (Fuller et al, 2007). Injury is best measured by using the player-injury rate per 1000 player hours. The current Scottish rugby union prevalence is 14 per 1000 player hours which compared to the prevalence of injury in Australian rugby league of 45 per 1000 player hours in a 1990 study (Clark et al, 1990). In schools' rugby a rate of 20 per 1000 player hours was reported in a study done in 1980 (Edgar et al, 1995). The above mentioned studies only focussed on epidemiology of injuries in rugby players but the more recent studies reported the epidemiology of ankle injuries specifically (Sankey et al, 2008; Brooks and Kemp, 2008).

In a recent study by the Scottish rugby union it was evident that at least one in every four players was injured during a single season. Forty three percent of these players were in the 20 – 24 year age group and this was five times higher than the incidence rate in the under 16 age group. In a team of fifteen players at least five new injuries were sustained during a season, in any area (Edgar et al, 1995). In South Africa a study done on incidence, nature and risk factors associated with injuries in the Super 12 competition revealed 55.4 injuries per 1000 player game hours and 4.3 injuries per 1000 player training hours. Although 25.8% were ligamentous injuries the most common sites were the pelvis, hip, knee and head. The total number of ankle injuries sustained was seven, thus a total of 11.3%. Only three of the injuries sustained were serious

(Holtzhauzen, et al, 2006). In conclusion the study underlined that it was the first of its kind to be done in South Africa and that there is a need for studies to collect epidemiological data on rugby injuries in order to provide the scientific background required to make recommendations to coaches and administrators to reduce risk of injury (Holtzhauzen et al, 2006).

Since the advent of professionalism in rugby, trends in injury epidemiology include:

- a higher incidence of injury than other team sports
- an apparent increase in injury risk in professional and amateur games
- a reduction in injury incidence with decreasing age and competitive level
- a significantly higher incidence of injuries during matches compared to training
- a high proportion of tackle injuries and second to that injuries sustained during rucks and mauls
- the most common sites for injury are the shoulder, knee, thigh, ankle and head
- an injury sustained during training is more likely to be related to chronic overuse injuries

(Brooks and Kemp, 2008; Holtzhausen, 2006).

Reasons for these trends are mostly speculative in the literature. Physical condition and fatigue have been cited as the most common causative factors for injury. The tackle is one of the most traumatic events during sport and the major risk for injury is during impact and when the athlete goes to ground Injuries are mostly sustained during games because of the high intensity at which they are played. Common overuse injuries occur with training and mostly with overexposure to training (Nelson et al, 2007; Holtzhausen et al, 2006). Ankle injuries comprised 15% of all training injuries in a study done on rugby players in England this however was still substantially less than the injuries sustained during matches (Sankey et al, 2008)

2.2.2 RECURRENCE OF INJURY

A recurrence rate of ankle injuries as high as 80 % has been reported in the literature (Gribble et al, 2004; Smith and Reischl, 1986; Denegar and Miller, 2002). Ankle injuries in rugby is also recurrent in 27% of injuries to the ankle in a study by Sankey et al, 2008 it was also reported that it is much greater than other recurrent injuries in the rest of the body which only makes up 18% of injury. A reported 21% of days absent due to injury could be related to recurrent ankle injuries (Sankey et al, 2008). It is evident that previous injury predisposes one to future injury. Some factors predicting re-injury have been identified and these factors are classified as mechanical and functional factors. Mechanical factors include insufficient healing time for the ligament, residual ligament damage and pre-existing biomechanical abnormalities like the rigid cavus foot, or over- / early pronation. Functional factors include balance and proprioceptive deficits, decreased neuromuscular control and weakness of secondary supporting structures (Liu and Jason, 1994) The literature reports that 20% of patients with an acute sprain will have residual complaints depending on the severity of the initial trauma and the effectiveness of the rehabilitation programme and whether or not an accurate diagnosis was made in the first place (Klenerman, 1998). Residual complaints include a feeling of weakness or the ankle wanting to ‘give way’, tenderness on palpation, pain or discomfort with running or jumping activities (Van der Wees et al, 2007). Despite the high risk of injury recurrence very little has been done with regards to ‘best practice’ or clinical practice guidelines after injury to avoid reinjury. Effective interventions have been reported in the past with great efficacy for athletes with a prior history of ankle injury and with cost-effectiveness of management especially physiotherapy interventions being kept in mind (Van der Wees et al, 2007; Hootman et al, 2007).

2.3 FUNCTIONAL ANATOMY AND BIOMECHANICS RELATING TO ANKLE INJURY

The discussion of the functional applied anatomy includes the bones, joints, connective tissue, muscle, ligaments and other structures comprising and supporting or surrounding the ankle joint. Reference will be made in each subsection to the risk of injury and the effect of injury on the involved structure and the healing process. The ankle joint is part of the lower limb and cannot be viewed in isolation; as it forms part of the kinetic chain. The lower limb has three major functions: locomotion, weight bearing and maintaining equilibrium and is divided into four parts namely the hip, the thigh, the leg and the foot (Moore, 1992).

2.3.1 PATHOMECHANICS OF THE ANKLE SPRAIN

Pathomechanics are related to the presence of abnormal anatomical variations which might predispose to future injury. The lateral ligament of the ankle is most commonly sprained due to excessive supination at the rear foot while the lower leg is still in external rotation as would occur during the foot strike phase of gait or when landing from a jump. A sprain occurs when external rotation of the leg is coupled with internal rotation or inversion of the calcaneus to a point where the tensile stretch limit is reached and subsequently the fibres will tear (Hertel, 2002).

The anterior talo-fibular ligament is most commonly torn followed by the calcaneo-fibular ligament due to its proximity to the talocrural joint and the increased motion of inversion once the anterior talo-fibular ligament strains (Anderson et al, 1962).

A wide range of abnormalities can occur in ankle biomechanics. Biomechanics are influenced by what is happening in the foot as well as the rest of the kinetic chain. Injury to the pelvis, hip, knee and the foot can predispose the ankle to

biomechanical changes. Muscle imbalances of any two muscles in the body can eventually affect the ankle because it is the most distal part of the chain linked by fascial slings. Habitual postures or positions will influence the biomechanics of the ankle joint (O' Sullivan et al, 1997; Motram and Comerford, 1998).

Within the ankle joint itself the translation of the subtalar joint related to pronation or supination can lead to abnormalities in joint motion. When the subtalar joint is in pronation the translational glide is increased, presenting as a 'give' or hypermobility of the subtalar joint. This is accompanied by an infero-medial glide of the talus and hypermobility of the forefoot which affects the push off during gait and will eventually render the ankle susceptible to injury. Characteristics of the overpronated foot include calcaneal eversion, prominence of the navicular and forefoot abduction with resultant dropping of the medial longitudinal arch (Hartley, 1995).

Different pathomechanical models have been described. The supinated foot will be rigid with decreased shock absorption and inability to adapt to uneven surfaces. This can be diagnosed based on inversion of the calcaneus, a high arch and plantar flexion of the forefoot (Donatelli, 1996). Lateral instability may be associated with excessive supination with signs of forefoot valgus, which results in an increased incidence of lateral ankle ligament sprains (Brukner and Khan, 2007). It has been suggested that an increased supination moment at the subtalar joint will lead to greater inversion and internal rotation of the rear foot during closed chain activities. The supination will lead to a more laterally deviated subtalar axis of rotation when the magnitude of subtalar supination is greater than the compensatory pronation moment (Fuller, 1999).

There is not much in the literature regarding predisposing factors to ankle injury but it is suggested that increased tibial varum (relative external rotation), increased non-pathological talar-tilt, poor postural control, interrupted proprioceptive input, and muscle imbalance in strength ratios of plantar- to dorsiflexion and inversion to eversion can all predispose the athlete to the initial or subsequent injuries (Hertel, 2002).

2.3.2. MECHANICAL ASPECTS OF INSTABILITY

The mechanical aspects include injury or insult to the anatomical structures of the ankle joint.

2.3.2.1 JOINTS AND BONY ARTICULATION

The ankle is a complex yet very functional triplanar joint or joint with three planes of motion and its main function is mobility and gait (Freeman and Wyke, 1967; Moore, 1992)

The main joint is known as the **talocrural** and functions like a hinge. Due to the bony alignment the weight of the body is distributed to the saddle shaped superior surface of the talus during stance. The medial and lateral malleoli provide additional articulation and stability to the ankle joint, which is uniaxial and only allows dorsi- and plantarflexion and the range of plantar flexion exceeds dorsiflexion and totals 100˚ of range. There are considerable normal variations possible and this makes standardized testing very difficult (Brukner and Khan 1995; Petty and Moore, 2001; Moore 1992). The bony anatomy of the talus, with the anterior part of the articular surface being wider than the posterior part, means that dorsiflexion is the position of 'close pack' where the bony constraints are at their greatest (Brukner and Khan, 2007) and thus the joint is most stable. This is important to underline the relative weakness during plantarflexion and inversion where bony congruency is less. This is directly related to greater stability in dorsiflexion and the ankle joint being more vulnerable during plantar flexion. Hence this is the mechanism of injury (Hunter and Fortune, 2000). For a functionally stable ankle the bony articulations have to be intact and well preserved. The shape of the talocrural joint allows for torque to be transmitted from the lower leg to the foot during the weight bearing phase of gait.

The **inferior tibiofibular joint** is an articulation between the inferior ends of the tibia and fibula. It is a syndesmosis that is supported by the inferior tibio-

fibular ligament. Joint motion includes a small amount of rotation (Moore 1992). It is relatively strong and only injured by greater forces and allows for accessory glide which is crucial to normal mechanical function of the ankle (Hertel, 2002; Moore 1992). Limited movement at this joint will predispose the ankle to injury because increased rotation has to then take place at the subtalar joint as a compensatory mechanism (Hartley, 1995).

Arthrokinematic impairments can contribute to chronic instability. In cases where the fibula is displaced inferiorly and anteriorly post injury. The anterior talo-fibular ligament will be relatively lax at rest allowing greater range of talar movement before the anterior talo-fibular ligament can control the motion hence making the joint more susceptible to sprain (Hertel, 2002).

The **subtalar joint** is the articulation between the calcaneus and talus. The subtalar joint functions to aid with shock absorption and also allows the foot to adapt to uneven surfaces. Through the movement supplied by the subtalar joint it is possible for the foot to remain flat while the leg is at an angle to the supporting surface. Joint motion here is limited to inversion and eversion (Jones and Barker, 1996; Moore, 1992; Hertel et al, 1999). Inversion sprain is most likely to occur with plantar flexion. The inversion component will inevitably be affecting the subtalar joint as well.

The triplanar nature of the joint renders it susceptible to injury because of the different movements taking place at the different articular surfaces and this makes rehabilitation difficult. The control over three rather than a single joint has to re-established (Denegar and Miller; 2002).

These three joints function as a unit and enable the coordinated movement of the rear foot which can never be seen in isolation in individual planes of motion but rather as motion about an axis of rotation oblique to the lower leg. There are three major contributors to the ankle joint's stability: the congruency of the articular surface, ligamentous or primary constraints and the musculotendinous restraints which allows for dynamic stabilization (Denegar and Miller, 2002).

Degeneration of the joint will also happen with formation of osteophytes or loose bodies drifting around the joint which can cause pain and future limitations to range and therefore render the ankle susceptible to injury (Liu and Jason, 1994).

2.3.2.2 FASCIA AND CONNECTIVE TISSUE

The connective tissue system surrounds the ankle joint and is susceptible to injury when ankle sprains occur. The greater the excursion of the joint capsule and ligaments, within normal tensile limits, the less likely sprains is to occur because with increased motion the muscles absorb the mechanical force energy without exceeding the tensile limits of the capsule or ligaments (Meyer and Meij, 1996; Jones and Barker, 1996).

There might be signs of synovial hypertrophy after injury that could possibly explain impingement anteriorly and pain with repetitive sprains. This underlines why pain is not an indication for a positive mechanical test for either talar tilt or anterior drawer sign (Brukner and Khan, 2007; Hartley, 1995).

2.3.2.3 LIGAMENTOUS STRUCTURES

The lateral ligament complex of the ankle consists of three parts:

- the anterior talofibular (ATFL) ligament is a long thin flat band and functions in plantar flexion to control inversion (Moore, 1992).
- the calcaneofibular ligament (CFL) is a cordlike structure. This ligament is not a strong passive constraint of the talo tibial joint but it has been suggested that it acts to limit dorsiflexion (Renstrom et al, 1988)
- the posterior talofibular ligament (PTFL) is described as a prime plantar flexion stabilizer coupled with it controlling eversion (Donatelli, 1996; Rundle, 1995) although according to other

authors it might be tight in dorsiflexion (Renstrom and Konradsen, 1997).

These ligaments provide the greatest support in dorsiflexion where support from fascial thickenings of the retinaculum provides added support and the joint is in the 'close pack' position. The orientation of the talus in the mortise and the strong interosseous ligament provides added support in plantarflexion. Injuries occur when the foot is grounded and the body weight is forcible passed over the plantarflexed and inverted foot (Brukner and Khan 2007; De Vries et al, 2006; Hertel 2002; Van Dijk, 2002; Hunter en Fortune 2000; Moore 1992; Renstrom et al, 1988).

The lateral ligament complex is at a greater risk for injury due to its relative weakness compared to the medial ligament and the relative instability of the lateral aspect of the joint (Brukner and Kahn, 1995). The anterior talofibular ligament is reported to be the weakest and the first ligament injured with an ankle sprain and is followed by injury to the calcaneo-fibular ligament and the posterior talo-fibular ligament. Rupture of the anterior talo-fibular ligament occurs as an isolated injury in 66% of all ruptures of the ankle ligaments and occurs in combination with a rupture of the calcaneofibular ligament in another 20% Because of the damage to these ligaments, an associated increase in the motion is present between the talocrural and subtalar joint thus resultant hyper mobility occurs (Hubbard, 2007).

There is suspected residual mechanical laxity after the initial injury to the ligaments that might account for less stability and leads to the ankle being vulnerable during functional activities; interestingly 11% of healthy individuals, with no mention of previous injury, show signs of asymmetry with ankle laxity tests namely the anterior drawer and talar tilt test (Hertel, 2002).

The healing time for ligamentous healing is between six weeks and three months. However in a systematic review on ankle injuries it has been shown that at testing there are still signs of mechanical laxity and functional instability between six months to a year after the initial injury (Hubbard and Hicks-Little, 2008).

2.3.2.4. MUSCULAR OR SECONDARY CONSTRAINTS

The ankle joint is not very well protected by muscles and is supported only by the tendons that run over the area. Tendons passing over the ankle include the flexor and extensor tendons of the foot, the tendons of tibialis anterior and posterior muscles and the peroneus triad. In addition there is the Achilles tendon which is the common insertion point for the soleus and gastrocnemius muscles (Moore, 1992). The talus is the only bone in the human body with no muscular attachments (Moore, 1992). There are some studies that suggest that the tendons will act as secondary constraints (Arnold and Docherty, 2004; Mattacola and Dwyer, 2002; Davies 1997).

Some studies reveal that the evertor muscle will act as the best secondary constraint to protect the foot at full inversion during the foot strike phase (Ashton-Miller et al, 1996). It has also been shown that latent onset of muscle function leads to failure of the protective muscle activation in the previously injured ankle. It is suggested that the stabilizers should pre-activate in anticipation of an event, in this case the heel strike (Mottram and Comerford, 1998). Interestingly neither plantar-flexion angle nor bracing has any effect on the reflexive activity of peroneus longus, brevis or the tibialis anterior muscle during unanticipated plantar flexion nor does inversion stress (Kernozek et al, 2008)

The peroneus complex is still widely regarded as the best eccentric control of supination of the rear foot which protects the ankle against lateral ankle injuries. The tibialis anterior, extensor digitorum brevis, extensor digitorum longus and peroneus tertius also functions eccentrically and can aid in lateral stability by slowing down plantarflexion to decrease forced supination of the rear foot (Hertel, 2002). Weakness or previous injury will render the ankle susceptible to future injury due to the deficits in the secondary constraints. When there is stiffness of the Achilles tendon and calf musculature there is limited dorsiflexion which will lead to talocrural inversion which will lead to increased subtalar pronation (Denegar et al, 2002)

2.3.2.5. NEURAL CONTROL

The lateral ligaments and the capsule of the joint are innervated by proprioceptors that relay important information regarding the position of the foot-ankle complex in space. Muscle spindles of especially the peroneal muscles contribute to proprioceptive input as well (Hertel, 2002).

Injury to any of the nerves in the area could be caused by compartment syndrome (due to swelling), epineural haematoma or nerve traction from an inversion motion. Peroneal nerve-conduction velocity can be reduced especially between days four to eight post-injury but even up to 22 days post inversion ankle sprain there could be reductions of conduction velocity. The result of this is muscular atrophy and performance deficits as with any neurological damage (Mattacola and Dwyer, 2002).Any deficits in proprioception or neural damage will result in a relatively 'weaker' ankle at greater risk for injury.

2.3.3 FUNCTIONAL ASPECTS OF INSTABILITY

The patient with functional instability has deficits to ankle control in postural control tasks. This is explained in part by the fact that the somatosensory receptors are disrupted and this generates a decreased motor response to maintain postural equilibrium (Santos and Lui, 2008).

Impaired proprioceptive input that leads to impairment to postural control has been evident in injured individuals who struggle to position the foot at certain angles (Rothermel et al, 2004). There is no conclusive evidence of peroneal nerve palsy but impaired cutaneous sensation is sometimes present as well as decreased nerve conduction velocity (Hertel, 2002). There is also evidence supporting the fact that when there is functional instability present the athlete takes longer to stabilize in the medio-lateral direction (De Norhona et al, 2008). This can be explained by the relative increase in inversion prior to ground contact in these individuals (Delahunt et al, 2006). Subjective as well as instrumented evaluations of patients after injury have identified the functional

insufficiencies in patients with suspected instability. The 'ankle strategy' of postural control refers to alternate pronation and supination to stabilize the foot and maintain the body's centre of gravity above the base of support (Hertel, 2002). It has been shown that differences in postural control often recover to insignificant levels in the months after injury whether the athlete adheres to a structured rehabilitation program or not. There is however a significantly higher incidence of recurrence of injury in the athletes who do not adhere to a rehabilitation management program (Holme et al, 1999).

Neuromuscular firing patterns and strength have also been seen to be affected and might predict re-injury. There is evidence that the patterns are not only affected locally at the affected structure but as far up as the firing pattern of gluteus medius can be affected (Hertel, 2002). There are differing opinions with regards to muscle strength deficits and no conclusive evidence can be gathered from the literature as to causes of weakness, related to neural control or muscle injury and resultant atrophy (Hertel, 2002; De Norhona et al, 2008).
It is also evident that patients with functional ankle instability take longer to stabilize after a single-leg jump landing than normal individuals (Ross and Guskiewicz, 2004) and this might be one of the predisposing factors to reinjury.

2.4 MECHANISM OF INJURY TO THE ANKLE JOINT

Injury of the lateral ligament complex is mostly sustained when the ankle is forcibly plantar flexed and inverted as the centre of gravity passes over the ankle joint. The order of injury to individual ligaments is anterior talo-fibular followed by the calcaneo-fibular ligament and lastly the posterior talo-fibular ligament. The injury occurs when the force applied through the ankle exceeds the tensile limits of the dynamic link between the leg and the planted foot, which has to bear the brunt of the concentrated forces (Walker 2003). Most patients explain the injury as a rolling over the ankle with inversion, plantar flexion or internal rotation (DiGiovanni et al, 2004).

2.5 CLINICAL SIGNS AND SYMPTOMS OF LATERAL LIGAMENT INJURY

The clinical history of a tear, in most cases, has the athlete reporting a loud sound likened to a snap or tear, occurring after forced or uncontrolled inversion of the foot. The site and area of pain will give a good indication of structures involved, most commonly the anterior talo-fibular ligament. Marked swelling and bruising can be present and in most cases this is a good indication of the severity of the injury (Brukner and Khan, 2007; Boruta et al, 1990).

When there has been an injury to the lateral ligament complex the athlete often reports an inability or difficulty in weight bearing on the foot and ankle. The degree to which the instability affects the ability to bear weight can be a predictor of the severity of the injury. The ability to walk on the foot usually excludes a fracture, based on the Ottawa ankle rules, which will be discussed later in this review (Stiell et al, 1995). Inability to bear weight on the foot is generally indicative of a sprain of the ankle joint except where normal local sensation or control from the central nervous system has been altered, rather indicating more serious pathology. Although most patients can put weight on the leg the gait pattern will be altered. They might have a shortened stance phase and a Trendellenburg gait can even develop over time. If central control is affected by neural damage, weight bearing might not be possible. Foot position and control of the stance phase could be affected due to pain or compensatory mechanisms. Crutches or alternative supports may be required (Woods et al, 2003).

In cases with a partial tear, active movement might be limited due to pain, especially plantar flexion and inversion which will reproduce symptoms. Where there has been a complete tear increased range of motion with less pain can be expected (Petty and Moore, 2001).

Objective testing is required to support the subjective evidence of an injury. Most authors agree that mechanical stability can be judged by two tests; this includes the anterior drawer sign and the talar tilt test, which will be discussed in detail later. These two tests describe the integrity of the lateral ligament complex and the talar tilt test specifically assesses the calcaneofibular ligament (Brukner and Kahn, 2007; Petty and Moore, 2001; Magee, 1992).

2.6 MECHANICAL INSTABILITY

2.6.1 DEFINITION

Mechanical instability is defined as the increase in accessory movement (arthrokinematic motion that cannot voluntarily be produced, e.g. the glide and roll of the talus in the mortise); which translates into an enlarged neutral zone or a stability dysfunction (Motram and Comerford, 1998). The neutral zone is defined as the range of joint motion that is produced with minimal internal resistance of the collagen tissues around the joint (Panjabi, 1992). It is also described as movement within the normal tensile limits of joint excursion (Petty and Moore, 2001)

Mechanical instability is usually the result of a tear or lengthening of one of the ligamentous structures supporting the joint. Changes that take place include pathological laxity, impaired arthrokinematics, synovial changes and the development of degenerative joint disease. Residual mechanical instability suggests a non-optimal healing process. The assessment of mechanical integrity is generally explained in single plane motion but it must be remembered that triplanar movement takes place at the ankle joint. Keeping this in mind, effective clinical testing by qualified clinicians according to most authors is the best diagnostic tool available (Brukner and Kahn, 2007; Petty and Moore 2001; Trojian and McKeag, 1998).

Lateral ankle sprains occur most frequently due to excessive supination of the rear foot about an externally rotated leg soon after initial contact with the

ground during gait or with landing from a jump (Brukner and Khan, 2007; DiGiovanni et al, 2004). The inversion and internal rotation of the foot coupled with external tibial rotation results in ligamentous strain. Strain refers to a force exceeding the tensile strength of the soft tissue structures. Most commonly, the anterior talofibular ligament is affected during sprain and this stresses the remaining ligaments through rotational instability (Hertel, 2002; Hunter and Fortune, 2000).

To understand the effect that the deficit in ligamentous integrity has on the ankle one must also consider that it would be difficult to pinpoint one specific area due to the complexities of the ankle (Hertel, 2002). A ligament sprain, in almost all cases is accompanied by widespread soft tissue damage, including muscular constraints, retinaculum and joint capsule injuries (Brukner and Khan, 2007; Liu and Jason, 1994).

2.6.2 GRADING OF LATERAL ANKLE INJURIES

The grading system which is based on clinical assessment remains a very subjective grading and is clinician determined, based on the criteria set out for sport scientists (Trojian and McKeag, 1998) The Ottawa ankle rules are explained later in this chapter and based on this most clinicians will make a preliminary diagnosis from their clinical assessment.

Lateral ligament injuries are classified into three grades by identifying certain characteristics. Grade I is described as a minor tear or ligamentous stretch. There is minimal if any disruption of ligamentous integrity. When an inversion stress is applied, pain is experienced on the lateral border or inferior to the lateral malleolus. No sign of laxity or mechanical joint instability is noted. The patient can still walk quite comfortably. There is minimal swelling and mild tenderness on palpation. A grade I should still have a normal talar tilt and anterior drawer test and should be able to return to play within ten days (Brukner and Khan, 2007; Denegar and Miller, 2002; Van Dijk, 2002).

A grade II injury is painful with applied ligamentous stress. This can be achieved by straining the joint into inversion more markedly in a plantarflexed position. Laxity might be evident but there is still a distinguishable end feel. This is described as an injury where the anterior talofibular ligament is torn but the calcaneo-fibular ligament is still intact. These patients present with moderate swelling and tenderness. These patients should still be able to weight bear with moderate discomfort depending on the individual's pain threshold. When a grade II is sustained there is increased translation of the ankle joint with the anterior drawer test, but the talar tilt might still be negative. Expected return to sport can vary from two to four weeks (Brukner and Khan, 2007; Denegar and Miller, 2002).

For a lateral ankle injury to be graded as a grade III, it should present with gross laxity without a discernable end feel. A complete or large tear of the anterior talo-fibular and calcaneo-fibular ligaments are suspected. Swelling, bruising and marked localised tenderness can be expected. In most cases there is a complete disruption of the ligamentous integrity. These patients cannot weight bear on the affected ankle, due to the instability. Very often these patients have minimal pain due to the complete disruption of the integrity of the ligament, especially with the ligament stress tests where the fibres cannot strain any further (Brukner and Khan, 2007; Denegar and Miller, 2002).When there is a suspicion of a grade III injury both tests for mechanical integrity will be positive and with optimal rehabilitation return to sport can be expected anything from five to eight weeks after the injury (Trojian and McKeag, 1998). Surgical intervention might also be required and this will change expected outcomes (Samoto et al, 2007).

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History, clinical examination and x-rays are the only indicated investigations for acute ankle sprain. X-ray investigations are only indicated when criteria for the Ottawa-ankle rules are met or where the signs and symptoms do not subside with conservative management. This will be elucidated later in this chapter (Stiell et al, 1995; Stiell et al, 1993).

2.6.3 OUTCOME MEASURES AVAILABLE TO TEST MECHANICAL INSTABILITY

2.6.3.1. OBJECTIVE CLINICAL ASSESSMENT

There are two schools of thought, one supporting and the other negating objective clinical assessment. It has been reported in the literature that diligent clinical examination is sufficient to determine the diagnosis in the clinical setting and that even though stress view x-rays are the gold standard for determining ankle ligament injury they should not be done in the acute setting but rather once signs of chronicity are noted again supporting the use of accurate clinical assessment (Trojian and McKeag, 1998; Greenman 1995). Clinically the use of two tests specific to the ankle joint have been advocated namely the anterior drawer test and the talar tilt test. It must be considered that these are clinical interpretations by the clinician on ankle joint laxity. Laxity has been determined to be joint specific in the lower limb based on a study that was done to determine the relative laxity at the ankle and knee joint compared to generalized laxity or hyper mobility and it was found that laxity in the lower limb is mostly joint specific (Pearsall et al, 2006). To determine the outcomes for ankle ligament laxity the two tests used were the anterior drawer and talar tilt tests which give an indication of joint excursion restricted by the ligaments of the lateral complex (Pearsall et al, 2006).

A sensitivity of 84% and 95% specificity of the anterior drawer test when tested directly after the injury have been reported (Van Dijk et al, 1996; Spahn, 2003). The anterior drawer test assesses the integrity of the anterior talofibular ligament and initial reliability may be suspect within 48 hours of injury, but after five days from initial injury, a sensitivity of 86% and a specificity of 74% have been reported (Van Dijk et al, 1996). A second test, the talar tilt test has been said to be an effective indicator of injury to the calcaneofibular ligament showing increased adduction of the talus during inversion in 10 degrees of plantar flexion when the ligament is not intact (Magee, 1992).

Testing mechanical instability involves establishing the integrity of the lateral ligament complex. The clinical assessment includes the anterior drawer (transverse plane laxity) and talar tilt test (frontal plane laxity) which basically disregards the issues of rotary instability (Petty and Moore, 2001; Trojian and McKeag, 1998; Starkey and Ryan, 1996).

These mechanical tests have been used the literature to determine ankle ligament injury either in isolation or in combination with stress view x-rays. The following studies show how these tests were implemented and support the use of these clinical examinations in the study (Avci and Sayli, 1998; Starkey and Ryan, 1996; Freeman, 1965).

In a study to measure mechanical laxity, participants had partial or complete ruptures of the lateral ligaments of the ankle and were compared based on intervention received whether or not immobilized. The investigator measured mechanical laxity with talar tilt stress radiographs. A positive talar tilt was defined as an inversion tilt of the talus of 6° or more on the affected side when compared with the unaffected ankle (Freeman, 1965)

In another study anterior drawer was measured at two weeks and again at six weeks after an acute lateral ankle sprain. Classification of a grade III inversion ligament injury was required to be included in the study. Individuals were excluded if they had a history of chronic instability or fracture or current tenderness of the deltoid or syndesmotic ligaments. The authors stated that the anterior drawer test of the injured ankle was compared with that of the opposite, healthy ankle. The authors reported that 30% of participants had a positive anterior drawer test at two weeks after injury and 11% had a positive anterior drawer test at six weeks after injury (Avci and Sayli, 1998). This suggests that there was an improvement of the anterior drawer test six weeks after initial acute injury.

In another study, by Cetti,et al, 1984, the anterior drawer and talar tilt tests were applied at eight weeks and 24 weeks after acute ankle sprain and initial injury was determined with stress radiographs taking six degrees or greater as a

positive talar tilt test and three millimetre or more side to side differences as a positive anterior drawer test. The eight and 24 week interval testing was done only with clinical evaluation supporting the notion that clinical testing is sufficient to determine ligamentous laxity (Cetti et al, 1984).

Suggested mechanical investigations for standardized testing include the use of the anterior drawer test, talar tilt test, the side-to-side test, the Thompson's test, the squeeze test and external rotation stress test for complete evaluation of all structures around the ankle joint (Trojian and McKeag, 1998).

2.6.3.1.1 ANTERIOR DRAWER TEST

The anterior drawer test is designed to indicate the severity of injury to the anterior talo-fibular ligament. This is achieved by evaluating the amount of anterior glide of the talus to the tibia. It had been suggested earlier that performing the test with 10◦ of plantar flexion will improve the sensitivity (Johannsen, 1978), and this is supported by more recent literature (Petty and Moore, 2001). The knee should be flexed to at least 40◦ to ensure a relaxed gastrocnemius which can if contracted or in spasm lead to a false negative (Kovaleski et al, 2008;Brukner and Khan, 2007; Petty and Moore, 2001). A recent study suggests that positioning is important to isolate the ankle for testing. The ankle should be positioned in 10˚ of plantar flexion and the knee at 90˚. The argument being that in this position the most anterior laxity of the ankle will be achieved to better isolate the capsular and ligamentous structures of the ankle (Kovaleski et al, 2008).

A positive anterior drawer test has a sensitivity of 73% and a specificity of 97% (Van Dijk, 2002). When accompanied by a skin dimple during testing there is a high correlation of approximately 94%, with rupture of the lateral ligament complex. A positive anterior drawer test with pain on palpation and signs of haemorrhage has a 100% sensitivity and specificity of 77% (Van Dijk, 1994). To determine laxity the test must be done on the affected and unaffected side and then a comparison must be made.

2.6.3.1.2 TALAR TILT TEST

The talar tilt test determines the amount of inversion of the calcaneus when the tibia is stabilized. This again is a comparative test for side to side differences. This is only an adjunct to the anterior drawer test and is reported to be less reliable in predicting injury. The talar tilt test can be used to assess the integrity of the calcaneofibular ligament by inversion stress, but is an unreliable test for ligamentous rupture with poor interrater reliability (Van Dijk, et al, 1996). This test is normally seen as a supplementary test only. Most clinicians use both tests to determine ankle ligament integrity. (Kovaleski, 2008; Trojian and McKeag 1998).

The effectiveness of the talar tilt test is supported in the literature and findings suggest that the talar tilt test is accurate in detecting injury to the anterior talofibular and calcaneofibular ligament in 97% of cases and despite positive signs ranging from 0° – 23° it has been established that a 10˚ difference is sufficient to indicate a positive talar tilt test (Chrisman and Snook, 1969).

Both tests have false positives and negatives in patients with previous rupture or patients with physiological laxity of ligaments without injury. This again re-iterates the importance of comparing left to right as discussed with the anterior drawer test.

2.6.3.1.3 NON-RADIOLOGICAL INSTRUMENTED MEASURABLE METHODS

Efforts to produce a non-radiological, but measurable method to determine joint stability have been expensive and not clinically effective (Breitenseher et al, 1997; Kerkhoffs et al, 2002; Stiell, et al 1992). Different instruments have been suggested for determining ankle instability but none were shown conclusively to be an effective method to determine mechanical integrity (Spahn, 2003, Kovaleski et al, 2002, 1990, Alexander, 1998).

In Germany an instrument developed by Spahn; the ‘Ankle Meter”, is a device to measure the anterior drawer test in ankle sprain. The instrument consists of two plastic scales (heel and tibia) with an attached pointer which is adjustable through a screw-nut and a measuring border fixed on the surface of the tibial scale. The border contains a slit for gliding of the pointer to a graduator. Initial investigation revealed acceptable interrater reliability and the possible early detection of failed ligament healing in the early stages (Spahn, 2003). The authors raised questions with regards to the sample size, the effect of pain and possible inaccuracies during measurement and further research was suggested before it could be assumed that the ankle meter was an effective tool to determine ankle ligament instability. It was suggested that the anterior drawer test could be measured but again the need to assess the involved as well as uninvolved leg was reiterated (Spahn, 2003).

The Ankle Arthrometer as used in a study on cadavers was found to be an effective tool to measure ankle subtalar joint complex laxity by imposing controlled load to determine the inversion eversion ratios at the subtalar joint complex and anterior-posterior tibial motion displacement. This was a controlled laboratory study and ignored the aspects of active muscular guarding and neural control of the movement by live subjects (Kovaleski et al, 2002). The Arthrometer was initially introduced to determine it’s usefulness as an objective measure of joint excursion in uninjured subjects in dominant compared to non-dominant ankles. This does not show it’s efficacy to detect ankle instability in injured subjects though (Kovaleski et al, 1999)

Research in the field of podiatry has shown that standard measuring apparatus is not effective or reliable and that leaves a gap to determine a reliable and effective measure for mechanical instability, which is ethically acceptable (Alexander, 1998).

2.6.3.2 RADIOLOGICAL INVESTIGATIONS

X-rays are the first line of investigation for ankle sprain second only to clinical history and physical examination. The gold standard for determining ankle injury is stress radiography which has been used to quantify the amount of subtalar tilt and the anterior displacement of the calcaneus from the talus. However the validity of the test has been challenged as well (Nyska et al, 1992; Stiell et al, 1995). Stress views include inversion (or talar tilt) and the anterior drawer tests. The stress view x-rays of the affected side must then be compared with those of the uninvolved ankle for both tests. Variables in determining the reliability of these tests include the degree of patient relaxation and cooperation, the amount of force applied the angle of ankle flexion, and the amount of laxity on the uninvolved side. The anterior drawer test is performed with a lateral view of the ankle in the neutral position. An attempt is then made to manually translate the foot anteriorly with respect to the leg. Translation of the talus with respect to the tibia in the sagittal plane is measured. A measurement of more than three mm is considered a positive finding for an anterior talo-fibular ligament injury (Safran et al, 1999; Anderson, 1962), but up to five mm of anterior translation or greater is accepted as a likely anterior talo-fibular rupture by most sources. The talar tilt test is used more often than the anterior drawer test and is believed to be more reliable. A mortise or anterior-posterior view is used with the ankle held in a neutral position in 10˚ plantarflexion with an inversion stress applied to the foot. The assumption behind this test is that the contralateral ankle is normal. Studies have accepted positive test results as a stressed angle of 5-15° greater than the uninjured side (Safran et al, 1999). In 97% of cases a 10° or greater difference is accepted as clinically significant (Chrisman and Snook, 1969) and this is still accepted as the norm (Petty and Moore, 2001). This correlates with a torn anterior talo-fibular ligament and calcaneofibular ligament.

Imaging is not indicated in every case and to save costs the OTTAWA-ankle rules were created. The rule state that X-rays of the ankle are only indicated when the pain in the ankle is coupled with one of the following criteria. Firstly it is important to determine whether or not the person can bear weight on the

affected side either immediately after the injury or during the evaluation at the emergency unit. Secondly bone tenderness at the posterior edge for 0-6cm up or on the tip of either malleolus is seen as an indicator for investigations required (Stiell et al, 1995; Stiell et al, 1993).

X-rays for diagnostic purposes of the foot on the other hand are based on the following criteria when coupled with midmost pain. Again inability to bear weight on the affected limb and then assessment of bony tenderness at the base of the fifth metatarsal or the navicular is undertaken (Stiell et al, 1995; Stiell et al, 1993).

The Ottawa ankle rules have been a very effective tool to limit patient exposure to unnecessary radiation. The patient with general ankle sprain should not be sent for an X-ray unless supported by the Ottawa rules (Auleley et al, 1997). General practitioners and casualty departments use the guidelines as set out by the Ottawa-rules to decide upon the necessity of x-rays post ankle injury. In most cases due to the severity of the injury stress views are not asked for and these views are only done once the patient sees an orthopaedic surgeon or presents with persisting functional limitations and pain. The accepted norm for x-rays include anterior-posterior, lateral and mortise views (DiGiovanni, et al, 2004).

The meticulous description of investigations required is suggested because a recent Cochrane Review could not establish conclusive evidence for the use of surgical versus conservative management but it was evident that surgical intervention related to more functional deficits than the more conservative approach (Kerkhoffs et al, 2007). And even if surgery is not indicated to manage the injury effectively an accurate diagnosis is required (Kerkhoffs et al, 2007) more so not to miss the diagnosis of avulsion fracture that is sometimes missed (Haraguchi et al, 2007).

Ethical considerations for radiography contribute to the difficulty of finding an objective measurement in research. The problem encountered with stress radiography is the fact that normal as well as previously injured athletes have to

be exposed to radiation to have a true comparison. With the ethical considerations regarding radiography, researchers have to look at other mechanical tests to determine functional stability of the ankle joint (Spahn, 2003; Trojian and McKeag, 1998). The financial implications of radiological investigations must also be considered.

Occasionally ultrasound has been advocated to investigate disruption of the lateral ligament complex of the ankle, changes in soft tissue can be observed and swelling visualized, but clear cut predictions cannot be made regarding the integrity of the ligament. CT-scan and MRI is not indicated in minor sprains, only where associated injury of the bony, osteochondral or tendinous or nervous system is suspected (DiGiovanni et al, 2004). A German study demonstrated MRI as being 100% accurate in diagnosing anterior talo-fibular ligament injuries. Interestingly this study also recommends MRI in the monitoring of conservatively treated ruptures (Kreitner et al, 1999). Using MRI to evaluate the talar tilt test has been proven reliable to detect complete double ligament rupture (ATFL and CFL) where the tilt was greater than 15 degrees compared to the uninjured side (Gaebler et al, 1997). Mostly CT and MRI are only done if the athlete or patient complains of persistent pain and instability despite the recent suggestion that MRI is playing an increasingly important role in detecting ankle injury, confirming diagnoses and predicting prognosis of ankle injury and associated complications and is seen as the modality of choice for evaluating ligamentous injury (Tham et al, 2008; Collins, 2008)

All of the above findings support the researcher's approach to use mechanical tests without confirmation of diagnosis through radiographic assessment. It is however evident that imaging is becoming increasingly important for the clinician to make an accurate diagnosis especially in athletes where persistent pain exists or recurrent injuries take place (Collins, 2008)

2.7 FUNCTIONAL INSTABILITY

2.7.1 DEFINITION

Functional instability is defined as the occurrence of recurrent ankle instability and the sensation of joint instability due to the contribution of proprioceptive, neuromuscular deficits and postural control (Hertel, 2002). In the past, it was loosely referred to as the giving way of the ankle compared to mechanically unstable ankles with an anatomical aetiology and even then it was reported that 40% of mechanical instabilities were subsequently deemed functionally unstable (Freeman, 1965).The ankle joint is stabilized by joint orientation, ligamentous restraints and muscular contraction controlled neurally, and therefore insult to any one of these components can lead to functional ankle instability. Earlier discussion on the anatomy and mechanical joint considerations has included each of the subsystems individually. The athlete often describes the problem as an intermittent 'giving way' of the ankle. Gait on uneven surfaces becomes challenging and a component of fear-avoidance is built in, where athletes are apprehensive regarding repeated episodes. Functional stability is controlled by balance and proprioception, which are both functions of central control. It is further complicated by residual mechanical laxity and strength deficits (Konradsen et al, 1998). For an ankle to be functionally stable it has to be able to adapt to the SAID-principle (specific adaptation to imposed demand) roughly translated into the patient being able to withstand the stresses placed on the tissue during the performance of activities required for the specific sport (Mattacola and Dwyer, 2002).

Previously it has been reported that patients with higher perceived instability showed signs of instability during functional performance more so than those with no perceived signs despite mechanical injury. It has also been shown that patients with similar reported deficits do not necessarily experience the same functional limitations (Buchanan et al, 2008).

2.7.2 PREDISPOSING FACTORS FOR FUNCTIONAL INSTABILITY

The exact aetiology of functional instability is unknown but has been described in a synopsis of predisposing factors as suggested by different authors (Bosien 1955; Freeman and Wyke 1967; Mattacola and Dwyer, 2002, Haraguchi et al, 2007). The possible reasons why functional instability occurs have existed for a while and were described as early as 1955.

- It is postulated that ligaments heal in a lengthened position due to scars filling the gap between the two torn ends (Mattacola and Dwyer, 2002; Denegar et al, 2002).
- Scar tissue is inherently weak and thus healed ligaments are also thought to be weaker (Mattacola and Dwyer, 2002)
- Persistent peroneal weakness especially described in the incompletely rehabilitated ankle (Bosien, 1955; Ashton-Miller et al, 1996)
- Hereditary hypermobility (Mattacola and Dwyer, 2002)
- Unrecognized disruption of the distal tibiofibular ligament which allows for increased tibio-fibular translation (Mattacola and Dwyer, 2002)
- Loss of proprioception of the foot related to injury of the mechanoreceptors and their afferent nerve fibres, impaired reflex stabilization and peroneal nerve dysfunction leading to delayed muscle response (Freeman and Wyke, 1967)
- The loss of relative absence of proprioception from hip and knee joint or relative signs of decreased postural control (Beynnon et al, 2002)

2.7.3 BALANCE AND PROPRIOCEPTION

It has been shown that the presence of ankle injury leads to sensorimotor deficits in athletes and that both feedforward and feedback mechanisms of control are altered. This is further qualified as alterations in conscious perception of afferent somatosensory information as input mechanism, reflex responses on a primitive level and with the output of efferent motor control (Hertel, 2008)

Balance or postural equilibrium depends on the ability of the afferent nervous system to determine the body's position relative to the ground assessing gravitational forces. For complete postural control, input from the vestibular, visual and somatosensory sources is required. The input information must then be analyzed and integrated by the central control system to determine the motor control required. The existence and importance of retraining the feed forward mechanism where the impending event is identified and muscular co-activation precedes the stimulus is required for normal kinetic control of motion (Hertel, 2008). This is in contrast with the feedback mechanism where re-establishing balance after an event challenging the system has occurred (Motram and Comerford, 1998).These two mechanisms present the components of proprioception.

Proprioception is sometimes referred to as the collection of sensations regarding joint movement (kinaesthesia) and joint position. Proprioceptors are found in joints relaying a message to the central nervous system regarding the position of the joint in space and related gravitational forces (Denegar and Miller, 2002). A very early definition of proprioception is that there are receptors that read neural inputs originating from structures around the joint including muscles and tendons (Sherrington, 1948). When mechanical stresses are applied, proprioceptors respond by generating neural impulses which are relayed to the central nervous system. Four types of receptors have been defined (Wyke, 1972). Type I respond to mechanical stress and have a low-threshold and slowly respond to external stress. These receptors are active in the joint whether it moves or not. Type II respond rapidly but still have a low threshold. These receptors only function momentarily at the onset of movement. Type III requires high-threshold stimuli to activate the mechanoreceptors which are only

active at the extremes of range of motion. Type IV play no part in an immobile joint and are only activated with deformation of major mechanical stress (Wyke, 1972). It is important for Type III and IV receptors to be active during activity especially with the load imposed during sporting activities where the sensory system has to assess and judge the different surfaces and ground contact and then has to adapt to it (Wyke, 1972).

More recently the somatosensory system has been described as being controlled by quick (mediating sensation of joint motion) and slow (relaying joint position and sensation) adapting mechanoreceptors, which can detect touch, pressure, pain, and joint motion and position (Taube et al, 2008). These receptors act as protectors for the ankle joint relaying information to protect the ankle. These mechanoreceptors will be suppressed after injury due to the presence of inflammation. Hertel, 2008 takes it further by referring to motorneuron excitability that has been reduced in subjects with chronic ankle instability which lead to reduced reaction time for peroneus and soleus but also more proximally the quadriceps and hamstrings have also been affected. There is no conclusive evidence to suggest that reflex reaction to inversion perturbation is reduced in the peroneus complex but it is suspected (Hertel, 2008). Muscle strength deficits are also attributed to the motorneuron pool excitability rather than actual damage to the muscle or tendon complex (Hertel, 2008).

The vestibular system, which responds to information from the vestibules and semicircular canals of the inner ear, helps to maintain overall body posture and balance. The visual system provides the central nervous system with visual cues for use as reference points in orienting the body in space. The somatosensory, visual and vestibular systems contribute to postural control and with acute injury there is deficits reported that recover quite quickly for the involved as well as the uninvolved leg with the latter improving much quicker. In the chronic ankle instability subjects marked differences in postural control was noted. There also seem to be a central mediation of postural control because it was evident that subjects who trained the injured ankle with rehabilitation had bilateral improvements in postural control tasks (Hertel. 2008).

The key role played by the somatosensory system helps to explain why some athletes tend to repeatedly injure certain joints. For example, when an athlete sprains an ankle, he/she usually damages not just the ankle ligaments but also the somatosensory system's mechanoreceptors which are dispersed throughout the ankle joint. As a result, kinaesthetic acuity for the ankle joint (the ability to detect ankle-joint movements) diminishes. As a result, the ankle remains relatively unstable long after the torn ligaments have healed. Naturally, researchers have been intrigued by the possibility that improved postural control might reduce the risk of injury - and even improve performance (Riemann, 2002). But each component is required to be intact, or in some way compensated for, before an ankle can be deemed functionally stable. There are two components to the assessment of functional instability. The first is static and the second dynamic postural control. The principle of functional balance testing rests on being able to measure the centre of balance and limits of postural sway to derive information regarding the sensorimotor systems involved in postural control (Mattacola and Dwyer, 2002). Proprioceptive feedback is crucial in the conscious and unconscious awareness of a joint or limb when dynamic movement occurs. Improved functional control is required for prevention and rehabilitation of ankle injuries (Ergen and Ulkar, 2008). Balance is decreased in individuals where time to stabilize upon ground reaction takes longer. This is evident in subjects with chronic ankle instability. The difference in response to perturbation may be indicative of central sensorimotor changes (Brown and Mynark, 2007). Spinal and supraspinal adaptations have been investigated and the use of balance training to improve postural control has been shown. There is also evidence to indicate that it can lead to increases in muscle power by improving motor performance through rehabilitative and preventative measures. This again underlines the plasticity of the sensorimotor system. (Taube et al, 2008, Hertel, 2008).

In a study by Hrysomallis et al, 2007 it was established that balance can be seen as a strong predictor of ankle and knee injuries and is regarded as a risk factor that can be modified with the correct management. This study also suggested that further studies be done to determine an optimal management plan for such injuries en the associated deficits (Hrysomallis et al, 2007).

2.7.3.1 OUTCOME MEASURES OF POSTURAL CONTROL

There are a multitude of tests available to determine static and dynamic control of postural sway and thus functional stability of the lower limb. These are often used to determine the functional and proprioceptive abilities of the ankle joint (Gribble et al, 2004; Susco et al, 2004; Friden et al 1989).

There are objective instrumented stabilometry tests available (Kinzey and Armstrong, 1998). In a study on Australian netball players, the FootTrak Motion Analysis System was used, to determine the angle of inversion of the calcaneus by using video equipment (Mashawari et al, 2003). In another study on netball players the NeuroCom Balance Master was used which measures force distribution during stance by using a force platform and a personal computer (Riemann et al, 1999). Good correlation between these and a clinical test, the Balance Error Scoring System (BESS) has been described (Riemann et al, 1999) and a similar test know as the Romberg position where the athlete is required to stand on one leg so the patient's ability to maintain the position can be assessed compared to the uninvolved side (Kawaguchi, 1999). The other non instrumented measure used, is length of time in equilibrium (Crotts et al, 1996). To determine dynamic control it has been suggested that the Star Excursion Balance Test (SEBT) be used (Olmsted et al, 2002). The advantages of using non instrumented measures is that expensive sophisticated equipment is not required although one must consider that these tests are much less sensitive and are only a subjective interpretation of the function of the whole kinetic chain during weight bearing and they do not only address the ankle joint (Olmsted et al, 2002). Other more dynamic assessments have been used to assess functional performance testing for participants with functional ankle instability namely the single-limb hopping test and single-limb hurdle test. The hopping test was shown to be an effective indicator of performance deficits and could also be used by clinicians as an assessment and treatment tool (Buchanan et al, 2008). There was also a high correlation found between subjects with reported functional ankle instability on a self-assessment questionnaire and the functional

stability tests for the single leg hopping test to the side and in a figure eight (Arnold et al, 2005).

2.7.3.1.1 STATIC POSTURAL CONTROL: BALANCE ERROR SCORING SYSTEM (BESS)

Static postural control is interpreted as the control required for maintaining postural control at rest. It is however suggested that the ability to maintain balance is decreased with exertion and not always related to stability of a specific joint's function (Susco et al, 2004).

Tests used in the literature for static control include the Balance Error Scoring System (BESS), (Riemann et al, 1999) and a computerized long force-platform sway measure of the Neurocom Smart Balance Master as well as the Chattanooga Balance machine (Troijan and McKeag, 2004). The results derived from clinical and computerized testing show good correlations between the two (Trojian and McKeag, 2004). Researchers have shown that postural control performance in single limb stance is related to risk of ankle sprain (Hertel et al, 2001).

The BESS was developed as a clinically objective assessment tool for the evaluation of postural-stability deficits after concussion. It was however shown that the test is both reliable and valid for head injured and healthy subjects in controlled laboratory environments (Riemann, et al, 1999; Susco et al, 2004). In previous studies the use of expensive computerized equipment has been advocated but similar results have been produced with moderate correlation between the NeuroCom Balance Master and the BESS (Yaggie, et al, 1999). As testing equipment is not available at the field-side, clinical tests are suggested as a more practical option (Riemann et al, 1999). The use of the BESS has been suggested in a study comparing different techniques for assessing balance but it must be clear that no one standing balance test whether functional or static can be used to isolate evaluation of solely the ankle joint (Guskiewicz and Perrin, 1996). As described earlier in this review the ankle is a

part of the whole kinetic chain and a deficit at any point in the chain would affect balance and ultimately postural control (Nyska et al, 2003; Riemann, 2002).

In a study on the effect of chronic ankle instability on postural control it could not be shown that injury to the ankle would be the sole causative factor affecting postural control and it is suggested that each individual must be assessed for possible contributions to postural instability (Riemann, 2002). It is evident though that the decreased afferent input through injury to mechanoreceptors can contribute to postural control deficits (Riemann, 2002).

The test is performed in three progressive stance positions with the difficulty rating increased: double leg, single leg and tandem stance. These are repeated on two different surfaces: firm and foam. The number of errors made by the subject in a period of 20 seconds is counted. If a subject made any errors the test is assumed as positive for the BESS. Errors include opening the eyes, lifting any part of the foot and stepping out of the stance position (Waterman et al, 2004)

2.7.3.1.2 DYNAMIC POSTURAL CONTROL: STAR EXCURSION BALANCE TEST (SEBT)

Dynamic postural control can be seen as the patients' ability to maintain balance while movement takes place and has been used to investigate the deficits in subjects with chronic ankle instability (Olmsted et al, 2002). Previously it has been used to investigate the lower extremity reach deficits in patients with chronic ankle instability and was shown to be an effective measure to determine reach deficits (Olmsted et al, 2002).

The suggested measure for dynamic postural control is the Star Excursion Balance Test (SEBT), which has been established as highly reliable and valid for both research and clinical purposes (Kinzey and Armstrong, 1998; Hertel et al, 2000; Gribble et al, 2004; Olmsted et al, 2002). The test is both meaningful and relevant to determine postural control. The SEBT appears to be sensitive in detecting reach deficits both between and within athletes with instabilities. It is

an effective means for determining reach deficits in subjects with possible functional instability. It is described as a functional test that quantifies lower extremity reach while challenging an individual's limits of stability (Olmsted et al, 2002). It must be noted that the SEBT is a dynamic assessment tool and tests the athlete's ability to maintain the centre of gravity over a stable base of support without losing balance while leaning or reaching activities are performed (Gribble et al, 2004). As with the BESS it must be emphasised that the test is not specific to determine only function at the ankle joint rather that it is a tool to assess postural control with associated incidental ankle findings

More recently the use of the dynamic postural stability index has also been advocated because it is seen as a sensitive measure of dynamic postural control and can detect the subtle differences between individuals with or without functional stability deficits (Wikstrom et al, 2007).

2.7.3.2 IMPLEMENTATION AND USE OF POSTURAL CONTROL

Return to competitive participation can only be effective once sport specific training has been done. For this to effectively take place the athlete must be able to stabilize joint motion through range of motion, thus control the excursion of the joint during normal movement. There are signs of central neural mediation of postural control described in the literature based on proprioceptive feedback. The recruitment of low frequency motor units will lead to tonic firing of the muscle which in turn stimulates local stabilizers to control the neutral position of the joint and aids in the postural holding associated with eccentric deceleration or resisting momentum (Grimby and Hannerz, 1976; Comerford 1997). This is supported by a study in which unilateral training increased bilateral postural control (Rothermel et al, 2004). By improving postural control of the unaffected limb there might be an overflow to the injured limb (Zöch et al, 2003). Effective rehabilitation strategies must be based on an understanding of the physiology of healing to prevent chronic ankle instability and to regain postural control and re-introduce the athlete to the sporting arena gradually. The most effective way to manage these patients is most certainly to prevent ankle injury in the first place. (Denegar and Miller, 2002).

While investigating the relationship between functional ankle instability and postural control it was found that the control of the ankle inversion position is affected where there is functional ankle instability. There are signs of decreased control in stance and time to recover from perturbation is longer in the ankle with functional instability (De Norhonha et al, 2008). In this study the 2.21 seconds was the mean recovery time in the instability group and 1.43 seconds in the external control group. The mean variability of the reference measure of instability for inversion was as follows: 2.0˚ for the instability group and 1.4˚ for the control group (De Noronha et al, 2008).

To get injured players back to competitive participation mechanical and functional factors have to be addressed and controlled and therefore standardized testing is required and will assist in effectively managing acute injuries and preventing chronic ankle instability.

It has been suggested that finding a standardized regime to evaluate and clinically monitor progress after acute ankle injury would be very useful to predict which athletes will be at risk of sustaining further injury or who have decreased functional stability (De Norhona et al, 2008; Denegar and Miller, 2002; Van Dijk et al, 1996).

2.8 CHRONIC INSTABILITY

2.8.1 MECHANICAL AND FUNCTIONAL FACTORS RELATING TO CHRONICITY

The stability of the ankle joint is affected after injury and pathomechanical changes occur which can lead to chronic ankle instability. The changes that occur include soft tissue changes in ligamentous structures, which heal with scar tissue (De Norhona et al, 2008).

Ligaments and tendons have the unique quality that collagen tissue is laid down in parallel bundles which forms a dense web of connective tissue designed to withstand crimping when loaded. Crimping is the ability of the tissue to withstand forces without unduly lengthening or eventually tearing. Normal connective tissue consists of minimal ground substance and scattered fibroblasts. When connective tissue is injured and tissue healing is in the repair phase there is re-epithelisation that leads to wound contraction and the reproduction of collagen. Build up and breakdown of collagen take place during the remodelling phase. The arrangement, orientation and aggregation of the newly grown tissue with existing tissue takes place in the remodelling phase with the formation of cross linkages that form adhesions. Where increased joint mobility is not addressed tissue repair is compromised and the torn ligaments heal in an elongated position if the talus remains anteriorly subluxed and repeatedly glides anteriorly. This result in hypermobility at the ankle joint in that direction with a compensatory decreased posterior glide, a compensatory hypomobility of dorsiflexion occurs. This in turn compromises the affected and surrounding joints (Denegar and Miller, 2002). When the joint is overloaded during the healing phase the healing process is compromised and the ligaments heal in lengthened positions. Where there is resultant hypomobility, due to the position mentioned earlier, the axis of rotation is changed. This leads to altered proprioceptive input to the central nervous system and a vicious cycle of instability may occur (De Vries et al, 2008; Denegar and Miller, 2002).

Because of the competitive nature of sport, a player is expected to return to sport as soon as possible and often the normal phases of healing post-injury are not observed. In the literature there is very little consensus about the time that is taken for a ligament to regain 85 – 95% of it's normal tensile strength and these figures ranges from 16 to 50 weeks (Woods et al, 2003; Houglum, 1992). Poor results after ankle sprain are also linked to intra-articular damage such as

chondral flaking, syndesmotic irritation as well as neural and musculotendinous damage. These are in most cases related to more severe ankle sprains (Sausser et al, 1983).

An earlier study showed that the anterior drawer and talar tilt tests were applied at eight weeks and 24 weeks after acute ankle sprain and initial injury was determined with stress radiographs taking 6˚ or greater as a positive talar tilt test and 3mm or more side to side differences as a positive anterior drawer test. The eight and 24 week interval testing was done only with clinical evaluation. The authors reported that approximately 12% of participants had a positive anterior drawer at eight weeks after injury. The number decreased to approximately 3% at six months after injury. Despite the small percentage of participants who had mechanical laxity as determined with manual stress tests, the authors reported that approximately 70% of participants had residual symptoms at eight weeks after injury; and 42%, at six months. Residual disability included functional instability, swelling, pain, abnormal gait, and tenderness (Cetti et al, 1984). Again this supports the fact that even though the athlete returned to sport there were still aspects of functional instability present which could predispose to future injury.

In the literature a distinct line is drawn between functional and mechanical instability but it is also postulated that they form a continuum of pathological contributions to chronic ankle instability (De Norhona et al, 2008, Riemann, 2002, Hertel, 2002)). Ligamentous injury leads to a mechanical stability deficit which in turn can lead to functional instability when there are repetitive challenges to the integrity of the ligament complex with inadequate healing time (Hertel, 2002). Certain predisposing factors to ankle injuries have been investigated and these include muscle tone abnormalities, proprioception problems and shortening of the capsule or tendinous structures which is thought to be due to inadequate sport specific training, specific for the activity to be performed. Changes in dynamic force distribution are evident in patients with chronic instability (Nyska, 2003). Provocative factors include accidents or trauma *(traumatic incidents overstraining the tensile limits of the joint)*, obesity *(the greater weight the greater the risk of injury)* and kinetic energy applied in excess of joint design limits *(force applied greater than the tensile limits of the*

joint during dynamic motion) (Foster, 2004). Other factors identified include gender, *(more laxity in females has been identified which might be related to hormones)*, height and weight distribution, limb dominance *(left or right)* and generalized laxity whether genetic or due to the need for joint excursion in certain sports such as dancing or gymnastics (Beynnon et al, 2002).

The line which represents a continuum between mechanical and functional instability that will lead to chronic ankle instability is supported by the study, by Hubbard and Hicks-Little, 2008. The study reported on two other studies where the use of stress radiographs and a manual stress examination to measure mechanical laxity after an ankle sprain were assessed. In the first study all patients in the study had a rupture of the anterior talo-fibular ligament alone or in combination with the calcaneo-fibular ligament. Rupture was verified arthrographically in all participants. The exact timeline when patients were examined was not reported. The role that recurrent injury may have played in the study is also unknown (Hubbard and Hicks-Little, 2008).

The second study objectively measured mechanical stability based on the manual anterior drawer test was used in yet another study. It was reported that all patients had a recent ankle sprain and had a ligament rupture verified by arthography. The manual anterior drawer test was performed to test mechanical laxity. To subjectively assess instability, participants were asked about residual symptoms, particularly a feeling of instability in the ankle, swelling, aching, pain on movement, and further sprains. A percentage of between 28 – 31% of participants still had a positive anterior drawer more than one year after the initial ankle sprain. Although most participants were symptom free at follow-up, 20% reported that their ankles felt unstable. Specifically, those participants reported that their ankles felt weaker and gave way (Hubbard and Hicks-Little, 2008).

Ankle sprains are often seen as recurrent injures and the literature shows this with percentages as high as between 56%, and 75% where players with a sprain reported previous injury to the lateral ligament complex of the ankle (Anandacoomarasamy and Barnsley, 2005; Woods et al, 2003; Nielsen, 1989). Most authors agree that an injury leads to re-injury and that this plays a role in

future athletic performance (Taube et al 2008, Woods, et al, 2003, Kawaguchi, 1999).

With injury there are alterations in the sensorimotor control system which affects the whole spectrum from conscious perception of the input from the somatosensory system, reflex reaction instituted by the body and efferent motor control deficits that are present. This again suggests that both the feedback and feed forward mechanisms of postural control is altered with ankle injury (Hertel, 2008).

There have been effective results shown with respect to the ankle and knee joint with the use of balance training to reduce postural control deficits and prevent future injury (De Norhona et al, 2008) Based on this the use of non-invasive electrophysiological imaging and imaging of the brain revealed that there is benefit in improvement of postural control with balance training to the extent that it improves postural control. This underlines the plastic nature of the sensorimotor system for spinal and supraspinal structures where adaptations to imposed demand can aid in injury prevention and improve athletic performance (Taube, 2008).

Subtalar joint motion has been investigated and it is evident that abnormal subtalar motion is linked to injury. Where there has been previous injury, subtalar laxity is often evident and when the subtalar ligaments do not control end range of pronation or supination the ankle is again at risk for further injury (Hertel et al, 1999).

The reaction time of a normal peroneal muscle occurs too slowly to control all movement, but there should be a degree of preparatory muscular activation from peroneus prior to ground contact with the foot. This is of cardinal importance for muscular control to protect the joint (Mattacola and Dwyer, 2002). The retraining of proprioception has also indicated a slower reaction time of the tibialis anterior and posterior which are inherently inverters of the foot thus protecting against further inversion during an ankle sprain (Kernozek et al, 2008).

Patients with chronic ankle instability have an altered gait pattern with longer duration of contact of the heel to central forefoot which indicates that weight transfer from heel strike to toe off is slowed down due to hesitation to transfer weight onto the forefoot. The delay in these patients towards the end of the stance phase is to ensure that the foot has enough time to stabilize. In most cases this is with the use of lateral shift of the centre of pressure. Increased lateral load of the foot in the stance phase could be due to reduced proprioceptive function and diminished peroneal strength, however further studies have shown that central / neurological control plays a greater part since there is no major difference between the injured and uninjured leg's strength (Nyska, et al, 2003).

2.9 PERCEIVED INSTABILITY: OUTCOME MEASURES

The following outcome measures were identified by Haywood et al, 2003. A study investigated through a structured review, the multi-outcomes measures for lateral ligament injury and established the most useful measures (Haywood et al, 2004).

Seven disease specific measures:

- Ankle Joint Functional Assessment Tool
- Clinical Trauma Severity Score
- Composite Inversion Injury Scale
- Kaikkonen Functional Scale (KFS)
- Karlsson Ankle Function Score (KAFS)
- Olerud and Molander Ankle Score (OMAS)
- Point System

(Haywood et al, 2004)

Two generic measures of health:

- McGill pain questionnaire
- Sickness Impact Profile

(Haywood et al, 2004).

The McGill pain questionnaire is a general questionnaire designed to determine the level of pain experienced and can be applied to any pain experience. The Sickness Impact Profile relates to the impact of a 'sickness' or injury on the person, thus the two generic tests are broad-based and non-specific for ankle injury. The conclusion was made that evidence supporting the use of five of the other tests is lacking and that they should be cautiously applied. The study by Haywood in 2004 does, however suggest that the Karlsson Ankle Functional Score and the Olerud and Molander questionnaire are the most promising where self- /patient-assessed evaluation of function is required (Haywood et al, 2004). The Olerud and Molander Ankle Score (OMAS) has been identified as an investigative tool previously used by other investigators and suggested by Olerud and Molander to make studies of ankle injury more comparable (Olerud and Molander, 1984; Rose et al, 2000).

The Olerud and Molander questionnaire has limited use for indicating subjective improvement in symptoms but it has been suggested that it can be effectively used to investigate the relationship between subjective and objective instability because the athlete can compare the self-evaluation questionnaire to the advice given by medical practitioners (Rose et al, 2000). In their study although significant improvement in objective tests and the Olerud and Molander questionnaire was shown there were still signs of Sway Index dysfunction which was tested through functional stability tests (Rose et al, 2000). This was evident for the injured and uninjured leg in the affected individual and raises the question of whether some individuals are predisposed by postural sway vulnerability (Rose et al, 2000). The use of the Olerud and Molander questionnaire is further supported by its effective use in some studies and it has been deemed reliable and valid in research (Rose et al, 2000). The

Olerud and Molander questionnaire firstly investigates the patient's clinical signs and symptoms including questions regarding pain, stiffness and swelling. The second part of the questionnaire is dedicated to determining the functional impact of the injury on the participant's ability to function in activities of daily life and sport. It also determines whether or not the participant requires external support in the form of taping or bracing, to function. The use of self-evaluation questionnaires are further supported by a study that assessed the dynamic postural stability deficits in subjects with self-reported ankle instability and it determined that the dynamic postural stability index was a sensitive measure of dynamic postural stability and was able to detect differences between functionally stable and unstable ankles (Wikstrom et al, 2007).

Another assessment tool, the foot and ankle ability measure (FAAM) has also been introduced as a self-assessment questionnaire to detect disability and dysfunction of the foot and ankle during activities of daily living and with sporting activities (Garcia et al. 2008).

2.10 MANAGEMENT OF ANKLE INJURIES

2.10.1 ACUTE STAGE

The acutely injured patient will present to general practitioners, casualty departments and more recently also physiotherapists and trauma assistants at field side, as first line practitioners and these patients have to be accurately assessed and correct management instituted. Once a decision has been made regarding further investigations based on the Ottawa ankle rules, diligent clinical examination must be done of all relevant structures (Fong et al, 2008; Petty and Moore, 2001).

Once it has been established that the nature of the injury does not require that further precautions be taken, the RICE- regime comprising of rest, ice, compression and elevation must be applied. In cases where weight bearing is affected the use of crutches or an external support may be advocated to protect

the ligaments and joint structures from any further damage (Van Dijk, 2002; Trojian and McKeag, 1998).

Once the acute inflammatory phase of healing has been addressed, functional rehabilitation needs to be undertaken. This might happen simultaneously depending on the severity of the injury and the symptoms experienced by the athlete or injured subject.

2.10.2 FUNCTIONAL MANAGEMENT PHASE

In the literature different approaches to rehabilitation have been suggested but it seems that a holistic functional rehabilitation regime renders the best outcomes. This is based on a 2002 Cochrane review that suggested that functional treatment seems the most appropriate management for acute ankle injuries but results have to be interpreted with caution because most trials are poorly reported and there were a variety of interventions evaluated. Assessing mechanical integrity was also not standardized in these trials (Kerkhoffs et al, 2002). There were results that indicated that early mobilization lead to earlier return to work and sports after surgical intervention (De Vries et al, 2008). There was low quality methodology in most of the studies covered by the review and therefore the evidence was not conclusive to support either conservative or surgical treatment (De Vries et al, 2008; Samoto et al, 2007).

To be functionally rehabilitated means that the athlete can return to competition. Return to competitive participation can only be effective once sport specific training has been done. For this to effectively take place the athlete must be able to stabilize joint motion through range of motion, thus control of the excursion of the joint during normal movement. There are signs of central neural mediation of postural control described in the literature based on proprioceptive feedback. The recruitment of low frequency motor units will lead to tonic firing of the muscle which in turn stimulates local stabilizers to control the neutral position of the joint and aids in the postural holding associated with eccentric

deceleration or resisting momentum (Grimby and Hannerz, 1976; Comerford 1997).

This is supported by a study in which unilateral training increased bilateral postural control (Rothermel et al, 2004). Researchers have shown that by improving postural control of the unaffected limb there might be an overflow to the injured limb (Zöch et al, 2003). There is also evidence to support the use of stochastic resonance stimulation which improved the centre of pressure measures in subjects with functional ankle instability after a six week training program and therefore lead to increased postural control (Ross et al, 2007).

Effective rehabilitation strategies must be based on an understanding of the physiology of healing to prevent chronic ankle instability and to reintroduce the fully rehabilitated athlete to active participation (Denegar and Miller, 2002). It has to be remembered the most effective management though is to prevent ankle injury in the first place (Denegar and Miller, 2002).

It has been suggested that finding a standardized regime to evaluate and clinically monitor progress after acute ankle injury would be very useful to predict which athletes will be at risk of sustaining further injury or who have decreased functional stability (De Norhona et al, 2008; Denegar and Miller, 2002; Van Dijk et al, 1996).

In the clinical setting it is up to the clinician to plan and then implement the rehabilitation programme. The following guidelines have been suggested:

- a comprehensive knowledge of the anatomy, physiology and biomechanics of the joint (Brukner and Khan, 2007).
- an understanding of how the locomotor system functions, specifically addressing the speed, acceleration, end of range stressors and mid-range control of motion so all mechanoreceptors are considered (Wyke, 1972)

- knowledge of the athlete's required functional needs (Brukner and Khan, 2007)
- addressing demands specifically related to the sport to which the athlete needs to return to (Molnar, 1988)
- effectively addressing sensorimotor deficits after acute ankle sprain (Hertel, 2008; Taube et al, 2008).

Based on the five points above any regimented rehabilitation programme can be developed. An important key to effective rehabilitation is establishing a baseline measurement of ankle function to be able to measure and document objective changes (Kawaguchi, 1999). The whole process is described in phases of healing, and rehabilitation should be based on the tensile strength of the healing tissue. The acute phase or acute inflammatory phase last from 48 – 72 hours and is focussed on limiting the amount of damage and protecting the injured tissue. The sub-acute phase lasts from day five after the injury to week six post-injury and only 15% of normal tensile strength is achieved during this phase and gradual loading is allowed. During this phase exercises should focus on regaining normal functional range of motion, decreasing swelling and inflammation, graduated return to full weight bearing, static resisted exercise to retain optimal strength. In this phase the focus should be on postural control exercises to avoid movement dysfunction and to address existing muscle imbalances which might have lead to the injury. Functional rehabilitation can be attempted after six weeks when the injured tissue has about 85% of its normal tensile strength and this phase can last up to two years (Hertel, 2008; McGuine and Keene, 2007; Mohammadi, 2007).

The functional rehabilitation included isometric, isotonic and isokinetic strengthening for open and closed chain, proprioception, balance retraining and stretching to ensure normal joint excursion (Brukner and Khan, 2007).

Stretching or regaining normal range of motion is required for normal locomotive activities. Where there are problems with relative flexibility, the body will adapt by predisposing another area to injury in order to regain

functional motion (Motram and Comerford, 1998). Secondary to flexibility is strength provided by the primary dynamic stabilizers for the joint. Here muscle strength, power and endurance are required for normal motor control (Davies, 1997). The concept of strength is based on concentric, eccentric, isotonic and isometric contraction of the controlling musculature and all these components must be addressed (Davies, 1997). Strengthening is based on the principles of: periodization, progression, overload, specificity and relative rest which allows a muscle to optimally function under loaded circumstances (Brukner and Khan, 2007; Davies 1997). Recently it has been showed that alterations in the afferent processes could affect the evertor's strength and timing of contraction and therefore the importance of proprioception is supported. The study by Santos and Lui, 2008 established deficit and non-deficit categories in functionally unstable ankles. There were definite balance and strength deficits in the injured group between the injured and non-injured ankle and also between players in the control group and those with functional ankle instability. Mechanical alterations were present in the functionally unstable ankle and can range from limited range of motion or joint laxity, proprioceptive deficit, muscular weakness, decreased balance to delayed neuromuscular reaction time (Santos and Liu, 2008). When there is functional ankle instability the medio-lateral stabilization is delayed. The somatosensory receptors are affected and this leads to a delayed motor response which in turn affects postural equilibrium. The results showed that there was a difference in performance of the single leg hop test for the stable and unstable groups in this study. The patients with instability took longer to recover than the stable group and had a greater variability of the reference measure for inversion (De Noronha et al, 2008). This supports retraining of feedback and feed forward mechanisms by improving proprioception and balance (Motram and Comerford, 1998). In a systematic review, by Zőch et al, 2003, it was revealed that the most effective program for rapid restoration of ankle movement, strength, endurance and proprioception is one that addresses each component individually. Disc training or balance retraining on a foam surface, for the ankle seemed to be the optimal exercise to improve proprioception and restore range of motion; the secondary support that seemed to be most efficient is taping or bracing to prevent injuries. The external support acts to control joint excursion. Strength deficits in both the injured and

uninjured leg can be improved by isokinetic training utilizing the cross-over effect of training (Zőch et al, 2003).

In a study on the supraspinal and spinal adaptations associated with balance training it was shown that in the past balance training was used to rehabilitate deficits in proprioception after injury (Taube et al, 2008). It also supported that the use of balance training to prevent injury is also advocated and it has also been shown that there might be improved motor control due to the input mechanisms to the central control system. It was evident that with balance training there were neurophysiologic changes that would ultimately influence the motor control. This study supports its use not only in athletes, but also the elderly and in injury prevention strategies (Taube et al, 2008).

Balance training has been showed to be effective in significantly reducing the risk of ankle injury in high school athletes playing soccer and basketball. A study to test this showed that the participants were divided into two groups where the first group only received conditioning exercises and the second was given a balance training program with great reduction in the incidence of ankle injuries in the balance retraining group (McGuine and Keene, 2006). A basketball-specific balance retraining program was also seen as effective to reduce acute ankle injuries in basketball players by using a wobble board for a home-based training program (Emery et al, 2007).

A study on soccer players by Ergen and Ulkar (2008) showed that balance training in effective in preventing ankle injuries. It is suggested that the athlete be managed by a comprehensive training programme that includes proprioceptive retraining to enhance functional joint stability for both prevention and management strategies (Ergen and Ulkar, 2008).

In another study, by Mohammadi (2007), on soccer players further supported the effectiveness of proprioceptive rehabilitation where it showed the effectiveness in a prevention study in soccer players compared to no intervention. The players who received proprioceptive input were however not

markedly improved from those who underwent a strength training program or were given orthotic support (Mohammadi, 2007).

In volleyball players there were significant reductions in ankle sprains for the players who had previous injury to the ankle once they were given a prescribed balance retraining program (Verhagen et al, 2004).

2.10.3 FUNCTIONAL MANAGEMENT OF ANKLE INJURIES IN RUGBY PLAYERS

Supports in the form of taping or bracing have been used with success in rugby union for the management of ankle injuries. It is suggested that the external support should be able to sustain forces between six and 56 kilograms for it to exceed the strength of the ligament. Tape cannot provide enough mechanical support but the proprioceptive effects may contribute to stability (Hume and Gerrard, 1998). Bracing has been shown to be effective in decreasing ankle inversion sprain and it has been suggested that the International Rugby Board should consider the use of ankle braces in rugby with stiff lateral components for protection (Hume and Gerrard, 1998). Effective bracing requires rehabilitation as well and should not be used in isolation. With bracing alone a relatively weak unstable ankle becomes progressively reliant on the support of the external device (Davies, 1997). Bracing however has definitely showed some benefit in reducing the incidence of recurrent ankle sprain in soccer players (Surve et al, 1994). In a comparative study the use of proprioceptive training, normal technical training or strength training and external supports were compared as to effectiveness and it was shown that there were benefit in all three approaches individually but there was no control group to compare this to (Stasinopoulos, 2004).

A structured warm-up program as part of training can significantly reduce acute severe injuries to the ankle and knee, reported at 50% reduction in the relative injury risk profile (Olsen et al, 2005). This structured program focused on exercises to

improve awareness and control of knees and ankles during standing, running, cutting, jumping, and landing. The regime consisted of balance and proprioceptive exercises including ball work wobble board and balance mat for warm up, exercises for specific sporting technique, balance and strength (Olsen et al, 2005). To finally refine rehabilitation a program for proprioception has to be included (Laskowski et al, 1997). The effectiveness of balance retraining has been underlined in a study on high school football players where inversion ankle sprain was reduced by 77% by a balance training intervention consisting of two phases namely pre-season including balancing on a foam stability mat for 5 minutes twice a day for a period of four weeks and in-season twice a week (McHugh et al, 2007).

The experienced clinician should be able to make an accurate diagnosis before instituting management and refer for specialist intervention if required. To make an accurate diagnosis, clinical reasoning should be based on a sound knowledge of the clinical presentation of lateral ankle injuries (Brukner and Khan, 2007). This is required to identify causative factors and to address these effectively.

2.11 THE IDENTIFICATION AND MANAGEMENT OF PREDISPOSING FACTORS

As mentioned earlier, the need for a national injury register for rugby injuries has been suggested to encourage effective management and injury prevention. Once injuries are identified a clinical picture can be created to enable clinicians to identify potential risk factors or establish a risk profile and effectively address the injured player (Holtzhauzen et al, 2006; Edgar et al, 1995).

Similar registers have been acquired in collegiate sports as explained in the section on incidence of injury (Harmer, 2008; Nelson et al, 2007; Hootman et al, 2007). In rugby two recent epidemiological studies were done in the UK (Sankey et al, 2008; Brooks and Kemp, 2008) and in South Africa a register was compiled during the Super Twelve competition to elucidate all rugby injuries (Hotzhauzen et al, 2007).

Such a register would make it possible to identify the injuries with high risk of incidence in rugby and allow making certain pre-season adaptations to avoid injury to be made as well as to protect the previously injured sites.

The existence of biomechanical factors should also be identified and addressed prior to the athlete participating in the season. When looking at the ankle the identification of the overpronated or oversupinated (rigid) foot; the foot with an abnormally everted calcaneus or cavus foot can aid in protecting the player from injury by managing the biomechanics through training and orthotic support. A simple balance evaluation can identify players with decreased postural control or functional instability and by addressing this before the season the athlete can be protected (Denegar and Miller, 2002).

2.12 CONCLUSION

This chapter included a comprehensive overview of the normal ankle joint. The effect of injury and possible abnormalities in anatomy and biomechanics which might predispose to future injury were discussed as pathomechanics. The key concepts of ankle instability were defined and a detailed description of outcome measures has been discussed as well as evidence advocating the use of various clinical tests.

The ankle joint and stability are managed differently by different medical professionals from the acute management in the casualty setting including the RICE – regime (Rest, Ice, Compression and Elevation) to surgical intervention by orthopaedic surgeons to rehabilitative therapeutic interventions by physiotherapists as well as orthotic support and bracing as advocated by podiatrists.

Relevant is the fact that ankle injuries occur particularly in the sporting population. These injuries if not managed effectively and expediently can lead to recurrence, which in turn can lead to chronic ankle instability. Where factors predicting chronic ankle instability are present, the sportsman will be adversely

affected, especially in sports where high loads are applied to the ankle and where change of direction is required, as in rugby.

There are differing opinions yet again with regards to assessment and management of lateral ankle ligament injuries. Diligent clinical testing by trained professionals should be advocated both for mechanical as well as functional instability. A correct diagnosis is required to institute an effective and comprehensive management plan for both the injury and the postural control deficits.

CHAPTER 3

3. METHOD

3.1 INTRODUCTION

This chapter includes a description of the design of the study, the selection of subjects, outcome measures and the statistical analyses that were used.

3.2 STUDY DESIGN

A cross sectional study design was used where all subjects were tested for perceived instability, exclusion criteria applied and all remaining subjects tested for positive signs of mechanical instability.

3.3 SUBJECTS

Subjects included all the players from the first team squads, from all the clubs in one region of the Gauteng Lions Rugby Union first division, namely the South Gauteng region.

All ten clubs in the region were invited to participate in the study however one club refused to participate and was thus not included.

A total of nine clubs out of the ten in the region participated in the study. Each squad included twenty players consisting of the fifteen players in the team and five reserves. Thus a total of 180 players were eligible for inclusion in the study.

3.3.1 INCLUSION CRITERIA

All players in the squad for the first teams were included in the study provided none had any of the exclusion criteria listed below.

3.3.2 EXCLUSION CRITERIA

- Previous surgery to the lateral ankle ligament complex or ankle joint
- Previous injury (within three months of the tests) of the lower extremity rendering the player out of active participation and therefore not currently playing.
- Patients with recently diagnosed concussion (within 1 month of the tests)
- Patients with ear infection, head cold or upper respiratory tract infection at the time of the study because this could affect the players' ability to balance.

3.4 ETHICAL CONSIDERATIONS

Ethical clearance was obtained ((Clearance Number: R14/49 (26-09-2005) – M050726); (See ethical clearance form Appendix E)), from the Committee for Research on Human Subjects at the University of the Witwatersrand.
Permission was given by the relevant authority on behalf of the Gauteng Lions Rugby Union to conduct the study. Consent was obtained from the management of each club and informed consent was obtained from coaches and players. (See Appendix C and D)

3.5 OUTCOME MEASURES

The tests used are divided into specific tests to determine the prevalence of ankle instability whether perceived, mechanical or functional and tests used to form a description of the clinical picture of players with ankle instability.

3.5.1 TESTS TO ESTABLISH PREVALENCE

1. Olerud and Molander questionnaire
2. Tests to determine mechanical integrity
    a. Anterior drawer test
    b. Talar tilt test / Stress inversion test
3. Test to determine functional instability: Balance error scoring system

3.5.2 TESTS USED TO DESCRIBE THE CLINICAL FINDINGS RELATED TO ANKLE INJURIES

1. Olerud and Molander questionnaire
2. Data questionnaire
3. Star excursion balance test

3.5.3 TESTS USED TO ESTABLISH PERCEIVED FUNCTIONAL LIMITATIONS

3.5.3.1 QUESTIONNAIRE

A questionnaire was developed to, establish demographic data, establish exclusion criteria and to establish possible factors that could create a clinical picture of players with mechanical and functional instability. This questionnaire was designed with input from coaches and medical personnel in the club rugby fraternity, to establish content validity (Partney and Watkins, 2000). (See appendix A)

The first section of the questionnaire was developed to establish the exclusion criteria. In the second section general information about the player was included namely position, occupation, time spent playing rugby at club level, age, height and weight. To compile the third section, an expert group of coaches and

medical personnel were consulted to develop questions that could establish a clinical picture of players with signs of instability and questions that could be used to determine risk factors as well as future suggestions for the management of these players in order to establish the content validity of the questionnaire.

To ensure that the questionnaire was clear and easy to understand a pilot study was undertaken on a group of players not involved in the main study and changes made as suggested by the participants. The researcher was present during the answering of the questionnaire and players could ask questions if required to do so.

3.5.3.2 OLERUD AND MOLANDER QUESTIONNAIRE

The Olerud and Molander questionnaire includes a detailed previous history of injury to the ankle ligament, determining the state of self assessed functional instability of the ankle as perceived by players. It is thus a subjective measure of the ability of the ankle to handle functional expectations during a game (Appendix B).

It is a short questionnaire designed to asses the problems, to which the ankle injury may be directly related. The information obtained was combined with the data generated by the testing procedures. Each player was asked to complete the questionnaire by indicating which of the options was best suited to the specific functional problems experienced, if any. Each answer is scored separately to contribute to the clinical picture and then a percentage is calculated to determine the patients' perceived functional limitations (Rose, et al, 2000). The Olerud and Molander questionnaire is marked in increments of five and therefore any signs of perceived instability suggested by the player will have a score of equal to or less than 95%.

The Olerud and Molander questionnaire is further divided into sub-sections. The sub-analysis gives an indication of the prevalence of clinical signs and symptoms of instability including pain, swelling and stiffness. The prevalence of functional limitations was derived from the players' ability or inability to run,

jump, squat or climb stairs. It also indicates supports required including taping, bracing or crutches and the effect on activities of daily life. This is also used to describe the clinical picture of players with reported ankle problems.

3.5.4 MECHANICAL INSTABILITY

3.5.4.1. ANTERIOR DRAWER TEST

For the anterior drawer test the subject was asked to lie supine and the knee was then semi-flexed to 40˚. This position was achieved with the use of a goniometer; this was done to eliminate the stabilizing effect of a tight gastrocnemius muscle on the excursion of the joint. The researcher was positioned in front of the subject. The one hand stabilized the lower leg while the researcher cupped the calcaneus with the other hand. The researcher used the forearm, of the hand cupping the calcaneus to support the foot in 10˚of plantar flexion. The foot position was again established by measuring with a goniometer. The test was performed by the researcher with the subject instructed to relax and to allow the researcher to move the ankle. The action performed was an anterior displacement or forward pull of the talus and calcaneus while the other hand stabilized the tibia with a constant force (Trojian and McKeag, 1998; Petty and Moore, 1996).

The anterior drawer test was deemed positive if the talus glided or slid anteriorly from under the ankle mortise. In certain cases where an audible clunk was heard the suspected instability was supported by the indication of talar subluxation which indicates greater excursion of the talus and thus instability. The literature mentions that patients might experience pain over the anterior aspect of the ankle joint during testing and this is possibly in part due to the impingement of the anterior synovium or the retinaculum, which in itself is not indicative of ankle ligamentous injury. (Trojian and McKeag, 1998). The researcher performed the anterior drawer test on all players.

3.5.4.2 TALAR TILT TEST / INVERSION STRESS TEST

For the talar tilt test the patient was positioned supine with the researcher sitting facing the patient. The test was performed by the researcher holding the calcaneus with one hand while the foot was positioned in the neutral position. The other hand was used to stabilize the lower leg, again around the distal tibio-fibular region. The researcher palpated the calcaneo-fibular ligament, with one finger to feel the gapping if present. The hand stabilizing the calcaneus applied an inversion stress by rolling the calcaneus inwards to cause talar tilt (Vinger and Hoerner, 1982; Starkey and Ryan, 1996).

The talar tilt test was deemed positive in the presence of excessive tilting or gapping or if the patient experienced pain while performing the test. A test is deemed positive if tilting or gapping greater than 3 – 5 mm is recorded, measured with a tape measure (Trojian and McKeag, 1998).The researcher performed the talar tilt tests on all players (Vinger and Hoerner, 1982; Starkey and Ryan, 1996).

3.5.5 FUNCTIONAL INSTABILITY

3.5.5.1 BALANCE ERROR SCORING SYSTEM (BESS)

The Balance Error Scoring System (BESS) is a test where the standing balance of a player is tested statically while trying to maintain a stable base of support under different testing conditions. For the purposes of this study two testing conditions on two different surfaces were used, namely single leg stance for left and right leg, on two different surfaces namely a firm surface (stable flat surface) and a foam surface (a foam block) On a firm surface control should be better, the foam surface supplies an added component that the player has to manage to maintain balance. Initially the player had to maintain his balance with his eyes open and was then asked to repeat the test but this time closing his eyes. The reason for closing the eyes is to remove the focus gained from visua

input to control balance
Single leg stance was performed as described standing on the dominant leg with the contra-lateral leg held in 30˚ of hip flexion and 90˚ of knee flexion (ranges were measured by a goniometer) and the foot held approximately 15 cm off the ground. (Dominance was established in the demographic questionnaire).

Each stance was performed firstly on a firm surface and repeated on a medium density foam block. The test was performed with the player standing in the required position for 20 seconds. The subject was asked to close his eyes and place his hands on his iliac crests, while maintaining the appropriate stance. If the subject fell out of position he had to return to the position as quickly as possible. When having the eyes closed the player could open his eyes and keep them open until balance was regained before closing the eyes again. The researcher, standing three metres away then recorded the amount of errors made by each subject during the test. A test was deemed positive if the player made a mistake and was graded according to the amount of mistakes made during the 20 second period.

Prior to performing the test the subject was instructed, shown and given an opportunity to practice the stance position. The reliability and validity of the above test was discussed in the literature review in chapter two (Susco et al, 2004).

3.5.5.2 STAR EXCURSION BALANCE TEST (SEBT)

The challenge of this test lies in maintaining a unilateral stable base of support while reaching in four directions with the opposite leg. The test was performed with the subject standing at the centre of a grid placed on the floor with four lines extending at 90˚ angles from the centre of the grid. A standard grid was made and used on each testing occasion. A verbal and visual demonstration of the procedure was given and then the subject was tested. The subject was instructed to keep his hands on his hips. The subject was required to lightly touch the furthest point on the line with the most distal part of the foot; this was done to ensure stability was achieved through adequate neuromuscular control

of the stance leg. The subject then had to return to the starting position. The examiner measured the reach after every repetition with a tape measure.

If the subject lost control of the stance leg and lost his balance or if the player could not control the reach foot position, it was deemed a failed SEBT and the subject was functionally unstable for this specific test. Losing control included not touching the line with the reach foot while maintaining weight bearing on the stance leg, lifting the stance foot from the centre of the grid, or losing balance at any point in the procedure. If a player was limited by pain and could not complete the test it was taken as a positive test for ankle instability and was included as a functionally unstable ankle. Prior to performing the test the subject was instructed, shown and given an opportunity to practice the stance position with corrections from the researcher. The reliability and validity of the test was discussed in chapter two (Gribble et al, 2004; Hertel et al, 2000).

3.6 PROCEDURE

3.6.1 PILOT STUDY PROCEDURE

The pilot study was performed to establish the clarity and reliability of the self assessment questionnaire including demographic data and the Olerud and Molander questionnaire as well as the clinical tests for mechanical instability. Mechanical tests were done to establish the inter- and intrarater reliability for the anterior drawer and talar tilt tests by having the researcher and an assistant physiotherapist test the players and compare results from these tests to establish interrater reliability. Interrater reliability was tested so that one tester, namely the researcher would be considered reliable and would be able to conduct all the tests. Interrater reliability was established by using the researcher and an assistant to assess the two mechanical tests on 14 players from a team not involved in the main study on the same day in two separate testing rooms so that they were blinded to the results scored by the other. The researcher tested a player and then the player went to the other room where the assistant tested the player until all 14 players had been tested. The researcher then repeated the tests

four days later in the same manner blinded to the initial results, to establish intrarater reliability. Good intrarater reliability confirms that the researcher would at any given time record similar results for the same player.

The pilot study was performed on the players of the second team of Alberton Rugby Club. The players completed the demographic questionnaire as well as the Olerud and Molander questionnaire on two separate occasions, four days apart to ensure test-retest reliability of the questionnaires.

The results of the pilot study are presented in Chapter 4

3.6.2 MAIN STUDY PROCEDURE

Each club in the South Gauteng region was asked to participate in the study by telephonically approaching the chairperson of the club. Information regarding the testing procedures was sent to the clubs via e-mail as well as the player and club consent forms. The researcher then pre-set a date and time to do the testing. Players were shown to a room where the testing apparatus had been set up. Informed consent was obtained from each player before participation. To determine perceived instability each player was then asked to complete the demographic data questionnaire and the Olerud and Molander questionnaire. After completion of the questionnaire the exclusion criteria were established before mechanical testing took place. The researcher tested the mechanical stability of both ankles of each player through the talar tilt and anterior drawer tests as previously described for the pilot study. The functional stability was assessed through the Star Excursion Balance Test and Balance Error Scoring System as described earlier.

3.6.3 STATISTICAL ANALYSIS

The data were captured in an Excel Spreadsheet and was then imported into Stata Release 10 statistical software for data analysis. The statistical analyses were performed on the data to determine the prevalence and establish a possible clinical presentation of ankle instability in club rugby players in the South Gauteng region.

The prevalence of mechanical and functional instability was presented as a percentage of the whole sample and reflects the number of existing cases of a disorder relative to the total population at a given point in time and is calculated as follows:

Prevalence = number of existing cases observed in the whole study sample at a given point in time / total number of subjects in the study sample and is described as a percentage (Portney and Watkins, 2002).

Prevalence of the symptoms was alluded to by the Olerud and Molander questionnaire and was determined and the association with previous ankle injury assessed using the odds ratio (OR) along with the 95% confidence interval and p-value to describe the presence of perceived signs of ankle instability in the population. The odds ratio can be defined as the odds of a clinical sign as depicted in the Olerud and Molander questionnaire if the subject reported previous ankle injury / those with no reported previous injury. This states that a subject has a specific percentage chance to experience a specific clinical sign after sustaining an injury.

The prevalence of mechanical and functional signs of ankle instability based on the mechanical and functional tests applied was determined.

The Chi-square test was used to compare the difference in clinical signs of mechanical ankle instability between the group who had never had any an ankle injury and the group who reported a previous ankle injury. Similarly the Chi-

square test was used to compare the differences in clinical signs of functional ankle instability between the group who had never had an ankle injury and the group who had a previous ankle injury. The results of the Chi-square test were confirmed by the Fisher's exact test.

Odds ratios for the risk of developing any of the features suggested in the Olerud and Molander questionnaire was included.

The different reaching distances and the total distance left and right sides, in the Star Excursion Balance Test, were compared using the paired t-test. The left and right sides of, the unstable and stable ankles, as derived from the mechanical testing were compared with respect to reach distances using the two-sample t test. Furthermore players with and those without previous injury were also compared.

All testing was done at the $p = 0.05$ level of significance.

CHAPTER 4

4. RESULTS

4.1 PILOT STUDY

4.1.1 TEST-RETEST RELIABILITY OF THE DATA COLLECTION QUESTIONNAIRES

The pilot study was used to determine the clarity of the two questionnaires. The Olerud and Molander questionnaire has been used in previous studies however no test-retest reliability scores were available. A test-retest reliability of greater than 90% was achieved as will be illustrated. The demographic questionnaire rendered similar results at 93.3%. The only change that occurred was because one player sustained an injury and therefore reported differently on the two questionnaires. The results of the pilot study revealed that parts of the data questionnaire had to be adapted for clarity. Appendix A.1 includes the initial questionnaire with the sections to be changed highlighted and Appendix A.2 has the questionnaire as used in the study for comparison. The questions that needed to be adapted included:

- the area of previous injury which was open ended with no choice, this was subsequently changed to eight areas frequently injured in the lower quadrant
- injury management where it had to be explained what a podiatrist and orthopaedic surgeon were, were verbally explained when the questionnaires were handed out to participants.
- phrasing of certain questions was changed e.g. for the questions pertaining to medication two options were added, one of no medication used because not all players required medication and one of chronic medication used daily for pain. There were also more

options added to the rehabilitation question as illustrated in Appendix A

- boxes were added where choices had to be made so that only a tick in the correct box was required.

Table 4.1 is an illustration of the test-retest reliability of the demographic and Olerud and Molander questionnaires as tested on two different occasions by the researcher.

Table 4.1: Test-retest reliability of the data collection questionnaires

TESTING OCCASION		**TEST DAY 1**	**TEST DAY 2**
QUESTIONNAIRE	**DEMOGRAPHIC QUESTIONNAIRE**	15 completed forms	15 completed forms 14 forms with the same results
	OLERUD AND MOLANDER	15 completed forms	15 completed forms 14 forms with the same results
TEST-RETEST RELIABILITY		**93.3%**	

The reason for the one form being different is the inclusion of one of the players who sustained an injury in the four days from the initial completion of the questionnaire to the second test day. Thus 100% test-retest reliability can be assumed if the one player was not included.

4.1.2 INTERRATER RELIABILITY

An interrater reliability of 100% was established with the researcher and the assistant physiotherapist agreeing on all subjects for both mechanical tests performed; namely the anterior drawer test (ADT) and the talar tilt test (TTT). Fourteen players were included in the pilot study from the fifteen who completed the questionnaires. One person was excluded due to a previous ankle fracture. Table 4.2 below illustrates results of the intterater reliability tests done by the two researchers. A (+) sign indicates positive results and a (-) sign a negative result.

Table 4.2: Interrater reliability

	TESTS	**ADT (+)**	**ADT (-)**	**TTT (+)**	**TTT (-)**
T E S T E R	**RESEARCHER 1**	6	8	4	10
	RESEARCHER 2	6	8	4	10
	INTERRATER RELIABILITY (%)	100%	100%	100%	100%

Based on the above interrater reliability achieved, both the anterior drawer and talar tilt tests were included. The interrater reliability suggests that similar results would have been reported by different physiotherapists performing the

tests. Therefore a single examiner, namely the researcher performing the tests was deemed to be adequate.

4.1.3 INTRARATER RELIABILITY

Intrarater reliability was confirmed by the researcher repeating the mechanical tests on the above subjects four days later. The same results were obtained for thirteen subjects. One subject sustained an acute ankle injury during a practice session and tested positive for the anterior drawer test which had been negative in the initial testing. Intrarater reliability was also 100% excluding the subject with the altered status of the ankle. These results are shown in Table 4.3.

TABLE 4.3: Intrarater reliability (illustrating positive tests)

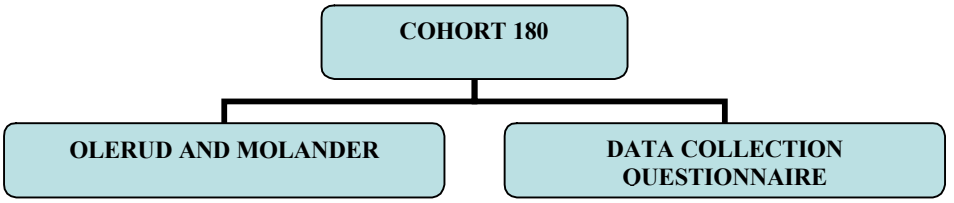
		EXAMINER – DAY 1		**EXAMINER – DAY 2**	
T E S T	**SIDE**	L	R	L	R
	ADT	6	8	6	9
	TTT	5	6	5	7
	INTRARATER RELIABILITY			100%	93%

With the one change from the player injured in the four days between testing, being ignored the intrarater reliability would also be 100%. The intrarater reliability supports the notion that one therapist would at any given time have recorded similar results for the same player.

4.2 THE MAIN STUDY

The aims of the study were twofold. Firstly to determine the prevalence of ankle instability in club rugby players using different testing conditions namely; perceived, mechanical and functional test, and secondly to describe the clinical picture of players with positive tests.

4.2.1 FLOW DIAGRAM TO ILLUSTRATE THE CHANGE IN SAMPLE SIZE THROUGHOUT THE STUDY



EXCLUSION CRITERIA:

1. Previous surgery to the ankle {14 excluded}
2. Injury to the lower limb rendering player out of active participation {11 excluded}
3. Patients with diagnosed concussion within 1 month {8 excluded}
4. Patients with ear infection, head cold or upper respiratory tract infection {10 excluded}

180 – 43 = 137

137 PLAYERS

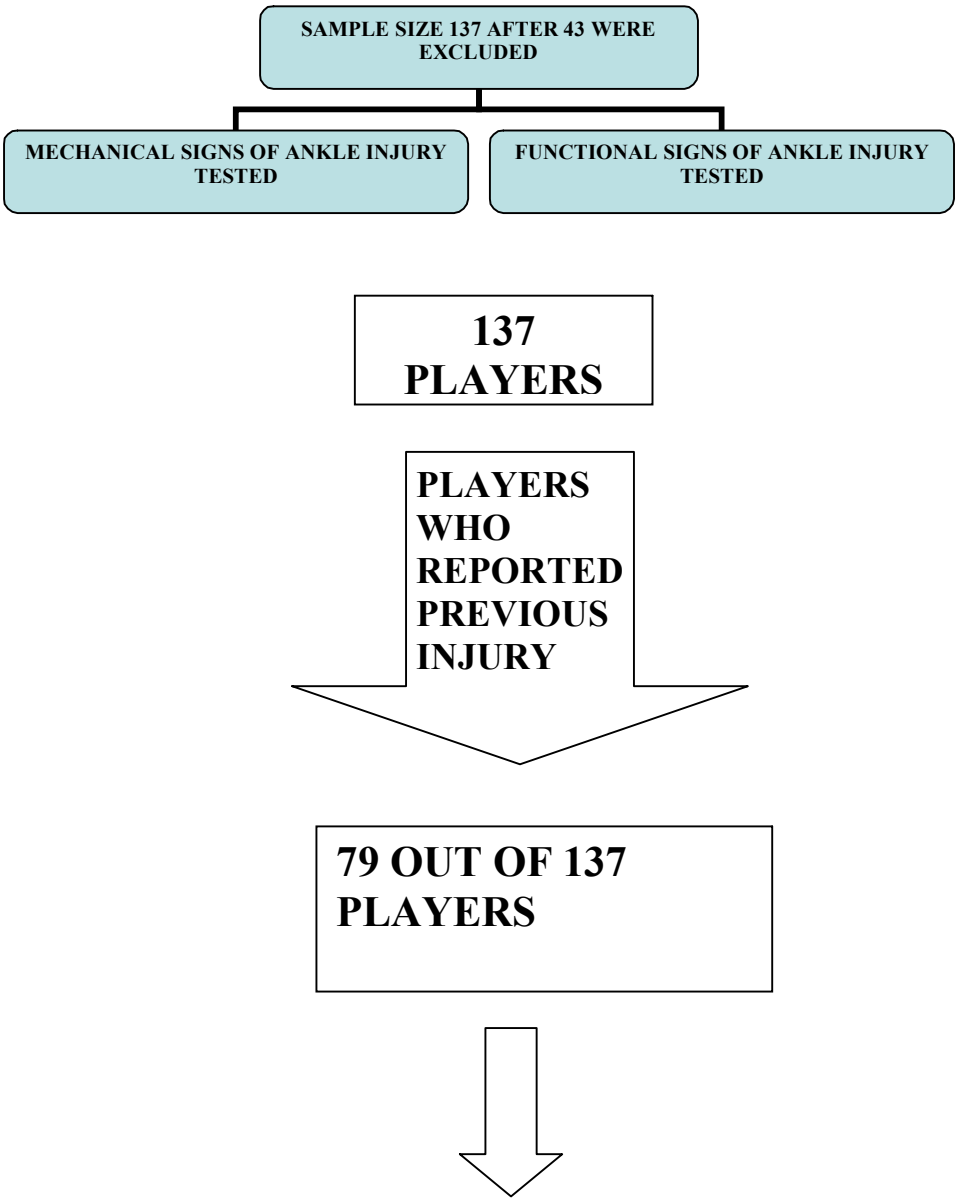


FIGURE 4.1 FLOWDIAGRAM TO ILLUSTRATE CHANGE IN SAMPLE SIZE THROUGHOUT THE STUDY

4.2.2 DEMOGRAPHICS OF THE SAMPLE

The sample consisted of 180 players who completed the demographic as well as the Olerud and Molander questionnaires. The 180 players were made up of 20 players per team in 9 of the 10 teams in the South Gauteng region as explained in Chapter 1.

4.2.2.1 DEMOGRAPHIC DATA

Table 4.4 illustrates the demographic data related to age, height and weight of the sample

Table 4.4: Age, height and weight of sample (n = 137)

PARAMETER PARAMETER	RANGE		MEAN (±SD)
	MINIMUM	MAXIMUM	
AGE	16 years	43 years	24 years (±4.7)
HEIGHT	156 cm	204 cm	181.5 cm (±7)
WEIGHT	60 kg	130 kg	93.6 kg (±14)

Age, height and weight distribution in the sample varies. Age from adolescent to earlier forties, weight from 60 to 130kg and height from 156cm to 204cm.

Table 4.5: Occupation and position (n= 137)

PARAMETER	SEDENTARY	PHYSICAL
OCCUPATION	**51.8% (71)**	**48.2 % (66)**
PARAMETER	**FORWARDS**	**BACKLINE**
POSITION	**53.3% (73)**	**46.7 % (64)**

In table 4.5 the occupations were divided into sedentary referring to corporate or office bound players and physical referred to those players who performed physical labour as part of their duties.

Forwards refer to positions one through eight and backline are the positions from scrumhalf to fullback.

4.2.3 THE PREVALENCE OF POSITIVE CLINICAL SIGNS OF ANKLE INSTABILITY

To establish the prevalence of ankle instability in club rugby players, three different aspects were addressed:

- clinical signs of perceived ankle instability derived from the Olerud and Molander questionnaire
- clinical signs of mechanical ankle instability using two objective clinical tests, namely the anterior drawer test and talar tilt test which establishes integrity of the lateral ligament complex
- clinical signs of functional ankle instability using the Balance Error Scoring system

4.2.3.1 THE PREVALENCE OF PERCEIVED ANKLE INSTABILITY

4.2.3.1.1 THE OLERUD AND MOLANDER QUESTIONNAIRE

A total of 180 players completed the questionnaires. The whole group was asked to complete the questionnaires and after this the exclusion criteria were applied and the sample size for further tests is thus different. An example of the scoring of the Olerud and Molander questionnaire can be seen in Appendix A. The results are illustrated in Table 4.6.

Table 4.6: The results of the Olerud and Molander questionnaire (n=137)

RESULTS	O + M Score	N= 137 (Percentage)
No perceived instability	100%	77(56%)
Perceived instability	< 95%	60(44%)

In the 137 players who were included in the study, 44% reported some signs or symptoms of instability as rated by the Olerud and Molander questionnaire.

This is only a broad indication of any clinical sign of instability and the Olerud and Molander Questionnaire was divided into sub-sections to further clarify the clinical picture.

4.2.3.1.2 SUB-ANALYSIS OF OLERUD AND MOLANDER QUESTIONNAIRE

Table 4.6 illustrates the sub-analysis of the Olerud and Molander questionnaire. This is used to describe the clinical signs and symptoms present in players with self-reported ankle problems.

Table 4.7: Results of the sub-analysis of the Olerud and Molander questionnaire (n=137)

PARAMETER	PERCEIVED PROBLEM (n = 137)
PAIN	38 (27.8%)
STIFFNESS	40 (29.2%)
SWELLING	20 (14.6 %)
STAIRS	16 (11.7%)
RUNNING	6 (4.4%)
JUMPING	8 (5.8 %)
SQUATTING	9 (6.6%)
SUPPORTS	23 (16.8%)
ACTIVITIES OF DAILY LIFE	11 (8%)

Pain (28%), stiffness (29%) and swelling (15%) were the most prevalent clinical signs and 17% of players reported that they required some kind of external support.

4.2.3.1.2 SUMMARY OF THE PREVALENCE OF CLINICAL SIGNS OF PERCEIVED ANKLE INSTABILITY

The final amount of players with perceived instability is **60/137 (44%)**, according to the Olerud and Molander questionnaire.

4.2.3.2 THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL INSTABILITY

To determine the prevalence of clinical signs of mechanical instability the anterior drawer test and talar tilt tests were used. These tests were only applied to players after the exclusion criteria had been applied and therefore the sample

size decreased to 137 from the initial 180. The percentage of players who showed signs of instability is illustrated in Table 4.8a

Table 4.8a: The prevalence of clinical signs of mechanical ankle instability (n=137)

POSITIVE OR NO CLINICAL SIGNS OF MECHANICAL INSTABILITY	**NUMBER OF PLAYERS**	**PERCENTAGE**
Number of players **with** positive clinical signs of mechanical ankle instability	60	43.8%
Number of players **with no** clinical signs of mechanical ankle instability	77	56.2%

The results in table 4.8a indicate that 60 players out of the total of 137 had some mechanical insult to the ankle irrespective of side of injury or ligamentous structure injured. This indicates the prevalence of clinical signs of mechanical instability.

4.2.3.2.1 SUMMARY OF THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY

Based on the mechanical tests, namely the anterior drawer and talar tilt tests the overall prevalence for positive clinical signs of ankle instability if **60/137 (43.8%)**.

4.3.2.2.2 SUBGROUPS OF MECHANICAL PREVALENCE

These results are now analyzed into subgroups in table 4.8b

Table 4.8b: The prevalence of clinical signs of mechanical ankle instability to summarize tests used side to side differences (n=137)

SIDE	TEST	PREVALENCE N (%)	95% CONFIDENC INTERVAL
LEFT	Anterior Drawer Test	31(22.6 %)	15.9 - 30.6%
	Talar Tilt Test	28(20.4 %)	14.0 – 28.2%
	TTT + ADT	25(18.2%)	14.00 – 22.2%
	ADT + TTT + Both	34(24.8%)	17.9 – 33.6%
RIGHT	Anterior Drawer Test	23(16.8 %)	10.9 - 24.1%
	Talar Tilt Test	23(16.8 %)	10.9 – 24.1 %
	ADT + TTT	20(14.6%)	10.4 – 18.0%
	ADT + TTT+ Both	26(18.9%)	14.5% - 23.0%
ONE SIDE ONLY -either left or right	ANY POSITIVE CLINICAL SIGN	45 (32.8%)	25.0 – 36.8%
BOTH SIDES	ANY POSITIVE CLINICAL SIGN	8 (5.8%)	3.4 – 8.8%%
LEFT	BOTH TESTS POSITIVE	25 (18.2%)	14.0 – 22.5%
RIGHT	BOTH TESTS POSITIVE	20 (14.6%)	10.4 – 16.8%
LEFT AND RIGHT	BOTH TESTS POSITIVE	53 (38.7%)	30.0 – 47.0%
LEFT AND RIGHT AND BOTH	ANY POSITIVE CLINICAL SIGN	60 (43.8%)	35.1 – 51.0%

Out of a total of 137 players 43.8% had positive tests for clinical signs of mechanical ankle instability irrespective of side of injury or ligament injured. When side to side differences are considered, the left had a higher percentage of 25% compared to the 19% reported for the right hand side.

4.3.2.2.3 THE COMPARISON BETWEEN PREVIOUSLY INJURED SUBJECTS AND THOSE WITH NO PREVIOUS MENTION OF INJURY

Table 4.9 illustrates the comparison between two sub-groups in the study. The one is the group who had a previous injury and the second group is the one who has never had any injury to the ankle joint.

Table 4.9a: The comparison between previous ankle injury and no reported previous ankle injury (n=137)

RESULTS	PREVIOUS ANKLE INJURY	NO REPORTED PREVIOUS ANKLE INJURY
	79 (57.7%)	58 (42.3%)

Table 4.9b: The prevalence of clinical signs of mechanical ankle instability (n = 137) divided into those with and those without previous injury

MECHANICAL TEST	**PREVALENCE - previous ankle injury**	**PREVALENCE – no previous ankle injury**	**p-VALUE : Chi-square**
ADT – Left	31.7% (25/79)	10.3% (6/58)	0.003 *
ADT – Right	24.1% (19/79)	6.9% (4/58)	0.01 *
TTT – Left	30.4% (24/79)	6.9% (4/58)	0.001 *
TTT- Right	21.5% (17 /79)	10.3% (6/58)	0.08 *
Combined Tests – Left	35.4% (28/79)	10.3% (6/58)	0.001 *
Combined Tests – Right	25.3% (20/79)	10.3% (6/58)	0.03 *

Combined Test – Left and Right	60.7% (48/79)	17.2% (5/58)	0.00 *

There were significant differences between the two groups for all but one of the tests; for the TTT-right which can at 0.08 be seen as marginally significant. This is based on the continuum below.

0 <SIGNIFICANT> **0.05** < MARGINALLY SIGNIFICANT > **0.1** < NOT SIGNIFICANT

FIGURE 4.2 ILLUSTRATION OF SPECTRUM OF SIGNIFICANCE

Table 4.9c: The prevalence of clinical signs of mechanical instability (n=137) divided into those with and those without previous injury for the players with a mechanical insult

MECHANICAL TEST	PREVALENCE - previous ankle injury	PREVALENCE – no previous ankle injury	p-VALUE : Chi-square
ADT – Left	80.6% (25/31)	19.4% (6/31)	0.007*
ADT – Right	82.6% (19/23)	17.4% (4/23)	0.01*
TTT – Left	85.7% (24/28)	14.3% (4/28)	0.001*
TTT- Right	73.9% (17 /23)	26.1% (6/23)	0.07*
Combined Tests – Left	82.4% (28/34)	17.6% (6/34)	0.002*
Combined Tests – Right	76.9% (20/26)	23.1% (6/26)	0.03*
Combined Test – Left and Right	80% (48/60)	20% (5/60)	0.000*

All the above percentages are above 70% for players who have a recollection of a previous injury to the ankle joint and who returned positive results for either

the anterior drawer or talar tilt tests. There are significant differences between all tests except for the TTT on the right which is marginally significant.

4.2.3.3 THE PREVALENCE OF CLINICAL SIGNS OF FUNCTIONAL ANKLE INSTABILITY

4.2.3.3.1. BALANCE ERROR SCORING SYSTEM

The prevalence of clinical signs of functional ankle instability for players is depicted in Table 4.10. This was based upon the results of the balance error scoring system

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Table 4.10: The prevalence of positive clinical signs of balance deficits relating to functional ankle instability (n=137)

SIDE	STANCE SURFACE	PREVALENCE OF FUNCTIONAL INSTABILITY: positive signs of instability/137(%)	95 % - CONFIDENCE INTERVAL
Left	**Firm – eyes open**	13 (9.5%)	5.1% - 15.7%
	Firm – eyes closed	88 (64.2%)	55.6% - 72.2%
	Foam – eyes open	65 (47.5%)	38.8% - 56.1%
	Foam – eyes closed	132 (96.4%)	91.6% - 98.8%
Right	**Firm – eyes open**	13 (9.5%)	5.1% - 15.7%
	Firm – eyes closed	76 (55.5%)	46.7% - 63.9%
	Foam – eyes open	66 (48.2%)	39.6% - 56.9%
	Foam – eyes closed	134 (97.8%)	93.7% - 99.5%

The more difficult the testing conditions are, the higher the prevalence of functional instability or decreased postural control. The highest percentages of

functional instability were found with the test performed on an unstable surface with the eyes closed, for the right leg (97.8%) and for the left leg (96.4 %).
The subjects were divided into those with previous injury and those without. This is illustrated in table 4.11

Table 4.11a: The prevalence of clinical signs of functional ankle instability as a comparison between uninjured and previously injured ankles (n=137)

SIDE	FUNCTIONAL TEST	NO PREVIOUS ANKLE INJURY	PREVIOUS ANKLE INJURY	p-VALUE
LEFT	Firm – eyes open	3/13 (2.3%)	10/13 (76.9%)	0.16
	Firm – eyes closed	32/88 (36.4%)	56/88 (63.6%)	0.04*
	Foam – eyes open	29/65 (44.6%)	36/65 (55.4%)	0.54
	Foam – eyes closed	56/132 (42.4%)	76/132 (57.6%)	0.17
RIGHT	Firm – eyes open	4/ 13(3.1%)	9/13 (69.2%)	0.32
	Firm – eyes closed	29/76 (38.2%)	47/76 (61.8%)	0.12
	Foam – eyes open	28/66 (42.4%)	38/66 (57.6%)	0.37
	Foam – eyes closed	57/134 (42.5%)	77/134 (57.5%)	0.17

The results in table 4.11a were only marginally significant for one test namely the test where a participant stood on the left leg on a firm surface with the eyes closed. This test is not a good indicator of ankle function and ankle injury, but more likely assesses the whole kinetic chain. It was also evident that there were minimal differences between the players with previous ankle injury and those without. This could be related to the increased difficulty of maintaining balance as a function of postural control rather than ankle instability.

Refer to table 4.9a for the players with reported previous ankle injury

In table 4.11a the percentages of players who recalled previous injury to the ankle were depicted for all the players with positive clinical signs of functional ankle instability. Here the percentages are much lower and can be ascribed to the sensitivity of the test. It is important to note that the balance error scoring system tests the whole kinetic chain not only the ankle joint.

4.2.3.3.2 PERCEIVED ANKLE INSTABILITY VERSUS OBJECTIVE ANKLE INSTABILITY

The table below depicts the number of players with perceived ankle instability with:

1. Positive clinical signs of mechanical instability
2. Positive clinical signs of functional instability

Table 4.12: The number of players with and without perceived instability who has positive clinical signs of ankle instability for mechanical and functional tests.

Positive clinical signs of mechanical instability with perceived instability	Positive clinical signs of mechanical instability with no perceived instability	Positive clinical signs of functional instability with perceived instability	Positive clinical signs of functional instability with no perceived instability
35/60 (58.3%)	21/53 (39.6%)	60/60 (100%)	0/77 (0%)

4.2.3.4 THE PREVALENCE OF CONCURRENT CLINICAL SIGNS OF MECHANICAL AND FUNCTIONAL ANKLE INSTABILITY

4.2.3.4.1. BALANCE ERROR SCORING SYSTEM

The prevalence of concurrent positive clinical signs of ankle instability for both mechanical and functional factors of ankle instability was established by dividing players with clinical signs of functional ankle instability into two groups; those with clinical signs of mechanical injury and those who showed no clinical signs of mechanical injury as tested by the anterior drawer and talar tilt tests. Table 4.13a illustrates the results. These tests were based on the 137 players included in the study.

Table 4.13a: Table to illustrate changes in the number of subjects for the group with and those without clinical signs of mechanical instability (n = 137)

TOTAL NUMBER OF PLAYERS INCLUDED	PLAYERS WITH MECHANICAL SIGNS OF INSTABILITY	PLAYERS WITHOUT MECHANICAL SIGNS OF INSTABILITY
N = 137	N = 60	n = 77
L = 137	L = 34	L = 103
R = 137	R = 26	R = 111

The above values are relevant for Table 4.13b where prevalence of concurrent clinical signs of mechanical and functional instability is depicted.

Table 4.13b: The prevalence of concurrent clinical signs of mechanical and functional instability using the balance error scoring system

SIDE	STANCE SURFACE	NEGATIVE SIGNS OF MECHANICAL ANKLE INSTABILITYn/total (%)	POSITIVE SIGNS OF MECHANICAL ANKLE INSTABILITYn/total (%)	p-VALUE
LEFT	**Firm – eyes open**	8/13 (61.5)	5/ 13(38.5%)	0.73
	Firm – eyes closed	62/88 (70.5%)	26/88 (29.5%)	0.001*
	Foam – eyes open	47/65 (72.3%)	18/65 (27.7%)	0.004*
	Foam – eyes closed	100/132 (75.8%)	32/132 (24.2%)	0.001*
RIGHT	**Firm – eyes open**	8/13 (61.5%)	5/13 (38.5%)	0.73
	Firm – eyes closed	58/76 (76.3%)	18/76 (23.7%)	0.002*
	Foam – eyes open	55/66 (83.3%)	11/66 (16.7%)	0.001*
	Foam – eyes closed	109/134 (81.3%)	25/134 (18.7%)	0.001*

For the balance error scoring system there were significant p-values for all but two tests, standing on a firm surface on the right and left leg with the eyes open. There is a significant difference between those with and those without mechanical ankle injury.

Each testing condition is more difficult or challenging than the one before. This explains the higher percentages of positive clinical signs of functional instability for more difficult positions. This supports the notion that this is not only an ankle test but tests the whole kinetic chain for postural control and any deficit in the kinetic chain might contribute to a player's inability to perform well in this test.
In Table 4.13c the above is further analyzed into two groups those who reported previous injury compared to those who reported no previous injury.

Table 4.13c: The prevalence of concurrent clinical signs of mechanical and functional instability as a comparison between uninjured and previously injured ankles

		NO CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY (L = 103; R = 111)			WITH CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY (L = 34; R = 26)		
SIDE	TEST POSITION	NO PREVIOUS INJURY	PREVIOUS INJURY	p-VALUE	NO PREVIOUS INJURY	PREVIOUS INJURY	p-VALUE
LEFT	Firm – e/o	1/8 (12.5%)	7/8 (87.5%)	0.18	2/5 (40%)	3/5(60%)	1.00
	Firm – e/c	27/62 (43.5%)	35/62 (56.5%)	0.43	5/26 (19.2%)	21/26 (80.8%)	0.01*
	Foam – e/o	25/47(53.2 %)	22/47 (46.8%)	0.86	4/18 (22.2%)	14/18 (77.8%)	0.08*
	Foam – e/c	51/100 (51%)	49/100(49 %)	0.90	5/32 (15.6%)	27/32(84.4 %)	0.001*
RIGHT	Firm – e/o	2/8 (25%)	6/8 (75%)	0.38	2/5 (40%)	3/5(60%)	1.00
	Firm – e/c	25/58 (43.1%)	33/58 (56.9%)	0.39	4/18 (22.2%)	14/18 (77.8%)	0.08*
	Foam – e/o	26/55(47.3 %)	29/55 (53.7%)	0.87	2/11 (18.2%)	9/11 (81.8%)	0.13
	Foam – e/c	51/109 (46.8%)	58/109 (53.2%)	0.64	6/25 (24%)	19/25 (76%)	0.05*

No significant changes were seen for this differentiation for the comparison between those with and those without previous injury for the group with no clinical signs of mechanical ankle instability. On the other hand the group that had clinical signs of mechanical ankle instability showed certain significant differences for the comparison between those with and those without previously reported ankle injury. There were marginal to significant differences for players with clinical signs of mechanical instability for standing on the left leg with the eyes closed on a firm surface and with

the eyes open and closed on a foam surface. On the right there were only marginally significant results on a firm and foam surface with the eyes closed. Furthermore the results in this table support the reasoning that the Balance Error Scoring System does not isolate the ankle joint and the results can not be related to the ankle joint specifically.

4.2.4 CLINICAL FINDINGS ASSOCIATED WITH ANKLE INJURIES IN CLUB RUGBY PLAYERS

4.2.4.1 PREVIOUS INJURY IN THE LOWER QUARTER AND PREVIOUS ANKLE INJURY

Table 4.14 illustrates the prevalence of previous injury in the lower quarter excluding the ankle compared to the perceived prevalence of ankle injuries in club rugby players. Here the lower quarter refers to lower back and pelvis, hip, knee, groin, hamstring, quadriceps and calf muscle. It includes both past and present injuries. This is a clear indication of the players' subjective view of their ankles compared to the rest of the kinetic chain of the lower quarter.

Table 4.14: Injury reports in the lower quarter excluding the ankle, and injury reported of the ankle (n = 137)

RESULTS	LOWER QUARTER	ANKLE INJURY
	63 (45.9%)	79 (57.7%)

Fifty eight percent of the players reported an ankle injury in their career, compared to 46% who reported other injuries in the lower quarter. The rest of the data in this section is based upon the 79 players who reported an ankle injury and subsequently n = 79

4.2.4.2 SIDE AND SITE OF ANKLE INJURY

Table 4.15 illustrates the side to side difference in ankle injuries both past and present

Table 4.15: Side and site of injured ankle (n = 79)

LEFT ANKLE	RIGHT ANKLE	DOMINANT SIDE	NON-DOMINANT SIDE	BOTH SIDES
30 (37.9%)	39 (49.4%)	42 (53.2%)	27 (34.2%)	10(12.7%))

The groups were divided into side: left or right and site referring to dominance. There were more injuries on the right and when site was established, it referred to the dominance; it was more often the dominant rather than non-dominant side that was injured.

4.2.4.3 TIME SIDELINED BY INJURY AND TIME TAKEN TO RECOVER

Table 4.16 illustrates the effect that the injury had on the player in:

- time sidelined: not sidelined at all, days (2 – 7 days after acute injury), weeks (4-6 weeks allowed for healing) or months (3-6 months)
- time taken to recover: days (2 – 7 days post acute injury), weeks (4 -6 weeks intermediate phase of rehabilitation), months (3-6 months post injury), never fully recovered
- time spend on the field of play post-injury: a full game (80 minutes), one half (40 minutes) or still on the bench not participating in games yet.

Table 4.16: Time and the ankle injury (n = 79)

TIME SIDELINED	FREQUENCY (Percentage)
NOT SIDELINED	16 (20.3%)
DAYS	16 (20.3%)
WEEKS	33 (41.8%)
MONTHS	14 (17.7%)
TIME TAKEN TO RECOVER	FREQUENCY (Percentage)
DAYS	40 (50.6%)
WEEKS	25 (31.6%)
MONTHS	4 (5.1%)
NEVER FULLY RECOVERED	10 (12.7%)
TIME SPENT ON THE FIELD	FREQUENCY (Percentage)
FULL GAME	72 (91.1%)
ONLY ONE HALF	5 (6.3 %)
BENCH ONLY	2 (2.5 %)

Thirteen percent of players reported that they never recovered but more than 90% of players had returned to full participation in rugby after the ankle injury including the 13% who has not recovered. Forty four percent of players returned to training and participation in matches after being sidelined for a few weeks. This is less than the time for optimal healing of six weeks that should be observed for soft tissue healing. Twenty one percent returned within days after the injury.

2.4.4 INJURY MANAGEMENT

For return to sport an injury has to be managed and Table 4.17.1 and Table 4.17.2 illustrate how players manage their injuries

Table 4.17a: Management of ankle injury and investigations required (n= 79)

INVESTIGATIONS REQUIRED	**FREQUENCY (PERCENTAGE)**
No investigations done	39 (55.7%)
X-rays	24 (34.3%)
Ultrasound	2 (2.9%)
MRI	2 (2.9%)
CT-Scan	3 (4.3%)
INJURY MANAGEMENT	**FREQUENCY (PERCENTAGE)**
Self	29 (41.4%)
Physiotherapist	31 (44.3%)
Biokineticist	2 (2.9%)
Orthopaedic surgeon	2 (2.9%)
Podiatrist	3 (4.3%)
General practitioner	2 (2.9%)

Table 4.17b: Management of ankle injury – use of medication (n= 79)

USE OF MEDICATION	NOTHING	ANTI-INFLAMMATORY	PAIN KILLER	BOTH
CURRENT	56 (70.9%)	12 (15.2%)	3 (3.8%)	8 (10.1%)
AT TIME OF INJURY	48 (60.8%)	18 (22.8%)	10 (12.7%)	3(3.8%)

The percentage of players using both anti-inflammatories and painkillers are higher for current use than use after the initial injury. Forty four percent of players reported having been to a physiotherapist for treatment and the second highest, 42% managed these injuries themselves. Most players did not have any investigations post-injury and second to that only X-rays seemed to have been done fairly regularly with 34% of injured players having x-rays taken with or without stress views.

4.2.3.5 EFFECT OF ANKLE INJURY ON PERFORMANCE OF SUBJECTS

In table 4.18 below the effect of the injury on the athlete's performance is illustrated

Table 4.18: The effect of ankle injury on the subjects perception of performance (n = 79)

EFFECT	PERCENTAGE AND FREQUENCY
No effect	37 (46.8%)
Speed	13 (16.5%)
Power	4 (5.1%)
Agility	8 (10.1%)
Speed and Power	1 (1.3 %)
Speed and Agility	9 (11.4%)
Power and Agility	4 (5.1%)
Speed, Power and Agility	3 (3.8 %)

Forty seven percent of players reported that the injury had had no effect on their ability to perform at their level of participation, although 16.5% reported a decrease in

speed and 10% reported limitations of agility. When combined a total of 53% stated some effect on their performance.

4.2.4.6 ODDS RATIOS RELATED TO THE CLINICAL FINDINGS OF THE OLERUD AND MOLANDER QUESTIONNAIRE

The Olerud and Molander questionnaires results were also compared to the players with reported previous ankle injury and the risk of developing any of the clinical signs after an initial injury is noted.

Table 4.19: Previous ankle injury as risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire

OLERUD AND MOLANDER SUB-CATEGORY	ODDS RATIO (OR)	95%-CONFIDENCE INTERVAL	p-VALUE
PAIN	4.59	(1.83;11.55)	0.001*
STIFFNESS	4.28	(1.73;10.58)	0.002*
SWELLING	4.91	(1.35;17.87)	0.016*
STAIRS	6.68	(1.33;33.53)	0.021*
RUNNING	1.84	(0.34;9.87)	0.477
JUMPING	2.23	(0.43;11.50)	0.339
SQUATTING	1.29	(0.29;5.70)	0.741
SUPPORTS	4.16	(1.32;13.16)	0.015*
ACTIVITIES OF DAILY LIVING *(1)*	8.02	(0.99;65.09)	0.051*

The odds ratio above indicates the likelihood of a subject with previous ankle injury to report or experience any of the above clinical signs, symptoms or functional deficits of ankle instability. This means that players with previous ankle injury are more than four times likely to have pain, stiffness and swelling. They are more than

six times likely to experience difficulty in climbing stairs and four times more likely to use supports. Finally they are possibly more than eight times more likely to have difficulty in activities of daily living.(see explanation below).

(1) Wide 95%- confidence interval due to the nature of the data, i.e. only one subject did not have a previous ankle injury among those who experience problems with activities of daily living.

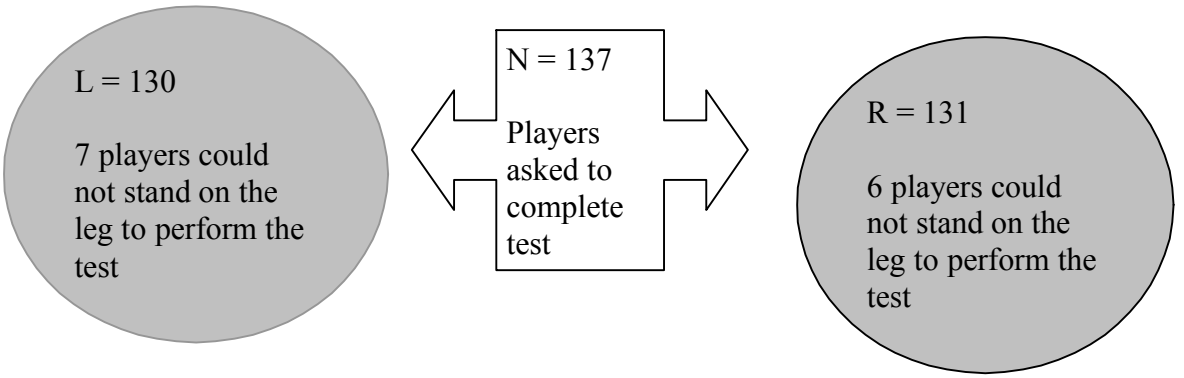
4.2.4.7 STAR EXCURSION BALANCE TEST

4.2.4.7.1 THE STAR EXCURSION BALANCE TEST FOR THE ANKLES WITH AND THOSE WITHOUT CLINICAL SIGNS OF MECHANICAL INSTABILITY

The Star Excursion Balance Test in this case depicts reach distances for left and right leg while comparing ankles clinical signs of mechanical instability to those without, as illustrated in Table 4.19.

The analysis is then further carried into comparing those individuals with previous ankle injury to players who have not sustained previous injury. This analysis is depicted in Table 4.20.

Of the 137 players who were asked to do the functional stability tests the following figure 4.2 illustrates the changes in Table 4.19 and Table 4.20 for the n-values



4.3 CHANGE OF SAMPLE SIZE (n) FOR THE STAR EXCURSION BALANCE TEST

Here some players could not perform the test because of inability to stand, weight bear and control the leg in space and against gravity not explaining the failure to stand on the leg.

Table 4.20: The Star excursion balance test for subjects with and those without clinical signs of mechanical instability

SIDE	DIRECTION OF REACH	MEAN(SD) – REACH DISTANCE (-)	MEAN(SD) – REACH DISTANCE (+)	N : ((-); (+))	p-VALUE
LEFT	ANTERIOR	95.3 (±15.4)	88.1 (±15.2)	130 (98;32)	0.02 *
	POSTERIOR	76.8 (±18.9)	74.0 (±19.5)	130 (98;32)	0.5
	SAME SIDE AS STANCE LEG	60.1 (±17.22)	54.56 (±18.8)	130 (98;32)	0.1
	OPPOSITE FROM STANCE LEG	87.4 (±16.4)	79.3 (±19.0)	130 (98;32)	0.02 *
	SUM OF REACH DISTANCES	319.5 (±52.2)	296.0 (±52.4)	130 (98;32)	0.03 *
RIGHT	ANTERIOR	92.9 (±16.0)	91.5 (±13.9)	131 (105;26)	0.7
	POSTERIOR	75.4 (±18.2)	73.1 (±20.0)	131 (105;26)	0.6
	SAME SIDE AS STANCE LEG	56.8 (±17.5)	51.5 (±17.3)	131 (105;26)	0.2
	OPPOSITE FROM STANCE LEG	87.1(±17.2)	86.0 (±17.0)	131 (105;26)	0.8
	SUM OF REACH DISTANCES	312.3 (±53.3)	302.1 (±48.85)	131 (105; 26)	0.4

From this table, significant differences between the (-), the ankle without clinical signs of ankle instability and the (+), the ankle with clinical signs of mechanical instability were found for the left with reaching anteriorly ($p = 0.02$), across the left leg to the left ($p = 0.02$) and also for the sum of the reach distances of the left hand side ($p = 0.03$). The players with clinical signs of mechanical instability on the left hand side could not reach the same mean distances as players without clinical signs of mechanical instability of their ankles.

4.2.3.7.2 THE STAR EXCURSION BALANCE TEST FOR THE ANKLES WITH AND THOSE WITHOUT MENTION OF PREVIOUS INJURY

The data gained from the Start Excursion balance test was again used but this time the comparison was made between previously injured and non-injured subjects. Results are depicted in Table 4.21

Table 4.21: The Star excursion balance test for subjects with or without previous ankle injury

SIDE	DIRECTION OF REACH	MEAN(SD) – REACH DISTANCE NO PREVIOUS INJURY	MEAN(SD) – REACH DISTANCE PREVIOUS INJURY	N : (NO PREVIOUS INJURY ; PREVIOUS INJURY	p-VALUE
LEFT	**ANTERIOR**	95.7 (±15.8)	92.3 (±16.3)	130 (51;79)	0.11
	POSTERIOR	77.2(±19.1)	75.9 (±19.2)	130 (51;79)	0.35
	SAME SIDE AS STANCE LEG	59.8 (±18.9)	58.2 (±15.5)	130 (51;79)	0.31
	OPPOSITE FROM STANCE LEG	87.2 (±21.0)	84.3 (±13.5)	130 (51;79)	0.17
	SUM OF REACH DISTANCES	319.8 (±57.6)	302.9 (±59.6)	130 (51;79)	0.07 *
RIGHT	**ANTERIOR**	94.6 (±16.5)	91.4 (±15.2)	131 (52;79)	0.1
	POSTERIOR	75.5 (±18.8)	74.9 (±18.4)	131 (52;79)	0.4
	SAME SIDE AS STANCE LEG	53.7 (±18.0)	57.2 (±16.3)	131 (52;79)	0.8
	OPPOSITE FROM STANCE LEG	87.4(±18.3)	86.8 (±16.3)	131 (52;79)	0.4
	SUM OF REACH DISTANCES	311.3 (±54.1)	302.4 (±70.8)	131 (52; 79)	0.2

In Table 4.20 there is only one marginally significant value for the sum of reach distances standing on the left leg. This again re-iterates that the ankle is not the only joint in the kinetic chain that needs to be considered or that there is no difference in a subject's ability to perform the test, irrespective of injury to the ankle.

4.3 CONCLUSION

The results of the study have been given in this section for the following:

Prevalence of the following:

1. Clinical signs of perceived ankle instability : 47% for the Olerud and Molander questionnaire and 51% for self-reported ankle injury
2. Clinical signs of mechanical ankle instability: 39% when laterality is ignored
3. Clinical signs of functional ankle instability: varied values based on the difficulty of the testing position
4. Clinical signs of concurrent mechanical and functional ankle instability: varied values based on the difficulty of the testing position

The comparison between injured and uninjured subjects was made for the clinical signs of mechanical and functional as well as the concurrent clinical signs of mechanical and functional ankle instability. For mechanical and functional clinical signs of ankle instability the presence of previous injury was related to clinical signs of the aforementioned.

The odds-ratios for previous ankle injury were determined to establish previous ankle injury as a risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire.

Finally clinical findings relating to ankle injuries were described for different factors including the side and dominance, investigations done and management instituted effect on player's ability and their return to the game. Results of the Star Excursion Balance Test revealed no significant differences between injured and uninjured subjects possibly due to the fact that it views the whole kinetic chain and not only the ankle joint in isolation..

CHAPTER 5

5. DISCUSSION

5.1 INTRODUCTION

This chapter includes a discussion of the results as described in chapter four. The prevalence of clinical signs of ankle instability in club rugby players is discussed for perceived, mechanical and functional deficits including a comparison between players who have had previous ankle injuries and those who did not report any previous injury to the ankle. The clinical findings related to ankle injuries in club rugby players in the Golden Lions South Gauteng region are also described.

5.2 THE PREVALENCE OF CLINICAL SIGNS OF PERCEIVED INSTABILITY

The 47% of players who reported some signs of instability is higher than the prevalence discussed in the literature, 10 – 30% (Zöch, et al, 2003; Garric, 1997). It must be remembered that this is a subjective evaluation by the player of the perceived status of the ankle. It is not inferred that these injuries were sustained as a result of playing rugby. There is also a very broad spectrum of questions included in the Olerud and Molander questionnaire that can be associated with ankle injury but the Olerud and Molander questionnaire was specifically designed to make research by different groups into ankle injuries more comparable whether sporting related, occupational or even in the military (Hertel, 2008; Rose et al, 2000). Documentation indicating the presence of any one of the signs or symptoms was taken to be a sign of a functional control deficit (Rose et al, 2000). Therefore this may have resulted in the high prevalence of perceived instability. The questionnaire is further divided into two sections which will now be discussed.

The first section of the questionnaire consists of the physical signs and symptoms and results reported here range from 15% – 29%, and these results are much closer to results as reported in the literature which range from 10 – 30% (Zöch, et al, 2003; Trojian and McKeag, 1998; Garric, 1997). The subsections include pain (27.8%), stiffness (29.2%) and swelling (14.6%). It is interesting that despite the reports of physical signs of ankle injury some of these players were still actively participating in practice sessions and games. This raises the question of whether they are predisposed to future injury due to inadequate healing time, management and rehabilitation. The literature reports an initial healing time as 4 – 6 weeks for orientation, aggregation and arrangement of soft tissue. In this phase normal function is possible but the athlete is still vulnerable to re-injury. Over a period of six months to two years the final tissue changes will still take place (Denegar and Miller, 2002; Zöch et al, 2003). Rehabilitation is the key to effective and successful return to sport. Acute management should include anti-inflammatory modalities and exercises to maintain range of motion. Once initial tissue healing has been observed, strength and proprioception has to be addressed and then a graduated return to sport must be supervised (Arnold and Docherty, 2004). The experienced clinician should also identify the internal and external precursors for future injury including biomechanical abnormalities, footwear and the need for bracing or taping (Zöch et al, 2003; Denegar and Miller 2002; Beynnon et al, 2002).

The functional limitations included four problems that are of particular interest to the rugby fraternity because all the maneuvers are used regularly on the field and in training. The following percentages of perceived problems were reported: running (4.4%), jumping (5.8%), stairs (11.7%) and squatting (6.6%). These players experienced problems with basic training techniques which suggest that they should not be participating in games and practices. The low percentages here can be ascribed to the stoic nature of the sportsman, the body's adaptation to limitation and the fact that these players want to continue playing the game (Hertel, 2008). Where the translation of a joint is not controlled there will be a long term negative impact on tissue structure and degeneration of the ankle and subtalar joint with the possible onset of early osteo-arthritis (Hertel, 2008; Denegar and Miller, 2002). If the continuum from acute ankle sprain with mechanical deficit to functional instability and then chronic instability is applied as earlier discussed, the ankle with perceived

instability may eventually end up categorized as chronic instability, this being a sure precursor for early degenerative arthritic changes (Gribble et al, 2004; Mattacola and Dwyer, 2002).

Seventeen percent of players reported the use of some sort of support with the highest percentage of the subjects reporting the need for strapping or bracing rather than the use of crutches. There seem to be conflicting ideas in the literature with regards to the use of taping and bracing. The need for taping and bracing is described as rehabilitative and protective. It is used to limit movements which might strain the structures that are healing and allow movement in the desired direction (Mohammadi, 2007; Surve et al, 1994). The use has been questioned by certain authors (Hume and Gerrard, 1998), who argue that this will lead to weakness of the supporting musculature and others that report only minimal effectiveness of bracing to restrict weight bearing inversion injuries in netball players (Mashawari et al, 2003). In clinical practice it certainly seems that there is some benefit to the use of taping and bracing (Wikstrom et al, 2006). There is no conclusive evidence to advocate the use of any specific external support for clinical efficacy or cost-effectiveness (Kerkhoffs et al, 2002).Team physicians in some of the top teams in the world report that their players are strapped as a precautionary measure to prevent injury (Wikstrom et al, 2006; Davies, 1997; Surve et al, 1994). Effective bracing requires preparation through rehabilitation and bracing is only indicated as part of a comprehensive treatment approach and is not suggested as the only management strategy (Davies, 1997). Soft and semi-rigid braces do not improve postural control but assist with the attenuation of vertical forces (Wikstrom et al, 2006). A study on soccer players did mention a fivefold reduction in the incidence of recurrent ankle sprains in soccer players who used the Sport-Stirrup orthosis (Surve et al, 1994). However reports from rugby players suggest that they feel safer with an external constraint and taping and bracing have been shown to have good effect to decrease ankle injuries and also have minimal effect on the performance of a subject (Sankey et al, 2008; Hume and Gerrard, 1998). Whether this is merely a placebo effect remains to be shown (Wikstrom et al, 2006).

From a rehabilitation point of view it is suggested that if an external constraint can be used to control motion it may be possible to prevent injury or recurrences through rehabilitation of postural control and muscular rehabilitation which are the anatomical

structures to regain stability the ankle (Kawaguchi, 1999). Failure of conservative management of the ankle has lead to the statement that any athlete who has had a significant lateral ligament injury should use protective strapping or bracing for any future participation in sport (Brukner and Khan, 2007; Davies, 1997). When looking at the ankle and subtalar joints and the muscular support it is evident that the joint is not crossed by any muscle and that support is only given by the tendons passing across the joint and ligamentous constraints (Moore, 1992). There is also not one single tendon attached to the talus, the only bone in the human body where there is no insertion point for a muscle or tendon. It may be that the anatomical features of the ankle (the bony congruency and ligamentous support are essentially the two restraining factors and if this is lost the joint is even more vulnerable to injury), relatively predisposes the joint to injury and the case for taping and bracing can possibly be made (Moore, 1992).

Twelve percent of players reported difficulty in performing activities of daily life due to their ankle injuries. Daily life is affected by the presence of clinical signs such as pain and stiffness which limits participation in certain activities. This is further linked to inability to climb stairs, run and jump which are all related to normal function in daily life. There were also a few of these players who had physical occupational duties which might have been more difficult to perform. This is an issue of concern as a certain percentage may suffer from chronic pain syndromes, early onset of osteo-arthritis and eventually gait disturbances which could well affect the rest of the kinetic chain including knee, hip and lumbar spine (Brukner and Khan, 2007; Motram and Comerford, 1998; Davies 1997).

5.3 THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL INSTABILITY

A seventeen percent prevalence of mechanical instability was seen for both the anterior drawer and talar tilt tests on the right hand side. For the left, the results were slightly different with the anterior drawer test being 23% and talar tilt test 20%. The different values for the left leg can be ascribed to the sensitivity of the talar tilt test to

determine injury to the calcaneo-fibular ligament where the anterior drawer test is more specific for the anterior talo-fibular ligament this would have been true for the right hand side as well. . It is deduced that more players injured the anterior talo-fibular ligament in isolation and this is supported in the literature (Trojian and McKeag, 1998; Hartley, 1995). The prevalence of mechanical instability in the subjects used for this study is slightly higher (43.8%) to what has been reported in the literature for ankle injuries in sport, 10 – 30% (Zöch et al, 2003), and relatively higher than the reported prevalence for ankle injuries in rugby players at nine to 15% (Sankey et al; Trojian and McKeag, 1998). To discuss this one must consider the traumatic impact experienced in the game of rugby to explain the higher prevalence reported in this study and consider the level at which the game is played, i.e. club, provincial or national. At a higher level injuries are usually managed by a multi-disciplinary medical team which might decrease the prevalence of injury with correct rehabilitation or identification of risk factors and pre-injury intervention. Club rugby players are rarely managed at the club and have to attend physiotherapy at their own cost. High reliance is placed on bracing instead of rehabilitation to ensure participation (Brooks and Kemp, 2008; Davies, 1997).

When laterality is ignored this percentage is even greater than when comparing left side to right side. Forty four percent of players had a problem with determined mechanical deficit on the left, right or even bilaterally. The prevalence of injury in club rugby players relates back to predisposing factors, rigors of the game, poor injury management, decreased postural control and wrong training methods (Brooks and Kemp, 2008). Clint Redhead, who was the physiotherapist to the recent World Cup winning South African rugby team verbally reported during a South African Sports Medicine Association presentation at the Morningside Medi Clinic that the preparation for this event started three years previously and that when a professional team prepares for international participation the season is divided into three phases. The first being the pre-season phase which includes screening for possible predisposing factors and conditioning training. Second, the season itself where injuries are managed and treated in a conservative fashion to enable return to sport when the player is conditioned and when healing time has been observed. The third and final session includes post-season management where niggling injuries and biomechanical factors are addressed. This is supported by the literature (Hunter and

Fortune, 2000; Brukner and Khan, 2007). In the build up to the 2007 Rugby World Cup the sports physicians involved felt that the players were being over-utilized and not being given sufficient time to recover from niggling injuries and a study was undertaken to indicate the incidence of injuries in the Super Twelve competition to show that these players needed more time to recover (Holtzhauzen et al, 2006). The dangers of the tackle were again underlined and there were mostly minor injuries of which chronic overuse injuries were mostly seen. Suggestions made then included that training in tackling and rucking techniques was important and that rules should be enforced to reduce risk of injury (Holtzhauzen et al, 2006). The management plan above is optimal at club rugby level but is not always applied to players at club rugby level where certain teams do not have an attending sports physician or physiotherapist and only a fortunate few will be able to afford private management by appropriate practitioners (Gabbet, 2004). The study did not determine if all ankle injuries sustained was purely due to rugby injuries and only states that there were injuries in the group of players.

The analysis were taken further and there were significant differences as expected for both the talar tilt test and anterior drawer test irrespective of laterality between the group who mentioned previous injury and the ones who had never experienced any previous injury. This again shows that there might be residual mechanical laxity after return to participation in sport or that the patients with some sort of mechanical deficit is more likely to sustain injuries. It asks the question of whether these players return to play too soon or whether they are not fully rehabilitated when they return to the game (Holtzhauzen et al, 2006; Garraway et al, 2000). This underlies the principle supporting clinical testing to establish ankle injury with mechanical deficits (Trojian and McKeag, 1998). This is also advocated in a study by Sankey et al in 2008 where grade I and II ankle injuries were accurately diagnosed based on clinical tests and where only more severe injuries required radiological investigations (Sankey et al, 2008). As expected there was a higher prevalence of mechanical deficits in rugby players with self-reported previous injury to the ankle. The use of self-reporting is supported by a recent article where it is suggested that the presence of previous injury and reduced function can be predictors of new injuries based on a player's self-reporting using a questionnaire (Steffen et al, 2008).

The evidence of presence of mechanical laxity in patients who reported previous injury to the ankle all rendered high percentages above 74% as would be expected.

5.4 PREVALENCE OF CLINICAL SIGNS OF FUNCTIONAL ANKLE INSTABILITY

A high percentage of players struggled to perform the more difficult balance testing positions (eyes closed or using the foam surface). Ninety six percent of players for the left leg and 98% of players for the right leg made mistakes on the balance error scoring system with their eyes closed on an unstable surface. When one considers that visual input is taken out of the somatosensory equation of proprioception, vestibular and visual input and that the proprioceptors are exposed to an unstable foam block and constantly have to adapt to the surface this is certainly the most difficult of the stance positions. This however mimics what is happening during a game. The visual input is not used for postural control, rather for assessing the information on the field. The grassy turf of a rugby field is not always even, and the foot must adapt to the ground with every step and contend with impacts from different directions during rucks, mauls and tackles.

On a stable surface with decreased visual input 64% (left) and 56% (right) were deemed functionally unstable. As soon as a player closed his eyes even when standing on a stable surface there were signs of instability. This is again probably pointing to the importance of visual input to the central nervous system to control the body in space (Ergen and Ulkar, 2008).

On an unstable surface with visual input the percentages dropped to 48% (left) and 48% (right) who showed signs of inability to control the ankle in space statically and this doesn't even consider the impact of movement on the ankle because it is only a static balance test. Perturbation is applied through the constant change in the foot position on the unstable surface. The test does not include the player's ability to read the surface or adapt to it during the stance phase and simultaneously allow the other foot to clear the ground and propel the body forward during dynamic movement. It

has been shown that players with reported functional ankle instability do take longer to stabilize after ground contact in a land from a single leg jump which assesses functional control (Ross and Guskiewicz, 2004). The more challenging the balance perturbation with progression of the test the greater the positive signs for instability as shown by the test for the combination of decreased visual input on an unstable surface where 96% on the left and 98% on the right showed functional signs of instability. For the balance error scoring system one must consider that the whole kinetic chain must be considered and a deficit anywhere in the chain could affect results What is evident from the results is that as the difficulty in stance surface increases as it is changed from firm to foam and with changes in visual input the results are poorer.

There is no consideration whether or not there is some sort of mechanical insult to the ankle ligament and thus this does not distinguish between players with positive mechanical signs of ankle instability namely torn or stretched ligamentous structures or those with no mechanical deficits. This might indicate that the lack of static postural control could be a precursor to injury as much as the after effect of it. This will be looked at further in the next section where concurrent mechanical and functional instability is discussed. This is not an isolated test for ankle instability but for static postural control so an insult to any one of the joints in the lower limb kinetic chain might result in positive signs for instability (Kawaguchi, 1999). Since the kinetic chain functions as a unit to produces movement and carry the weight of the body one cannot isolate the proprioceptive input from one joint to another.

The analysis was again taken further by dividing the group into those with and those without previous mention of ankle injury. There were only one significant difference and that was for players standing on a stable surface with the eyes closed on the left leg. This is a possible indication that the predisposing functional deficits could lead to future injury rather than injury contributing to the functional deficit upon balance testing. These results also ignore injury to the lower back, spine, hip and knee which might be the contributing factors to the decreased postural control affecting balance and proprioception, rather than the ankle itself. In players with positive clinical signs of functional ankle instability the percentages varied from 55% to 69%, which is less than the confirmed percentages for mechanical instability but again is expected

considering that the test is not specific to the ankle joint and includes the affects from the rest of the kinetic chain. The results were not very significant for the comparison

This also raises the question of the possibility of the presence of decreased postural control being the predisposing factor to injury (at the ankle and other parts of the kinetic chain) and not necessarily the result of a mechanical insult to the proprioceptors (Gribble et al, 2004). This will be further illustrated in the following paragraph where concurrent functional and mechanical problems are discussed.

5.5 THE PREVALENCE OF CONCURRENT CLINICAL SIGNS OF FUNCTIONAL AND MECHANICAL ANKLE INSTABILITY

For the balance error scoring system there were only two significant p-values, one on the right and one for standing on the left leg. The increased difficulty of each testing condition must be considered for the results showed. This explains the higher percentages for more difficult positions. This supports the notion that this is not only an ankle test but tests the whole kinetic chain for postural control and any deficit in the kinetic chain might contribute to a player's inability to perform well in this test (Susco et al, 2004).

From this it can possibly be concluded that standing on the right leg on a firm surface the players with clinical signs of mechanical disruption was only marginally significant and those with eyes open on a firm surface for the left leg compared to those without any mechanical signs of instability of the ankle.

For the rest of the results, eyes opened or closed on a stable or unstable surface, there were no significant differences between players with mechanical insult compared to players with no previous mechanical insult to the ankle. Two factors can be considered here to explain this. As referred to previously the ankle cannot be isolated by the balance error scoring system and injury to the rest of the kinetic chain must be considered as a contributory factor

(Kawaguchi, 1999). In this study only a quick subjective screening was done to establish contributions from the rest of the kinetic chain. The results might have been influenced by the presence of injury to the knee, hip or even centrally by irritation of the exiting nerve roots from the lumbar spine. The lack of significant differences between the injured and uninjured ankle can also indicate that mechanical instability is not necessarily an indicator of functional instability as measured by the balance error scoring system. It might actually be seen as a predictor of the possible lack of postural control mediated by the central nervous system (Taube et al, 2008).

The analysis was again applied to players who mentioned previous injuries to the ankle and those who have not and the findings were again that there were only marginally significant differences for players with clinical signs of mechanical ankle instability in the comparison between the group with previously mentioned ankle injury and those with no previous injuries. For all the other positions there were no significant differences. This indicates that there might be underlying proprioceptive deficits that might be present before injury and subsequently be the predisposing factors to injury.

5.6 FUNCTIONAL INSTABILITY AS A COMPONENT OF POSTURAL CONTROL AND BALANCE

A recent change in the management of sports injuries, in the United Kingdom, Australia and New Zealand has come from research indicating that the lack of postural control due to lifestyle and habitual postures resulting in muscle imbalances might be the precursor to functional instability (Comerford and Mottram, 1998; Richardson and Jull, 1995; Lee, 1996; O'Sullivan et al, 1997). Other determined intrinsic factors include forefoot varus and overpronation (Sanky et al, 2008) Most of the research has been done on the lower back and shoulder joints but can be applied to the rest of the kinetic chain. For years rehabilitative therapists have managed only the involved joint but from this recent research the emphasis has changed. A group of physiotherapist in the United Kingdom have started a group called "Kinetic Control"

and they apply specific tests to assess the translation of the joint to assess the presence of stiffness (restrictions) or hypermobility (gives) and then to rehabilitate the dysfunction in the kinetic chain or central control deficit and not only the localized problem, with good effect (Comerford and Mottram, 1998). Considering the results from this study, that there is not necessarily a specific mechanical injury to the ankle joint that relates to functional stability deficits, it indicates that decreased postural control for the functional stability tests might be the culprit. This supports the notion to manage postural control deficits by screening for 'gives' and 'restriction' and to control joint excursion throughout range of motion to prevent injury. The sporting population is more exposed to risk of injury and if pre-season screening can identify problems in postural control these can be addressed to prevent those injuries related to lack of postural control (Kaminski et al, 2003). It was shown that fatigue and chronic ankle instability can lead to postural control deficits and the opposite can also be true that existing postural control deficits might influence the stability of the ankle joint (Gribble et al, 2004).

This also supports the importance of a holistic approach to the patient that can be implemented to prevent injury and as an injury management tool rather than resorting only to localized management of the involved joint. This brings rehabilitation back to considering periodization and control from the core to the periphery (Brukner and Khan, 2007; Van Dijk, 2002). Postural control or kinetic control has been suggested as fundamental to neuromusculoskeletal rehabilitation, by different authors (O'Sullivan et al, 1997; Motram and Comerford, 1998). This refers to gaining control over the base of movement and then the peripheral joints. When one considers normal biomechanics of forward motion, each joint in the lower limb kinetic chain must be intact and translation movement controlled. When there is an abnormality anywhere in the chain it will have to be compensated for somewhere else in the chain (O'Sullivan et al, 1997; Motram and Comerford, 1998). There are basic control and adaptation mechanisms with balance training leading to neurophysiological adaptations and improved motor control. Emphasis is placed on the plasticity of the sensorimotor system relating to spinal and supraspinal structures which improve motor performance especially muscle power (Taube et al, 2008).

Traditional believes were that with acute ankle injury there was damage to afferent sense receptors with resultant proprioceptive deficits which lead to recurrent giving way of the ankle and slower response time for the peroneus to active to protect the joint (Freeman and Wyke, 1967; Freeman, 1965). The initial model was described in terms of feedback from the articular proprioceptors to the central nervous system. This however does not consider alpha motor neuron pool excitability and feed forward supported by the gamma motor neuron system. It has been showed in the literature that proprioception is affected irrespective of the presence of clinical signs of mechanical instability after any ankle injury (Konradsen et al, 1998). It has also been shown that individuals with chronic ankle instability looses a sense of position and upon ground contact the foot position is not optimal to transfer weight and has a suppressed ability to sense force but despite this one cannot only regard afferent input; the somatosensory and central nervous system effects must also be considered (Hertel, 2008).

In physiotherapy the work of Motram and Comerford, 1998; O'Sullivan et al, 1997; Vleeming, 1997 Richardson and Jull, 1995; Sahrman, 1993 and Panjabi, 1992 suggest that most overuse injuries can be prevented and managed by addressing movement dysfunction locally (at the injured joint) and globally from the core to the periphery. Spinal and supraspinal adaptations have also recently been investigated by Taube, 2008 and Santos and Lui, 2008. Functional control of movement is the use of low force continuous muscle activity in all positions of joint range and in all directions of joint motion. The specific stabilizing muscle is activated locally to control translatory joint motion acting as a support and protector of the joint. This is particularly important in mid-range or the so-called neutral position of the joint where capsular and ligamentous support is minimal and even more so when the primary constraints have been injured as is the case with the mechanically unstable ankle. The second level of control required is through range control and this is supplied by the global stabilizers.

When movement is not controlled by local and global stabilizers it can be described as a movement dysfunction. Poor movement habits or postural control might inhibit the global stability muscles leading to stiffness or shortening of global mobilising musculature because they in turn have to fulfil the role of the stabilizer. This leads to

imbalances in the global stability system with resultant loss of global control leading to what is called “gives” and “restrictions” (Motram and Comerford, 1998). A give is defined as uncontrolled movement in one direction, in the case of the mechanically unstable ankle the resultant increased inversion and calcaneal adduction is seen as a “give” into inversion. A restriction is normally what is found in the opposite direction to maintain a degree of relative stability. In the ankle joint the medial structures will compensate with possible limited calcaneal abduction and ankle eversion. Direction specific mechanical stress and strain of the joint, soft tissue and neural structures will lead to cumulative micro-inflammation (Comerford and Mottram, 1998).

This is often seen in cases of the overpronated or supinated foot where the result is pain and pathology (Hertel, 2002).This leads to a cycle of continued imbalance of the global stability system with further overload of already strained tissues, degenerative changes in the movement system and ultimately motor control deficit of the local stability system. All of the above eventually leads to a higher risk for recurrence. The injured ankle when not managed can have the following changes to compensate for lateral ligament instability; either forming a rigid cavus foot with splinting of muscles to control the instability or overpronation or early pronation in the stance phase of gait. This keeps the lateral structures in a shortened position requiring higher levels of muscular co-activation to compensate for joint laxity to maintain optimal joint alignment (Riemann, 2002). This is where it is seen that any instability cannot be viewed in isolation and that it is often the sum total of a number of injuries resulting in micro trauma that ends in the clinically unstable ankle (Riemann, 2002).

This does not exclude the presence of mechanical instability through trauma, with resultant complete rupture of the ligamentous structure. It just suggests that when the healing process has taken place the functional components have to be addressed before the player returns to competitive participation. (Motram and Comerford 1998; O’Sullivan et al, 1997; Sahrmann, 1993).

Players in this study showed signs of the lack of these components. In certain cases movement dysfunction was obvious as shown by the static Balance Error Scoring System and the dynamic Star Excursion Balance Test that will be discussed in the next section. Management of players at club rugby level should be more holistic. The

club rugby scene forms the base from which provincial players and then the national team are selected so these players should be managed to protect them from injury and to prevent recurrences from their initial injury.

One thing that is clear is that there are certain alterations in feedback and feed forward mechanisms after ankle sprain but it has not been clearly shown if this is merely local to the ligamentous structure or based on spinal or supraspinal effects (Hertel, 2008).

5.7 THE CLINICAL FINDINGS RELATED TO ANKLE INJURY

5.7.1 GEOGRAPHICAL AND DEMOGRAPHICAL DATA

Gauteng Lions Club Rugby consists of 10 clubs covering a vast area from North West Province and Gauteng. These players come from a wide geographical area and from diverse backgrounds. The group includes students, professionals and players from a more physical occupational environment. Experience ranges from players who have played rugby at this level for ten years to players who have only just started playing rugby at club level. It was difficult to group players according to the demographic or geographic data and these influences were not addressed in this study. The clubs have major differences in financial aid, player remuneration, training equipment, playing fields and other resources such as medical professionals available to the club. These can also play a role in predicting the clinical picture. Only two clubs had access to full time physiotherapy management, while four of the clubs had physiotherapists only for strapping and games, and three clubs had no professional medical assistants. The information above was reported on by the contact person at the clubs.

In this sample the average age was 24 but ranged from 16 – 43 years of age. The average is normal for club rugby because the feeding ground for clubs is post-matric players; but the two extremes should be considered. Players of 16 years cannot be mature enough to compete against their older counterparts and the risk of serious injury is possible but was not shown in this study. This is supported by school's rugby

rules limiting the minimum and maximum age of players playing at open level. As players age, their level of fitness and other risks must be considered as they could play a part in injuries (Gabbet, 2004). Player's heights ranged from 156cm to 204cm. The weights ranged from 60kg to 130kg.

5.7.2 PREVALENCE OF INJURIES

Forty six percent of the players included in the study reported injuries elsewhere in the lower quadrant in comparison to 58% who reported ankle injuries. The ankle injuries reported, ranged from a slight sprain to complete ligamentous rupture of the ankle or even fractures. This can partially explain the results of the Balance Error Scoring System where injuries elsewhere must be considered when assessing proprioceptive deficits because the ankle is a component of a whole kinetic chain. It is again a higher prevalence of reported ankle injury compared to injury anywhere else in the lower quadrant, and in comparison to the literature where only 10 – 30% of injuries are reported (Zöch et al, 2003). This perceived prevalence could be higher because it was only a player perceived prevalence and was not supported by the mechanical testing in the study.

A total of 79 players reported an injury of the ankle joint, either previous or current. Ten of the 79 reported bilateral injuries while 38% reported injury of the left and 49% reported right sided injury. This in comparison to the mechanical injury results of 25% left and 19% right although it must be remembered that the questionnaire did not distinguish between different levels of injury and whether or not the mechanical deficit had healed. A true comparison is however not entirely possible because the subjective questionnaire did not specifically refer to grade or severity of injury and an injury could range from a slight sprain to severe ligamentous rupture. The side of injury relates closely to the dominance where the dominant side was reported in 53% of cases as the most injured side. A higher prevalence is reported here for ankle injuries in club rugby players than is reported in the literature for ankle injuries in sport (Zoch et al, 2003; Garric, 1997).

5.7.3 TIMELINES FOR RECOVERY

The literature suggests that optimal healing takes places within four to six weeks from the time of injury with adequate rehabilitation. The experienced clinician should guide the player in his return to sport to ensure maximal strength, proprioception and preparation of sport specific exercises (Brukner and Kahn, 2007; Van Dijk, 2002). Fifty one percent of players felt that they only needed a few days to recover from the injury where 32% reported a few weeks of recovery time. Only 5% of the players observed the recovery time as suggested in the literature (Petty and Moore, 2001). This may be considered as one of the reasons for the recurrence of injury. These players often return to play with niggling injuries because they fear losing their place in the team while they are observing healing time. This is particularly important because players are not contracted, and they are only remunerated for games played and observing recovery time results in a loss of income, this is purely anecdotal in discussion with the coaches and management at the clubs and is only speculative. Therefore they return to play as soon as possible rather than within the medically accepted period. The statistic that raises concern is that 13% of players currently on the field felt that their injury had not recovered sufficiently. This can be a predictor for future injury, chronic ankle instability and an indicator of poor rehabilitation (Hertel, 2008).

In this study 20% reported not having been sidelined after the injury and returned to play, whereas 20% rested for a few days and resumed playing. Forty two percent did not participate for at least four weeks. None of the players contributing to these figures observed the six week period of optimal tissue healing and functional rehabilitation. A total of 18% took a few months before their return to active participation. The questionnaire did not consider the severity of injury but it is evident that certain players returned to play without any form of rehabilitation or injury management, a total of 42% self managed their injuries. The players who returned early mentioned the importance of participation for remuneration; pressure from coaches and teams; and not realizing how serious the injury was. A large percentage

was never properly managed before return to sport and this might have predisposed them to future injury.

Ninety one percent of players returned to a full 80 minutes of play. When considering the previous statistics there are players still hampered by ankle injuries playing a full game of rugby. Three percent were still on the bench following injury and struggling to make a full return to sport in part related to their absence giving opportunity to another player who might then make the position their own or the coach not being happy with the functional status of the player for return to sport. Six percent of players were only involved in forty minutes or one half of the game. Coaches are often reluctant to bring these players back and so use them as impact players in the second half or only for the first half until they've regained full match fitness (Holtzhauzen et al, 2006).

5.7.4 INJURY MANAGEMENT STRATEGIES

Initially 39% of the 79 players who reported injury used medication compared to 29% who were still using medication for ankle pain or swelling at the time of completing the questionnaire . This indicates that there are a lower percentage of players who experienced pain and swelling and still required medication. Twenty three percent of the sample initially used anti-inflammatories but 15% still used anti-inflammatories before or after a game to reduce pain and inflammation. If one considers the number of players who have returned to full participation the use of medication is hardly surprising. This again indicates inadequate healing time and recurrent or persistent inflammatory response due to joint irritation. This is cause for concern because anti-inflammatories mask the body's natural protective pain response. Acute severe pain was managed with painkillers in 13% of the injuries. Four percent experienced pain of chronic nature and still required painkillers. There were 10% who used a combination of painkillers and anti-inflammatories at the time of the study. This may mean that a player is using medication to decrease his pain to be able to participate with possible resultant re-injury because the body's natural protection mechanism namely pain is subdued. These players will probably be labeled the 'difficult ankle' group who

reports persistent pain and discomfort, because they are constantly causing more irritation to already injured structures (Petty and Moore, 2001).

The players who were still using medication to manage their condition should be assessed by an experienced clinician and sooner rather than later a management plan needs to be instituted. The players will require management of pain and inflammation before the rehabilitation process is started. The benefits of rehabilitation have been shown in the literature to reduce pain, manage instability and prevent recurrence (Van Dijk, 2002). The gold standard for management if proper rehabilitation of the ankle injury has failed is the use of radio isotopic bone scan. This can be used to determine injury which is hard to clinically confirm with diagnostic tests including stress fracture, avascular necrosis or tendon avulsion. More recently arthroscopic investigations have also been suggested and once it has been confirmed further management can be instituted (Brukner and Khan, 2007; Kerkhoffs et al, 2007).

A high percentage of players, 42%, self-managed their injury with no intervention from any medical practitioner. This could be one of the reasons why healing time and guidelines for return to sport were not observed. A high percentage, 44%, had at some stage been assessed and managed by a physiotherapist. This possibly indicates the failure of physiotherapy as a management strategy, non-compliance of players to suggested intervention or inadequate rehabilitation due to financial constraints. The results here also suggest that symptomatic treatment leads to a quick decrease in pain and the inflammatory response but full rehabilitation is rarely completed before return to sport because from the player's perspective recovery has taken place. From an intervention perspective proper rehabilitation requires injury management of six weeks and then rehabilitation and periodization before return to sport is possible (Brukner and Khan, 2007). This might explain the high failure rate of conservative intervention. What was also not established in this study was the type of physiotherapy and management done. The literature does however suggest that physiotherapists adhere to the clinical guidelines for management and intervention in the application of an ankle injury management plan (Van der Wees et al, 2007) Only a few of the players presented to general practitioners, orthopaedic surgeons, podiatrists or biokineticists.

The question arises when regarding post-injury and management outcomes whether they were fully rehabilitated and how many of these players fulfilled the *'back to sport criteria'* before returning to games and full sport participation. There should be a good relationship between player, coach and clinician to manage a player successfully. The player must be informed with regards to the injury, the time required to heal, the rehabilitation required and self-management strategies in the acute phase. For physiotherapy to succeed the physiotherapist must contract with the player and the coach and a conservative approach tend to yield much better outcomes (Van Dijk, 2002). Physiotherapy is still the primary intervention and the challenge for physiotherapists is to address all components of the neuro-musculoskeletal system and manage these players properly. A suggested post-injury management plan is included in Appendix F based on the literature review.

When this study was initiated an objective, quantifiable measure was required to determine the integrity of the lateral ligament of the ankle. The gold standard for this is stress view radiography (Stiell, 1995). Due to ethical considerations this was not possible and comparing previous investigations was not useful because only 30 % of injured players had x-rays done. The low percentage of investigations done could be related to the use of a set of guidelines, the OTTAWA-ankle rules which was discussed in the literature review (Stiell et al, 1995). Stress views are not indicated in the acute setting and most players have only had a standard x-ray to rule out any bony pathology. Two players had MRI-scans performed and three had CT-scanning to assist in making a diagnosis. All the above investigations are only a diagnostic tool and once a fracture is excluded injury management should be instituted based on the findings of diligent clinical examination.

5.7.5 EFFECT OF INJURY

Although 47% of the sample reported that the injury had no effect on their performance; speed, power and agility were affected singly or in combinations in 53% of the players. These players are the ones who could be predisposed to future injury and may not always be able to compete at their pre-injury level. When an injury hampers the speed, agility or power of players they cannot perform well. Since club

rugby is seen as the breeding ground for provincial and national players these players require top level performances to be able to step up a level. The challenge for the physiotherapist managing ankle injuries is to regain peak performance levels in the club rugby player (Van Dijk, 2002). This means addressing the whole kinetic chain from the local injury to postural control to create a stable base for movement (Mottram and Comerford, 1998; O Sullivan et al 1997.

5.7.6 ODDS RATIOS RELATING TO THE CLINICAL FINDINGS OF THE OLERUD AND MOLANDER QUESTIONNAIRE

There were significant p-values noted for the following categories of the Olerud and Molander questionnaire: pain, stiffness, swelling, stairs, and the use of supports and the effect on activities of daily living. The players with previous ankle injury have a greater risk of experiencing any of these clinical signs at any given point in time.

Pain is a known inhibitor for muscle function and control and can therefore suppress the protective mechanism of the ankle (Hertel, 2008). The presence of swelling has been documented as one of the reasons for the suppression of proprioceptive, afferent input (Konradson en al, 1998). Stiffness forces the change into foot positioning during ground contact which again predisposes to further injury. All of the above signs and symptoms underline the fact that the presence of a previous injury to the ankle irrespective of cause or severity can influence or predispose the athlete or rugby player to future injury as suggested by the use of self-reporting (Steffen et al, 2008).

When considering functional activities the players with clinical signs of ankle instability will struggle to climb stairs and the injury will affect their daily lives and lead to the use of taping and bracing to enhance stability around the ankle for functional activities and return to sport.

5.7.7 PERFORMANCE DEFICITS AS INDICATED BY THE STAR EXCURSION BALANCE TEST

There were only marginally significant changes for the Star Excursion balance test for players with clinical signs of mechanical instability compared to players with no clinical signs of mechanical instability and this only for the left leg. When players with self-reported previous injury were compared to those with no previous injury the results were pretty similar.

These results again underline that performance deficits in the lower limb cannot be attributed to a single joint and that the coordinated function of the whole lower kinetic chain needs to be intact. Obvious contributions have been seen from the proximal joints in the chain and it cannot be said that the afferent local receptors are the only contributors because of central neuromuscular effects (Hertel, 2008; Gribble et al, 2004; Bullock-Saxton, 1994)

5.7.8 CONCLUSION

Players at club level in the South Gauteng region present with three main problems singly or in combination:

- Perceived clinical signs and symptoms of lateral ankle instability
- Clinical signs of mechanical ankle instability
- Clinical signs of functional ankle instability in the presence of absence of ankle injury whether reported on or of mechanical nature.

5.8 CLINICAL RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

5.8.1 CLINICAL RECOMMENDATIONS

Considering the results of this study and the clinical picture derived from the results, a clinical recommendation is to develop a standardized, comprehensive management plan that could improve post-injury results and lead to graduated return to sport for these athletes. In addition the compilation of a pre-season screening tool to detect biomechanical abnormalities and postural control deficits should be considered.

Each club was informed of the status of the players tested and based on the literature review suggestions were made and given to the club's sports physician for further management to be instituted.

5.8.2 SUGGESTIONS FOR FUTURE RESEARCH

Based on the investigations done in this study the development of a pre-season screening tool can be advocated using tests as used in this study. This can be used to determine predisposing factors for recurrent injuries or to determine current injury status. Future studies could look at implementing the screening tool and using data to set up a management plan for these players.

In this study it has been shown that there is a high prevalence of ankle injuries in Club Rugby players and this re-iterates the importance of the development of a holistic management plan to reduce and control ankle injuries in Club Rugby players. Future research might include setting up a relevant plan, implementing this plan and then testing the prevalence thereafter with the idea to reduce perceived, mechanical and functional parameters of lateral ankle instability.

5.9 LIMITATIONS OF THIS STUDY

The lack of a sedentary control group to make comparisons between rugby players and non-sportsmen was a limitation of this study and can be considered in future studies.

The balance tests used, namely the SEBT and BESS are both subjective tests but again effective, valid and reliable data have been produced and thus supported the use of these tests in the study. A further limitation of the use of the balance tests is that they are not localized only to the ankle and will be influenced by injury anywhere in the kinetic chain.

This study was limited by the ethical considerations and indications for x-rays which are the gold standard investigations to confirm the mechanical integrity of the lateral ligament of the ankle. However diligent clinical assessment has been advocated in the literature as effective, reliable and valid to determine lateral ankle ligament integrity after an injury.

CHAPTER 6

6. CONCLUSION

The aims of this study were to determine the prevalence of clinical signs of ankle instability for perceived, mechanical and functional factors of stability and to relate the clinical findings of ankle injuries in club rugby players in South Gauteng.

In answer to the objectives the following can be concluded:

The prevalence of clinical signs of perceived ankle instability in club rugby players in Gauteng was derived from the Olerud and Molander questionnaire and is 47%; from players self-assessment 58% reported an injury to the ankle in their lives. These are higher than figures reported in the literature.

The prevalence of clinical signs of mechanical ankle instability irrespective of laterality is 44% and is slightly higher than figures reported in the literature. There are significant differences between those with and those without reported previous injury.

The prevalence of clinical signs of functional ankle instability for the Balance Error Scoring System ranged from 44.8% to 93.8%, the great difference here is due to the different stance surfaces and difficulty in performing the tests. This is suggestive of the fact that postural control rather than functional ankle instability could be the precursor of injury or re-injury. There were no really significant differences for the comparison of the group with reported injury to the ankle to those with no report of previous ankle injury.

The prevalence of concurrent clinical signs of mechanical and functional instability did not yield significant results. This supported the notion that mechanical instability is not necessarily a precursor for functional instability but possibly the effect of decreased postural control that might predispose to injury. There were also only

clinically significant differences between the group with mention of previous injury and the one where no previous injury to the ankle was reported for players with an existing clinical signs of mechanical instability.

Odds-ratios to elucidate the presence of previous ankle injury as a risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire revealed between a four to nine times likelihood for a person with previous ankle injury to experience pain, stiffness, swelling and difficulty with climbing stairs and requiring the use of some support for the ankle.

The clinical findings related to ankle injuries in club rugby players can be summarized as a single component or combination of factors including perceived, mechanical and functional signs of instability.

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APPENDIX A.1: DATA QUESTIONNAIRE USED IN THE PILOT STUDY

NAME:	**AGE:**
WEIGHT:	**HEIGHT:**
OCCUPATION:	**POSITION:**
YEARS PLAYED AT THIS LEVEL:	**1 2 5 10**
PREVIOUS INJURY IN THE LOWER BODY QUADRANT OTHER THAN ANKLE : (IF YES STATE AREA OF INJURY) **N0 YES**	**LOWER BACK HIP KNEE ANKLE HAMSTRING QUADRICEPS CALF MUSCLE PELVIS**
PREVIOUS ANKLE INJURY: **YES NO**	**SIDE OF INJURY: (ankle)** **RIGHT LEFT**
SITE OF INJURY: (ankle) **DOMINANT NON-DOMINANT**	**TIME SIDELINED BY INJURY: (ankle)** **DAYS WEEKS MONTHS**
CURRENT USE OF MEDICATION: (for your ankle) **ANTI-INFLAMMATORY PAINKILLER**	**MEDICATION REQUIRED DURING PERIOD OF INJURY:(ankle)** **ANTI-INFLAMMATORY PAINKILLER**
IF USING MEDICATION INDICATE WHEN (for your ankle): **BEFORE GAME DURING GAME AFTER GAME**	**DATE OF INJURY: (ankle)**
TIME TAKEN TO RECOVER: (ankle) **WEEK MONTH SEASON NEVER FULLY RECOVERED**	**REHABILITATION: (ankle)** **NONE PHYSIO BIOKINETICS**
HOW HAS THE ANKLE INJURY AFFECTED YOUR PERFOMANCE? **DECREASED :** **SPEED POWER AGILITY**	**SINCE THE INJURY HOW MUCH TIME DO U SPEND IN THE GAME?** **FULL (80 mins) BENCH** **HALF (40 mins)**
PREVIOUS SURGERY TO ANKLE	**YES NO**

APPENDIX A.2: DATA QUESTIONNAIRE

NAME:	**AGE:**
WEIGHT:	**HEIGHT:**
OCCUPATION:	**POSITION PLAYED:**
YEARS PLAYED AT THIS LEVEL: 1 □ 2 □ 5 □ 10 □	**PREVIOUS SURGERY TO THE ANKLE?** YES □ NO □
FLU, HEAD COLD OR EAR INFECTION: (Currently) NO □ YES □	**RECENT CONCUSSION:** (Sidelining you from the game within 1 month) NO □ YES □
PREVIOUS INJURY IN THE LOWER BODY QUADRANT OTHER THAN ANKLE : (Last 3 months sidelining you from the game) (IF YES STATE AREA OF INJURY) N0 □ YES □	**AREA OF INJURY**: LOWER BACK □ HIP □ KNEE□ ANKLE □ HAMSTRING □ QUADRICEPS □ CALF MUSCLE □ PELVIS □
PREVIOUS ANKLE INJURY: YES □ NO □	**DATE OF INJURY:** _____
SIDE OF INJURY: RIGHT □ LEFT □	**SITE OF INJURY:** DOMINANT □ NON-DOMINANT □
TIME SIDELINED BY INJURY: DAYS□ WEEKS □ MONTHS□	**MEDICATION REQUIRED DURING PERIOD OF INJURY:** NONE □ ANTI- INFLAMMATORY □ PAINKILLER □
CURRENT USE OF MEDICATION: NONE □ ANTI-INFLAMMATORY □ PAINKILLER □	**WHEN DO YOU USE MEDICATION:** NEVER □ PRIOR TO GAME □ AFTER GAME □ DAILY FOR CHRONIC PAIN □
TIME TAKEN TO RECOVER: WEEK □ MONTH □ SEASON□ NEVER FULLY RECOVERED □	**INJURY MANAGEMENT:** SELF □ PHYSIOTHERAPIST □ ORTHOPAEDIC SURGEON □ BIOKINETICS □ PODIATRIST □
INVESTIGATIONS REQUIRED: X-RAYS □ULTRASOUND □ MRI □ CT-SCAN □	**HOW HAS THE ANKLE INJURY AFFECTED YOUR GAME?** DECREASED : SPEED □ POWER□ AGILITY□
HOW MUCH TIME DO YOU SPEND ON THE FIELD? FULL □ BENCH □ HALF □	THANK YOU FOR COMPLETING THE QUESTIONNAIRE!

APPENDIX B.1: OLERUD AND MOLANDER QUESTIONNAIRE

Please indicate if you experience any of the following signs or symptoms and tick to the appropriate degree

PARAMETER	DEGREE	TICK
1. PAIN	NONE	25
	WALKING ON UNEVEN SURFACES	20
	WALKING ON EVEN SURFACES	10
	WALKING INDOORS	5
	CONSTANT AND SEVERE	0
2. STIFFNESS	NONE	10
	STIFFNESS	0
3. SWELLING	NONE	10
	ONLY EVENINGS	5
	CONSTANT	0
4. STAIRS	NO PROBLEMS	10
	IMPAIRED	5
	IMPOSSIBLE	0
5. RUNNING	POSSIBLE	5
	IMPOSSIBLE	0
6. JUMPING	POSSIBLE	5
	IMPOSSIBLE	0
7. SQUATTING	NO PROBLEM	5
	IMPOSSIBLE	0
8. SUPPORTS	NONE	10
	TAPING / STRAPPING	5
	STICK / CRUTCH	0
9. DAILY LIFE	SAME AS BEFORE INJURY	20
	LOSS OF TEMPO	15
	CHANGE OF OCCUPATION DUE TO INJURY	10
	SEVERELY IMPAIRED WORK CAPACITY	5

(Rose, Lee, et al, 2000)

The Olerud and Molander questionnaire were scored as follows. Each player would be able to get a score of 100 if there were no problems identified relating to ankle injury. The final column of the Olerud and Molander is not included in the questionnaire handed out to players and in Appendix B.2 there is an example of a questionnaire as completed by one of the players where after the scoring was done.

APPENDIX B.2 EXAMPLE OF COMPLETED QUESTIONNAIRE

APPENDIX C: INFORMATION AND INFORMED CONSENT LETTER

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

Dear _____

I am Eloize Mellet, a Masters student in the Department of Physiotherapy at the University of the Witwatersrand and I'm investigating the prevalence of ankle instability of club rugby players in the South Gauteng region.

Research in other sports has indicated that ankle injury is one of the most common injuries in the sporting fraternity with a very high recurrence rate. Clinically it has been evident that rugby players are also at risk and often experiences instability or giving way of the ankle. Your cooperation in this study will help us to establish how real a problem this is.

What is expected from you?

Your club falls within the South Gauteng region and has given us permission to continue with the study. You are invited to complete the questionnaires that will be handed out. The first is a general questionnaire to determine whether or not you have had an ankle injury and the extent of the injury will then be further highlighted in the subsequent questions. The first four questions determine your further participation in the study. The second questionnaire is called Olerud and Molander and all questions pertain to your ankle. I will explain the

questionnaires and how to go about your answers. Your ligaments will then be tested with two tests to determine if they are intact. Balance will also be assessed. The testing procedures will take approximately a half an hour to complete.

There is no obvious chance of danger or injury to you through the testing procedures and you may decide at any time to withdraw from the study. All information will be kept strictly confidential and your anonymity is assured.

You will not directly or immediately benefit from this study but it is my hope that the evidence gained will be used to set up a pre-season screening protocol (including the tests performed in the study) to avoid recurrent ankle injuries which leads to instability.

If you have any queries they can be forwarded to Eloize Mellet at contact number 082 321 7739.

If you are happy to participate in the study and for data obtained to be used in this research product please sign the attached consent form. If you decide not to participate be assured that you will not be prejudiced in any way.

With thanks

Eloize Mellet

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

CONSENT FORM

I, _____ AGREE TO PARTICIPATE IN THE STUDY AND ALLOW THE RESEARCHER TO USE DATA OBTAINED THROUGH THE QUESTIONNAIRE AND TESTING PROCEDURES. I HAVE READ THE INFORMATION SHEET AND I AM SATISFIED THAT THERE ARE NO DANGERS INVOLVED IN THE STUDY. I UNDERSTAND THAT DETAILS OF MY RESULTS WILL BE CONFIDENTIAL AND THAT I WILL NOT BE PREJUDICED IN ANY WAY.

NAME: _____

SIGNATURE: _____

DATE: _____

APPENDIX D: LETTERS OF CONSENT TO SOUTH AFRICAN RUGBY UNION, GAUTENG LIONS RUGBY UNION AND CLUBS

10/03/2007

THE SOUTH AFRICAN RUGBY FOOTBALL UNION

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and I would like to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from SARU and would appreciate it if you could complete and sign this letter.

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research on behalf of SARU.

Name: _____

Date: _____

Signature: _____

10/03/2007

THE GAUTENG LIONS RUGBY UNION

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and I would like to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from GLRU and would appreciate it if you could complete and sign this letter.

With thanks

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research on behalf of GLRU.

Name: _____

Date: _____

Signature: _____

28-06-2006

_____

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and have selected to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from the management of your club and would appreciate it if you could complete and sign this letter. I have obtained consent from SARU and GLRU to conduct this study.

Included with this letter you will find the suggested protocol, which explains the aims and objectives of the study.

I will contact you to determine what will be a suitable time for the research to be conducted if you agree to it.

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research; on behalf of the club.

Name: _____

Date: _____

Signature: _____

APPENDIX E: ETHICAL CLEARANCE FORM

APPENDIX F: SUGGESTED MANAGEMENT PLAN

1. Sound clinical assessment
2. Instituting anti-inflammatory measures to reduce pain, swelling and inflammation in the acute phase; including ultrasound, cryo- and heat therapy and interferential.
3. Once the acute phase has been observed active painfree motion should be initiated to regain and maintain normal range of motion. Healing tissue must be protected in this stage either limiting weight bearing or using external supports
4. Once the initial phases of healing has been observed rehabilitation must start including:
    a. Range of motion exercises to regain range of motion and maintain available ranges
    b. Strength training
    c. Localized stabilisation exercises
    d. Global postural control
    e. Balance and proprioception
5. Return to sport rehabilitation will include sport specific drills, change of direction-control and plyometrics.

(Based on management as suggested in: Ergen and Ulkar, 2008; Sankey et al, 2008; Brukner and Khan, 2007; Van der Wees et al, 2007; McGuine and Keene, 2006; Surve et al, 1994)

APPENDIX G: DATA COLLECTION SHEET FOR OBJECTIVE TESTS

NAME	
NUMBER	
LEGLENGTH (L)	**LEGLENGTH ®**
REACH DISTANCE (L) **ANTERIOR** **POSTERIOR** **LEFT** **RIGHT**	**REACH DISTANCE ®** **ANTERIOR** **POSTERIOR** **LEFT** **RIGHT**
STANDING FIRM (EYES OPEN) **BOTH LEGS** **LEFT LEG** **RIGHT LEG**	**STANDING FIRM (EYES CLOSED)** **BOTH LEGS** **LEFT LEG** **RIGHT LEG**
STANDING FOAM (EYES OPEN) **BOTH LEGS** **LEFT LEG** **RIGHT LEG**	**STANDING FOAM (EYES CLOSED)** **BOTH LEGS** **LEFT LEG** **RIGHT LEG**
ANTERIOR DRAWER TEST (L)	**ANTERIOR DRAWER TEST ®**
TALAR TILT TEST (L)	**TALAR TILT ®**

APPENDIX H: LETTER TO CLUBS - REPORT BACK ON RESULTS

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

13-05-2009

Dear Madam / Sir

Re: Master's Study – Ankle Injuries in Club Rugby Players

Herewith, I express gratitude for your willingness to participate in the study to determine the prevalence of clinical signs of ankle instability in rugby players at Club Rugby level.

The results of the study have shown that there is a high prevalence of clinical signs of ankle instability in the following categories:

- Perceived instability referring to a player's self evaluation of his ankle function was determined at 47% of players in the South Gauteng region.
- Mechanical instability referring to specific tests for ligament integrity rendered results of 39% of the players in the South Gauteng region with some mechanical deficit
- Functional tests varied for different testing surfaces and the key finding based on this was that players had difficulty with balance and proprioceptive tests and as suspected the more difficult the testing position the more problematic performance of the test was.

Furthermore the likelihood of certain signs being present after ankle injury was determined and the following were the most evident:

- Pain
- Swelling
- Stiffness
- The use of ankle supports: bracing and taping

This is important to note because the players who reported this was after an initial injury and all these factors indicate possible susceptibility to future injury.

There were also signs of insufficient injury management and early return to play which again rendered these players more susceptible to future injury.

I suggest that you share the above with the attending physician or physiotherapist for further management. If you require further assistance in this regard feel free to contact me for advice and treatment suggestions from the latest literature. The study and results are available for your perusal if so required.

Your co-operation and contribution to the study is appreciated.

Yours Sincerely

Eloize Mellet
B.Sc. Physiotherapy (UOFS)

APPENDIX I: PHOTOGRAPHS OF MECHANICAL AND FUNCTIONAL TESTS AS PERFORMED IN THE STUDY

1. THE ANTERIOR DRAWER TEST



PHOTOGRAPH I.1 GONIOMETER USED TO DETERMINE KNEE POSITION AT 40ó OF KNEE FLEXION



PHOTOGRAPH I.2 GONIOMETER USED TO POSITION ANKLE AT 10ó OF PLANTAR FLEXION



PHOTOGRAPH I.3 PERFORMANCE OF THE ANTERIOR DRAWER TEST

2. TALAR TILT TEST

Position for the test is determined as in Photgraph I.1 and I.2 and the test performed as below



PHOTOGRAPH I.4 PERFORMANCE OF THE TALAR TILT TEST

3. THE BALANCE ERROR SCORING SYSTEM



PHOTOGRAPH I.5 EYES OPEN AND CLOSED STANDING ON A FIRM SURFACE



PHOTOGRAPH I.6 EYES OPEN AND CLOSED STANDING ON A FOAM SURFACE

4. THE STAR EXCURSION BALANCE TEST

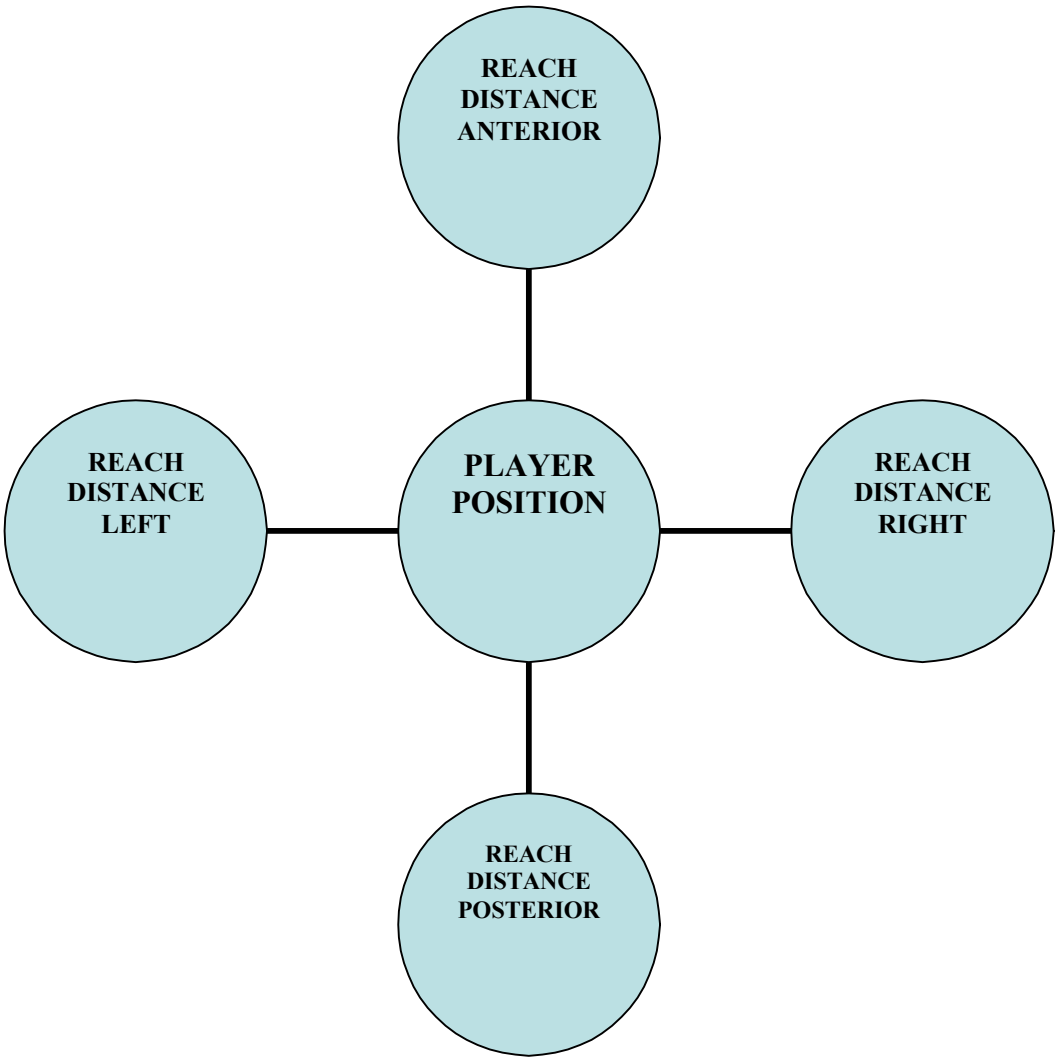


FIGURE I.1 DEPICTING GRID FOR STANCE POSITION

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

Eloize Mellet

A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, in fulfillment of the requirements for the degree of Master of Science in Physiotherapy

Johannesburg, 2009

DECLARATION

I, Eloize Mellet declare that this dissertation is my own work. It is being submitted for the degree of Master of Science in Physiotherapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree of examination at this or any other University

_____

6th day of November 2009

ABSTRACT

INTRODUCTION

Rugby is a high impact sport with many injuries reported in the literature. A high rate of ankle injury is reported with resultant recurrence of these injuries. There is however only scarce epidemiological data with minimal detail to highlight clinical findings and prevalence of ankle injuries especially in the club rugby fraternity.

AIMS

This study investigated the prevalence of clinical signs of ankle injuries in rugby players at club rugby level in the South Gauteng region. The data collected was used to identify the clinical signs related to ankle instability for perceived, mechanical and functional parameters and was applied to determine the difference between players with and those without previous injury.

METHODOLOGY

The researcher obtained ethical clearance to do the study from the Human Research Ethics Committee of the University of the Witwatersrand. Permission was obtained from the Golden Lions Gauteng Rugby Union to use players in the South Gauteng region. One hundred and eighty players from nine clubs in the region participated in the study. Informed consent was obtained from all parties concerned and players were asked to complete a battery of tests.

To determine the prevalence of clinical signs of perceived instability each player was asked to complete a data questionnaire and the Olerud and Molander questionnaire. The data questionnaire also included questions pertaining to the exclusion criteria.

Objective testing was done to determine the clinical signs of mechanical instability of both ankles of each player through mechanical tests; the talar tilt and anterior drawer tests.

Balance and proprioception were assessed through the Star Excursion Balance Test (SEBT) and Balance Error Scoring System (BESS) which is used to indicate clinical signs of functional instability and these tests were used to determine the prevalence of clinical signs of functional instability and to relate the clinical signs of functional instability to the other clinical findings.

RESULTS

The prevalence of ankle injuries at club rugby level is discussed for the different parameters of instability. The prevalence of clinical signs of perceived instability based on the Olerud and Molander questionnaire is 47%, as reported by the player and is further described in a sub-analysis of perceived problems. The prevalence of clinical signs of mechanical ankle instability, when laterality is ignored is 38.7%. The prevalence of clinical signs of functional ankle instability depends on the surface and the visual input and is greater as the challenge or protuberance increases in difficulty. The clinical signs of perceived, mechanical and functional ankle instability are further described and related to other clinical findings for two groups, namely those with and those without previous injury to the ankle and as expected clinically significant differences were noted with the players with previous injury recording a higher prevalence for perceived and mechanical parameters. The odds ratios for the presence of certain clinical signs revealed significant p-values for the presence of pain, stiffness and swelling and the need for supports e.g. bracing or taping and the affect on activities of daily living.

DISCUSSION

In this study there is a high prevalence of clinical signs of ankle instability in club rugby players for perceived, mechanical and functional parameters, compared to the prevalence reported in the literature. From the study the clinical findings associated

with the presentation of ankle injuries in club rugby players have been established and related to the perceived, mechanical and functional signs of instability. Differentiation between players with reported ankle injury and those without were also done and significant differences were noted between the two groups for perceived and mechanical parameters but where the functional assessment was done it supported the fact that balance and proprioception tests included the whole kinetic chain and does not view the ankle in isolation. It was evident that previously injured players were more likely to sustain future injury to the ankle and odds-ratios to support this showed an increased risk of the presence of swelling, stiffness and pain for players with previous injury and the greater need for the use of supports and influence on activities of daily life.

The information gathered can be used in the future to set up a management plan for pre-season screening, assessing and addressing individual predisposing biomechanical factors, managing acute injuries successfully and rehabilitation in the post-season phase.

ACKNOWLEDGEMENTS

- Prof AV Stewart
- Dr P Becker – Medical Research Council – Pretoria
- The Gauteng Lions Rugby Union (Mr W Moolman)
- Players and officials of the rugby clubs in the South Gauteng region that were involved in the study
- Michael Mabasa and Joanne Sklaar – M. Sc. Physiotherapy
- Howard Alexander - Podiatrist

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CHAPTER 1

1. INTRODUCTION

1.1 INTRODUCTION TO THE CONCEPTS

Ankle injuries are sustained regularly in the sporting population (Ergen and Ulkar, 2008; Samuel and Obehi, 2008). Lateral ankle injuries are among the most common injuries sustained, making up 10 – 30 % of all sports injuries (Zoch et al, 2003). Eighty five percent of these injuries involve the lateral ligament complex and in the most part are due to an inversion sprain (Tropp et al, 1985). The anterior talofibular ligament is an extension of the joint capsule and is a long, thin ligament which renders it susceptible to injury (Hunter and Fortune, 2000).

There are many different sporting codes with different movements and levels of control required at the ankle joint. Both a high prevalence and a high incidence of ankle injuries have been reported in various sporting codes (Trojian and McKeag, 1998; Fong et al, 2007; Hootman et al, 2007).

An 80% recurrence rate of ankle injuries has been reported (Smith and Reischl, 1986; Denegar and Miller, 2002). Twenty percent of patients with acute ligament sprain will complain of residual symptoms after the observation of normal healing time for the mechanical insult to the tissue, which will predispose them to future injury. This can be attributed to continued joint dysfunction, pre-existing anatomical and biomechanical factors or inadequate rehabilitation (Denegar and Miller, 2002; Aiken et al, 2008; Sankey et al, 2008; Liu and Jason, 1994; Mohammadi, 2007)

Pre-season screening is becoming a requirement to managing sporting teams and examinations are performed not only to asses the match fitness of a player,

but also to establish the presence of biomechanical abnormalities which might predispose a player to injury. The use of a standard set of tests to determine ankle stability and then addressing components at risk including range of motion, strength and proprioception may lead to a decrease in the incidence or recurrence of injury (Lui and Jason, 1994). In order to consider what tests can be used the different levels of ankle instability which forms a continuum needs to be considered: mechanical (*disruption of the integrity of the ligamentous supports)*, functional *(increased range of motion of the joint not exceeding the physiological constraints)* and chronic *(the acutely injured ankle that has been poorly managed and where reinjury occurs regularly with the presence of mechanical and/ or functional factors)* ankle instability.

Very little evidence in the literature related to anatomical and biomechanical factors predicting re-injury or predisposing an athlete to injury is available (Morrison and Kaminski, 2007; Denegar and Miller, 2002). Based on the anatomical and biomechanical models, the ankle joint is stabilized by joint orientation, ligamentous restraints and muscular contraction which are controlled by the central nervous system, through the peripheral nerves. Insult to any one of these components can lead to ankle injury. When there are abnormalities in the biomechanics, such as cavovarus, increased foot width and increased calcaneal eversion, it is speculated that the ankle is more susceptible to injury (Morrison and Kaminski, 2007).

Three different kinds of testing of ankle instability are reported in the literature namely: perceived, mechanical and functional tests to determine stability (Denegar and Miller, 2002; Nyska et al, 2003; Susco et al, 2004; Olmsted et al, 2002; Trojian and McKeag, 1998). Perceived ankle instability is the subjective self-evaluation of the player with regards to ankle function and is established by using questionnaires (Olerud and Molander, 1984). Mechanical instability, is the increase in accessory movement (arthrokinematic motion that cannot voluntarily be produced e.g. the glide and roll of the talus in the mortise) which translates into an enlarged neutral zone (Panjabi, 1992). The neutral zone can be defined as the area of minimal internal resistance to joint excursion, supplied by collagen tissue. Mechanical instability is usually the result of a tear or

lengthening of one of the ligamentous structures supporting the joint. Residual mechanical instability suggests a non-optimal healing process, which in turn could lead to functional ankle instability (Denegar and Miller, 2002). Functional ankle instability together with mechanical instability are the precursors to chronic ankle instability which is caused by recurrent disruptions of the ankle integrity with resultant perceived and observed instability or a combination of these (Denegar and Miller, 2002). A recent definition of functional ankle instability is the occurrence of recurrent injuries and the sensation of joint instability due to the contribution of proprioceptive, neuromuscular and postural control deficits (Hertel, 2002). It is suggested that functional instability can be present without any mechanical deficits (Gribble et al, 2004).

With the high incidence, prevalence and recurrence of ankle injuries it has been reported that even though the mechanical integrity of the ligamentous structures are accounted for athletes are vulnerable to re-injury and this is classified as functional ankle instability referring to joint motion beyond voluntary control but within physiological constraints, again referring to larger excursion greater than the neutral zone with or without mechanical deficits (Tropp, 1986). The continuum of stability leads to the intermittent feeling of giving way, difficulty to perform on uneven surfaces with resultant mental and physical distrust of the integrity of the ankle (De Norhona et al, 2008; Denegar and Miller, 2002).

Due to the advent of professionalism in rugby in 1995 a higher incidence of injury than in other team sports has been reported (Brooks and Kemp, 2008). In rugby, the greatest proportion of injuries happen during match play and the most prominent mechanisms of injury are related to the tackle. Sites that are at risk are the shoulder, knee, thigh, ankle and head. The most common injury type is ligamentous sprain (Holtzhausen et al, 2006). Ankle injuries in rugby players have been reported as one of the most common injuries and combined with Achilles tendon injuries account for more than half of the absences due to injury (Sankey et al, 2008). The incidence rate for all injuries in rugby union during a Super 12 rugby season is 55.4 per 1000 game play hours (Holtzhausen et al, 2006). There are no data available on time lost due to ankle injuries in rugby players but in soccer 12% of lost time is secondary to ankle injuries and ankle

sprains account for 10 – 15% of all time lost due to injury in professional, college and high school football (DiGiovanni et al, 2004; Trojian and McKeag, 1998; Garric, 1997). In a collegiate study ankle injuries account for 15% of all injuries sustained across the spectrum of all the sports assessed (Hootman et al, 2007).

Very little is known about the epidemiology of ankle injuries. It has been suggested that studies be done to investigate the risk factors for specific high-risk injuries and to assess the effects of discrete prevention strategies in rugby union (Brooks and Kemp, 2008). Valuable information can be extracted from such studies, because to be successful in the modern sporting arena, peak physical conditioning is required and can only be achieved if there are no mechanical or functional deficits in the kinetic chain, or if these deficits can be compensated for, through rehabilitation (Motram and Comerford, 1998). In contact sports such as rugby, demands on the ankle include rapid acceleration and deceleration and explosive changes in direction, as well as the ballistic impact of jumping and landing (Woods et al, 2003). More contact (69%) than non-contact (31%) injuries have been described in the literature. The tackle causes the most contact injuries explaining 62% of all contact injuries (Woods et al, 2003). Once an injury is sustained the management determine the outcomes (Zoch et al, 2003; Van Dijk, 2002)

Management of ankle injuries should include acute treatment to reduce pain and swelling and the observation of healing time but most importantly correct rehabilitation (Kawaguchi, 1999; De Norhona et al, 2008). Rehabilitation by a physiotherapist has been shown to be effective in reducing the risk of future injury (Arnold and Dogherty, 2004). A holistic approach should include exercises to gain and maintain range of motion and strength retraining as well as enhancement of motor control through the feed forward mechanism of proprioceptive retraining. The “Kinetic Control” model includes four phases, namely motor control including core or local stability and global stability; core strengthening and traditional strengthening with the focus on functionality and performance stability (Motram and Comerford, 1998; Zöch et al, 2003). Lastly

sport specific drills must precede graduated return to sport (Mattacola and Dwyer, 2002).

1.2 SIGNIFICANCE OF THE STUDY

This study sets out to establish a prevalence of ankle injuries in Club Rugby players and to describe clinical factors relating to ankle injuries. The information derived from this study will serve to assist in setting up an assessment protocols and management strategies to effectively manage these injuries in the future. It will also make the rugby fraternity aware of the prevalence of these injuries and what effect it has on the players.

1.3 PROBLEM STATEMENT

There is no specific literature reporting on the prevalence of ankle injuries in Club Rugby players and comparisons between injured and uninjured players. There is also not literature supporting clinical findings related to ankle injuries in this specific group. Even though reports on incidence and prevalence of ankle injuries in sport have been done in the past limited information is available in the South African setting. The other factor that is evident is that injury can lead to recurrence which sets up the continuum for chronic ankle instability. Identifying risk factors for injury and implementing preventative measures is becoming increasingly important for the professional sportsman.

1.3 RESEARCH QUESTIONS

- What is the prevalence of positive clinical signs for perceived, mechanical and functional instability in club rugby players in South Gauteng?

- Is there a difference in prevalence between those with and those without previous injury to the ankle?

- What are the clinical findings related to ankle instability in these players?

1.4 AIMS

The aims of the study are:

- To determine the prevalence of ankle injuries at club rugby level in South Gauteng in terms of positive clinical signs of perceived, mechanical and functional ankle instability and establish the difference in prevalence if there is any between those with previous injury and those with no previous injury.

- To describe findings relating to the clinical presentation of ankle instability of these players

1.5 OBJECTIVES

To establish:

- The prevalence of clinical signs of perceived ankle instability and perceived functional limitations in club rugby players.

- The prevalence of positive clinical signs of mechanical instability of the ankle in club rugby players.

- The prevalence of positive clinical signs of functional instability in club rugby players

- The prevalence of concurrent positive clinical signs of mechanical and functional instability in club rugby players

- To compare positive clinical signs of mechanical and functional ankle instability in players with and those without previous injury

- To describe the clinical findings for club rugby players with positive clinical signs and symptoms of ankle instability

(Perceived parameters are those that the subject subjectively observes and interprets. Objective parameters are those measured by the researcher and based on objective tests for mechanical and functional instability)

CHAPTER 2

2. LITERATURE REVIEW

2.1 INTRODUCTION

This review encompasses literature found in the fields of physiotherapy, orthopaedics, podiatry, biokinetics and general sports medicine. This discussion will include an array of definitions used throughout the text relating to ankle injury and stability; a summary of injury frequency including prevalence and incidence of injury reported in a sedentary population, sporting population and specifically in rugby; a summary of the functional anatomy of the ankle including the joints and surrounding structures referring to normal and abnormal biomechanics, injuries, outcome measures used to evaluate the ankle and the latest research done on sporting injuries focussing on rugby and concentrating on ankle injuries.

2.2 INJURY FREQUENCY - DEFINITION

Injury frequency is a measurement used in statistics and describes the epidemiology of injury or disease occurrence. It describes the total number of affected subjects within a group of which the total population number is known, e.g. all the club rugby players in the South Gauteng region. This number reflects the risk of 'disease' or injury for the specific group. This is used to compare results with other groups with similar features e.g. players from different regions or in different sporting codes. The two depictions for injury frequency are prevalence and incidence (Portney and Watkins, 2000).

Supporting the use of prevalence rather than incidence stems from the definitions used in the literature:

Prevalence is defined as the proportion reflecting the number of existing cases of a disorder relative to the total population at a given point in time. This indicates the probability that the particular disorder is present in an individual at a specific moment in time. A simple calculation is:
The number of existing cases of a disease at a given point in time / the total population at risk. In this study it will refer to the total number of rugby players with ankle injury at the specific time (point) of testing (Portney and Watkins, 2000).

Incidence on the other hand refers to the number of new case of a disorder in a population during a specified time period. If used this would refer to all the new cases of ankle injury sustained during a time period e.g. a rugby season (Portney and Watkins, 2000).

2.2.1 ANKLE INJURY FREQUENCY IN DIFFERENT POPULATIONS

2.2.1.1 SPORTING POPULATION

Ankle injuries are commonly sustained whether in a normal sedentary population but even more so in sporting populations. Ankle injuries in the non-sporting population are not very well researched and a search of the literature did not reveal any isolated studies on the topic, only referring to patients presenting to an accident and emergency unit with ankle injury. In most cases these were still related to sport or activity and did not identify the level at which the sport is played (Aiken et al, 2008; Fong et al, 2008). It has been reported that 10 – 30% of all sporting injuries are ankle injuries (Zöch et al, 2003; Garric 1997).. In a recent study on ankle injuries sustained in sport, 81.3% of these injuries were ligamentous and 10.4% were more serious including fractures (Fong et al, 2008).

The lateral ankle ligament complex is more vulnerable and 85% - 95% of all injuries to the ankle occur at the lateral ligament complex (Tropp et al, 1985;

Geiringer, 1997). The reason for the vulnerable nature of the lateral ligament complex can be found in the fact that the anterior talo-fibular ligament which is only a continuation of the anterior joint capsule is actually a very long and thin ligament which renders it susceptible to injury (Hunter and Fortune, 2000). Ankle sprain is the major injury to the ankle in 33 sporting codes out of a total of 43 investigated and the ankle is only second to the knee as the most common site of injury (irrespective of the nature of the injury) sustained in 24 out of 70 sports assessed (Fong et al, 2007). Fifteen percent of all injuries in collegiate sports were ankle ligament injuries and this was the most common injury over all sports (Hootman et al, 2007). The incidence of ankle injury is particularly high in court games and team sports such as rugby, soccer and volleyball (Fong et al, 2007). A study on high school athletes in different sporting codes relating to ankle injuries reported ankle injuries at 22.6% of all high school sport injuries sustained (Nelson et al, 2007). There was no mention made of the mechanical tests implemented in these studies to determine ankle injury.

Table 2.1 below include figures that indicate the frequency rate of lateral ankle injuries in the different sporting codes.

Table 2.1 ANKLE INJURY FREQUENCIES IN DIFFERENT SPORTING CODES

SPORTING CODE	INJURY FREQUENCY	LEVEL PLAYED	REFERENCE
Basketball	37.4% - *incidence*	Not specified	Fong et al, 200
Soccer	31.7% - *incidence*	Not specified	Fong et al, 200
Hiking	5.8% - *incidence*	Not specified	Fong et al, 200
Soccer	18.75 per 1000 athletic exposure – *rate of injury*	Collegiate level	Agel et al, 200
Spring football	1.34 per 1000 athletic exposures – *rate of injury*	Collegiate level	Hootman et al,
Basketball – men	1.30 per 1000 athletic exposures – *rate of injury*	Collegiate level	Hootman et al,
Football	24.1% - *incidence*	High school	Nelson et al, 2
Soccer	33.6% - *incidence*	High school	Nelson et al, 2
Volleyball	10.6% *incidence*	High school	Nelson et al, 2
Basketball	23.8% *incidence*	High school	Nelson et al, 2
	25% - *rate of injury*	Collegiate	Hootman et al,
Boys basketball	7.74/ 10000 athletic exposures – *rate of injury*	High school	Nelson et al, 2
Boys football	6.52 /10000 athletic exposures – *rate of injury*	High school	Nelson et al, 2
Basketball	45% - *rate of injury*	Not specified	Trojian and McKe
Soccer	31% - *rate of injury*	Not specified	Trojian and McKe
Fencing	13% – *rate of injury per athletic exposures*	National	Harmer, 2008
Rugby	13.3% - *rate of injury*	High school	Collins et al , 2008
Basketball – female	1.12 per 1000 athletic exposures – *rate of injury*	Professional	Kofotolis and Kell

2.2.1.2 RUGBY UNION INJURIES

Ankle injuries have been reported on in a spectrum of sports and have been one of the most commonly injured body sites (Nelson et al, 2007; Fong et al, 2007; Mashawari et al, 2003; Dietzen and Topping, 1999). Many sports have the components of the strain imposed on the ankle by the game of rugby, for example basketball has explosive jumps and controlled landing, as with rugby when a player leaps in the line-out or takes a high ball. There is rapid acceleration and deceleration in rugby and the impact of tackles is similar to soccer and American football. Netball and basketball demand rapid acceleration to be able to elude an opponent, leaping into the air for high balls, intercepts or rebounds off the posts after an attempted goal as well as explosive directional changes (Steele and Milburn, 1987). All the above can be compared to the strain imposed on the ankle structures in the rugby player. In rugby explosive power is needed for jumping or initializing a dart, change of direction, and with changing pace during running. Tackles and ground reaction forces impact on landing from jumping or in contact situations. Ankle injuries are especially common where the ankle is exposed to jumping and sidestepping activities (Zöch et al, 2003).

The previous literature on rugby union injuries is made up of epidemiological studies and case reports. Prospective epidemiological studies suggested that ankle injuries account for between eight percent and 20% of all injuries in rugby (Sankey et al, 2008; Brooks et al, 2005; Bathgate et al, 2002). The information from the Super 12 on New Zealand players showed 10% of injuries as ankle injuries (Targett, 1998) and international Australian players at 11% (Bathgate et al, 2002), international players at the 2003 World Cup at 14% (Best et al, 2005) and Scottish district players at 20% (Garraway et al, 2000). It has been suggested that prospective epidemiological studies would be useful to identify injuries, and to subsequently set up management and prevention strategies (Brook and Kemp, 2008). Most of the evidence based literature is focussed on elite professional sportsmen and little is known about the game and its injuries at an amateur level. The comparison from professional international rugby to

club rugby union as an injury per 1000 hours is a ratio of 60 to 40 (Brooks and Kemp, 2008).

Injury profiles have determined that the lower limb is the site most commonly injured with the knee, thigh and ankle being named as the 'hot spots' for injury. In the ankle, lateral ligament injuries are the most common injury sustained followed by Achilles tendon strain. The study by Hume and Gerard, 1998 underlines the importance of investigating and identifying the relationship between risk factors either intrinsic or extrinsic that might contribute to injury. The ankle has been investigated in the past (Hume and Gerard, 1998) but it is suggested that more detailed information be gathered. There have also recently been advances made by the International Rugby Board suggesting a consensus statement to determine injury definitions and suggested procedures for data collection for future studies in rugby union (Fuller et al, 2007).

More contact than non-contact injuries have been described in the literature for rugby players at, 69% versus 31% and that tackling whether being tackled or enforcing the tackle explains 62% of ankle injuries (Woods et al, 2003). Tackles are the game event responsible for the highest number of injuries and most time lost, but collisions and scrums present the highest risk of injury per event (Fuller et al, 2007). The most causative events for injury is suggested by Sankey et al, 2008 as contact injuries at 52%, non-contact at 35% and unknown mechanisms at 12%. The ankle made up 40% of all injuries sustained during lineouts and 71% of these injuries were related to being stamped on and 29% to being taken out at the lineout (Sankey et al, 2008). In rugby league the incidence of injury at junior and senior level has been investigated and it was concluded that injury prevention strategies should be implemented to reduce the incidence, severity and cost of injuries (Dietzen and Topping, 1999). Suggested strategies included coaching on defensive skills, correct tackling and falling techniques and methods to minimise absorption of impact forces in tackles. Practising attacking and defensive drills when fatigued may also lead to players making appropriate decisions under pressure in a match situation (Gibbet, 2004). With the introduction of rugby in the United States a study to determine injury and plan prevention strategies was done and again adequate pre-season training,

conditioning and coaching were mentioned as requirements for injury prevention. It was suggested that protective gear should be used, e.g. wraps, tape, joint sleeves, scrum caps and facial grease (Dietzen and Topping, 1999). Coaches should be trained to handle medical emergencies. It was also suggested that players needed proper pre-season training and to be taught techniques to manage tackles and falls to avoid injury. The study advised medical surveillance not only at games but also during training. (Dietzen and Topping, 1999) This underlines the importance of the coach, sports physician and player working together to achieve a common goal (Brukner and Khan, 2007).

Various authors have urged that injury registers of different sporting codes be compiled (Sankey et al, 2008; Brooks and Kemp 2008; Edgar et al, 1995). Recently in South Africa a national register of rugby injuries has been called for and it has been suggested that proper epidemiological studies are required to compile such a register (Holtzhauzen et al, 2006), past studies have included studies on schools rugby (Upton, 1996; Nathan et al 1982). This is based on a recent study done in England by Brooks and Kemp (2008) who determined that investigations into high risk injuries are required and that assessing the effects of injury prevention strategies is important. A suggested set of criteria include the following: stage of the game when the injury was sustained, the phase of play, when the injury was sustained on a seasonal timeline, the level at which the game was played and weather conditions on match day. The nature of the injury and resultant complications should be accurately established for this to be effective (Edgar et al, 1995; Clark et al, 1990). This is particularly relevant to ankle injuries because it has been established that a considerable proportion of injuries to professional rugby union players occur at the ankle joint (Brooks and Kemp, 2008).

Based on the suggested criteria the study by Sankey et al, 2008 revealed that most injuries were diagnosed clinically and that radiological investigations were mostly required for more severe cases. Time of injury during matches was confirmed at 12% in the first quarter and 23% in the third quarter, 30% in the second quarter and 35% in the fourth quarter.

Epidemiological studies have only recently been undertaken and the injuries sustained by a cohort of players have been described. Lateral ankle injuries were most commonly reported for both matches and training sessions (Sankey et al, 2008). Forwards, especially second row forwards were at greater risk for injury and it is speculated that it is possibly the combination of speed and power required as a loose forward in the modern day game that might be the causative factor. Players reported that in more than a quarter of cases injuries were recurrent (Sankey et al, 2008).

Rugby is the sport with the highest risk per player-hour of injury. (Sankey et al, 2008). As early as 1970 concerns were raised about the high number of rugby injuries and rugby rules were changed which subsequently lead to less serious spinal injuries. However it is evident that tackling and being tackled are related to modern day rugby injuries, especially ankle injuries (Fuller et al, 2007). Injury is best measured by using the player-injury rate per 1000 player hours. The current Scottish rugby union prevalence is 14 per 1000 player hours which compared to the prevalence of injury in Australian rugby league of 45 per 1000 player hours in a 1990 study (Clark et al, 1990). In schools' rugby a rate of 20 per 1000 player hours was reported in a study done in 1980 (Edgar et al, 1995). The above mentioned studies only focussed on epidemiology of injuries in rugby players but the more recent studies reported the epidemiology of ankle injuries specifically (Sankey et al, 2008; Brooks and Kemp, 2008).

In a recent study by the Scottish rugby union it was evident that at least one in every four players was injured during a single season. Forty three percent of these players were in the 20 – 24 year age group and this was five times higher than the incidence rate in the under 16 age group. In a team of fifteen players at least five new injuries were sustained during a season, in any area (Edgar et al, 1995). In South Africa a study done on incidence, nature and risk factors associated with injuries in the Super 12 competition revealed 55.4 injuries per 1000 player game hours and 4.3 injuries per 1000 player training hours. Although 25.8% were ligamentous injuries the most common sites were the pelvis, hip, knee and head. The total number of ankle injuries sustained was seven, thus a total of 11.3%. Only three of the injuries sustained were serious

(Holtzhauzen, et al, 2006). In conclusion the study underlined that it was the first of its kind to be done in South Africa and that there is a need for studies to collect epidemiological data on rugby injuries in order to provide the scientific background required to make recommendations to coaches and administrators to reduce risk of injury (Holtzhauzen et al, 2006).

Since the advent of professionalism in rugby, trends in injury epidemiology include:

- a higher incidence of injury than other team sports
- an apparent increase in injury risk in professional and amateur games
- a reduction in injury incidence with decreasing age and competitive level
- a significantly higher incidence of injuries during matches compared to training
- a high proportion of tackle injuries and second to that injuries sustained during rucks and mauls
- the most common sites for injury are the shoulder, knee, thigh, ankle and head
- an injury sustained during training is more likely to be related to chronic overuse injuries

(Brooks and Kemp, 2008; Holtzhausen, 2006).

Reasons for these trends are mostly speculative in the literature. Physical condition and fatigue have been cited as the most common causative factors for injury. The tackle is one of the most traumatic events during sport and the major risk for injury is during impact and when the athlete goes to ground Injuries are mostly sustained during games because of the high intensity at which they are played. Common overuse injuries occur with training and mostly with overexposure to training (Nelson et al, 2007; Holtzhausen et al, 2006). Ankle injuries comprised 15% of all training injuries in a study done on rugby players in England this however was still substantially less than the injuries sustained during matches (Sankey et al, 2008)

2.2.2 RECURRENCE OF INJURY

A recurrence rate of ankle injuries as high as 80 % has been reported in the literature (Gribble et al, 2004; Smith and Reischl, 1986; Denegar and Miller, 2002). Ankle injuries in rugby is also recurrent in 27% of injuries to the ankle in a study by Sankey et al, 2008 it was also reported that it is much greater than other recurrent injuries in the rest of the body which only makes up 18% of injury. A reported 21% of days absent due to injury could be related to recurrent ankle injuries (Sankey et al, 2008). It is evident that previous injury predisposes one to future injury. Some factors predicting re-injury have been identified and these factors are classified as mechanical and functional factors. Mechanical factors include insufficient healing time for the ligament, residual ligament damage and pre-existing biomechanical abnormalities like the rigid cavus foot, or over- / early pronation. Functional factors include balance and proprioceptive deficits, decreased neuromuscular control and weakness of secondary supporting structures (Liu and Jason, 1994) The literature reports that 20% of patients with an acute sprain will have residual complaints depending on the severity of the initial trauma and the effectiveness of the rehabilitation programme and whether or not an accurate diagnosis was made in the first place (Klenerman, 1998). Residual complaints include a feeling of weakness or the ankle wanting to ‘give way’, tenderness on palpation, pain or discomfort with running or jumping activities (Van der Wees et al, 2007). Despite the high risk of injury recurrence very little has been done with regards to ‘best practice’ or clinical practice guidelines after injury to avoid reinjury. Effective interventions have been reported in the past with great efficacy for athletes with a prior history of ankle injury and with cost-effectiveness of management especially physiotherapy interventions being kept in mind (Van der Wees et al, 2007; Hootman et al, 2007).

2.3 FUNCTIONAL ANATOMY AND BIOMECHANICS RELATING TO ANKLE INJURY

The discussion of the functional applied anatomy includes the bones, joints, connective tissue, muscle, ligaments and other structures comprising and supporting or surrounding the ankle joint. Reference will be made in each subsection to the risk of injury and the effect of injury on the involved structure and the healing process. The ankle joint is part of the lower limb and cannot be viewed in isolation; as it forms part of the kinetic chain. The lower limb has three major functions: locomotion, weight bearing and maintaining equilibrium and is divided into four parts namely the hip, the thigh, the leg and the foot (Moore, 1992).

2.3.1 PATHOMECHANICS OF THE ANKLE SPRAIN

Pathomechanics are related to the presence of abnormal anatomical variations which might predispose to future injury. The lateral ligament of the ankle is most commonly sprained due to excessive supination at the rear foot while the lower leg is still in external rotation as would occur during the foot strike phase of gait or when landing from a jump. A sprain occurs when external rotation of the leg is coupled with internal rotation or inversion of the calcaneus to a point where the tensile stretch limit is reached and subsequently the fibres will tear (Hertel, 2002).

The anterior talo-fibular ligament is most commonly torn followed by the calcaneo-fibular ligament due to its proximity to the talocrural joint and the increased motion of inversion once the anterior talo-fibular ligament strains (Anderson et al, 1962).

A wide range of abnormalities can occur in ankle biomechanics. Biomechanics are influenced by what is happening in the foot as well as the rest of the kinetic chain. Injury to the pelvis, hip, knee and the foot can predispose the ankle to

biomechanical changes. Muscle imbalances of any two muscles in the body can eventually affect the ankle because it is the most distal part of the chain linked by fascial slings. Habitual postures or positions will influence the biomechanics of the ankle joint (O' Sullivan et al, 1997; Motram and Comerford, 1998).

Within the ankle joint itself the translation of the subtalar joint related to pronation or supination can lead to abnormalities in joint motion. When the subtalar joint is in pronation the translational glide is increased, presenting as a 'give' or hypermobility of the subtalar joint. This is accompanied by an infero-medial glide of the talus and hypermobility of the forefoot which affects the push off during gait and will eventually render the ankle susceptible to injury. Characteristics of the overpronated foot include calcaneal eversion, prominence of the navicular and forefoot abduction with resultant dropping of the medial longitudinal arch (Hartley, 1995).

Different pathomechanical models have been described. The supinated foot will be rigid with decreased shock absorption and inability to adapt to uneven surfaces. This can be diagnosed based on inversion of the calcaneus, a high arch and plantar flexion of the forefoot (Donatelli, 1996). Lateral instability may be associated with excessive supination with signs of forefoot valgus, which results in an increased incidence of lateral ankle ligament sprains (Brukner and Khan, 2007). It has been suggested that an increased supination moment at the subtalar joint will lead to greater inversion and internal rotation of the rear foot during closed chain activities. The supination will lead to a more laterally deviated subtalar axis of rotation when the magnitude of subtalar supination is greater than the compensatory pronation moment (Fuller, 1999).

There is not much in the literature regarding predisposing factors to ankle injury but it is suggested that increased tibial varum (relative external rotation), increased non-pathological talar-tilt, poor postural control, interrupted proprioceptive input, and muscle imbalance in strength ratios of plantar- to dorsiflexion and inversion to eversion can all predispose the athlete to the initial or subsequent injuries (Hertel, 2002).

2.3.2. MECHANICAL ASPECTS OF INSTABILITY

The mechanical aspects include injury or insult to the anatomical structures of the ankle joint.

2.3.2.1 JOINTS AND BONY ARTICULATION

The ankle is a complex yet very functional triplanar joint or joint with three planes of motion and its main function is mobility and gait (Freeman and Wyke, 1967; Moore, 1992)

The main joint is known as the **talocrural** and functions like a hinge. Due to the bony alignment the weight of the body is distributed to the saddle shaped superior surface of the talus during stance. The medial and lateral malleoli provide additional articulation and stability to the ankle joint, which is uniaxial and only allows dorsi- and plantarflexion and the range of plantar flexion exceeds dorsiflexion and totals 100˚ of range. There are considerable normal variations possible and this makes standardized testing very difficult (Brukner and Khan 1995; Petty and Moore, 2001; Moore 1992). The bony anatomy of the talus, with the anterior part of the articular surface being wider than the posterior part, means that dorsiflexion is the position of 'close pack' where the bony constraints are at their greatest (Brukner and Khan, 2007) and thus the joint is most stable. This is important to underline the relative weakness during plantarflexion and inversion where bony congruency is less. This is directly related to greater stability in dorsiflexion and the ankle joint being more vulnerable during plantar flexion. Hence this is the mechanism of injury (Hunter and Fortune, 2000). For a functionally stable ankle the bony articulations have to be intact and well preserved. The shape of the talocrural joint allows for torque to be transmitted from the lower leg to the foot during the weight bearing phase of gait.

The **inferior tibiofibular joint** is an articulation between the inferior ends of the tibia and fibula. It is a syndesmosis that is supported by the inferior tibio-

fibular ligament. Joint motion includes a small amount of rotation (Moore 1992). It is relatively strong and only injured by greater forces and allows for accessory glide which is crucial to normal mechanical function of the ankle (Hertel, 2002; Moore 1992). Limited movement at this joint will predispose the ankle to injury because increased rotation has to then take place at the subtalar joint as a compensatory mechanism (Hartley, 1995).

Arthrokinematic impairments can contribute to chronic instability. In cases where the fibula is displaced inferiorly and anteriorly post injury. The anterior talo-fibular ligament will be relatively lax at rest allowing greater range of talar movement before the anterior talo-fibular ligament can control the motion hence making the joint more susceptible to sprain (Hertel, 2002).

The **subtalar joint** is the articulation between the calcaneus and talus. The subtalar joint functions to aid with shock absorption and also allows the foot to adapt to uneven surfaces. Through the movement supplied by the subtalar joint it is possible for the foot to remain flat while the leg is at an angle to the supporting surface. Joint motion here is limited to inversion and eversion (Jones and Barker, 1996; Moore, 1992; Hertel et al, 1999). Inversion sprain is most likely to occur with plantar flexion. The inversion component will inevitably be affecting the subtalar joint as well.

The triplanar nature of the joint renders it susceptible to injury because of the different movements taking place at the different articular surfaces and this makes rehabilitation difficult. The control over three rather than a single joint has to re-established (Denegar and Miller; 2002).

These three joints function as a unit and enable the coordinated movement of the rear foot which can never be seen in isolation in individual planes of motion but rather as motion about an axis of rotation oblique to the lower leg. There are three major contributors to the ankle joint's stability: the congruency of the articular surface, ligamentous or primary constraints and the musculotendinous restraints which allows for dynamic stabilization (Denegar and Miller, 2002).

Degeneration of the joint will also happen with formation of osteophytes or loose bodies drifting around the joint which can cause pain and future limitations to range and therefore render the ankle susceptible to injury (Liu and Jason, 1994).

2.3.2.2 FASCIA AND CONNECTIVE TISSUE

The connective tissue system surrounds the ankle joint and is susceptible to injury when ankle sprains occur. The greater the excursion of the joint capsule and ligaments, within normal tensile limits, the less likely sprains is to occur because with increased motion the muscles absorb the mechanical force energy without exceeding the tensile limits of the capsule or ligaments (Meyer and Meij, 1996; Jones and Barker, 1996).

There might be signs of synovial hypertrophy after injury that could possibly explain impingement anteriorly and pain with repetitive sprains. This underlines why pain is not an indication for a positive mechanical test for either talar tilt or anterior drawer sign (Brukner and Khan, 2007; Hartley, 1995).

2.3.2.3 LIGAMENTOUS STRUCTURES

The lateral ligament complex of the ankle consists of three parts:

- the anterior talofibular (ATFL) ligament is a long thin flat band and functions in plantar flexion to control inversion (Moore, 1992).
- the calcaneofibular ligament (CFL) is a cordlike structure. This ligament is not a strong passive constraint of the talo tibial joint but it has been suggested that it acts to limit dorsiflexion (Renstrom et al, 1988)
- the posterior talofibular ligament (PTFL) is described as a prime plantar flexion stabilizer coupled with it controlling eversion (Donatelli, 1996; Rundle, 1995) although according to other

authors it might be tight in dorsiflexion (Renstrom and Konradsen, 1997).

These ligaments provide the greatest support in dorsiflexion where support from fascial thickenings of the retinaculum provides added support and the joint is in the 'close pack' position. The orientation of the talus in the mortise and the strong interosseous ligament provides added support in plantarflexion. Injuries occur when the foot is grounded and the body weight is forcible passed over the plantarflexed and inverted foot (Brukner and Khan 2007; De Vries et al, 2006; Hertel 2002; Van Dijk, 2002; Hunter en Fortune 2000; Moore 1992; Renstrom et al, 1988).

The lateral ligament complex is at a greater risk for injury due to its relative weakness compared to the medial ligament and the relative instability of the lateral aspect of the joint (Brukner and Kahn, 1995). The anterior talofibular ligament is reported to be the weakest and the first ligament injured with an ankle sprain and is followed by injury to the calcaneo-fibular ligament and the posterior talo-fibular ligament. Rupture of the anterior talo-fibular ligament occurs as an isolated injury in 66% of all ruptures of the ankle ligaments and occurs in combination with a rupture of the calcaneofibular ligament in another 20% Because of the damage to these ligaments, an associated increase in the motion is present between the talocrural and subtalar joint thus resultant hyper mobility occurs (Hubbard, 2007).

There is suspected residual mechanical laxity after the initial injury to the ligaments that might account for less stability and leads to the ankle being vulnerable during functional activities; interestingly 11% of healthy individuals, with no mention of previous injury, show signs of asymmetry with ankle laxity tests namely the anterior drawer and talar tilt test (Hertel, 2002).

The healing time for ligamentous healing is between six weeks and three months. However in a systematic review on ankle injuries it has been shown that at testing there are still signs of mechanical laxity and functional instability between six months to a year after the initial injury (Hubbard and Hicks-Little, 2008).

2.3.2.4. MUSCULAR OR SECONDARY CONSTRAINTS

The ankle joint is not very well protected by muscles and is supported only by the tendons that run over the area. Tendons passing over the ankle include the flexor and extensor tendons of the foot, the tendons of tibialis anterior and posterior muscles and the peroneus triad. In addition there is the Achilles tendon which is the common insertion point for the soleus and gastrocnemius muscles (Moore, 1992). The talus is the only bone in the human body with no muscular attachments (Moore, 1992). There are some studies that suggest that the tendons will act as secondary constraints (Arnold and Docherty, 2004; Mattacola and Dwyer, 2002; Davies 1997).

Some studies reveal that the evertor muscle will act as the best secondary constraint to protect the foot at full inversion during the foot strike phase (Ashton-Miller et al, 1996). It has also been shown that latent onset of muscle function leads to failure of the protective muscle activation in the previously injured ankle. It is suggested that the stabilizers should pre-activate in anticipation of an event, in this case the heel strike (Mottram and Comerford, 1998). Interestingly neither plantar-flexion angle nor bracing has any effect on the reflexive activity of peroneus longus, brevis or the tibialis anterior muscle during unanticipated plantar flexion nor does inversion stress (Kernozek et al, 2008)

The peroneus complex is still widely regarded as the best eccentric control of supination of the rear foot which protects the ankle against lateral ankle injuries. The tibialis anterior, extensor digitorum brevis, extensor digitorum longus and peroneus tertius also functions eccentrically and can aid in lateral stability by slowing down plantarflexion to decrease forced supination of the rear foot (Hertel, 2002). Weakness or previous injury will render the ankle susceptible to future injury due to the deficits in the secondary constraints. When there is stiffness of the Achilles tendon and calf musculature there is limited dorsiflexion which will lead to talocrural inversion which will lead to increased subtalar pronation (Denegar et al, 2002)

2.3.2.5. NEURAL CONTROL

The lateral ligaments and the capsule of the joint are innervated by proprioceptors that relay important information regarding the position of the foot-ankle complex in space. Muscle spindles of especially the peroneal muscles contribute to proprioceptive input as well (Hertel, 2002).

Injury to any of the nerves in the area could be caused by compartment syndrome (due to swelling), epineural haematoma or nerve traction from an inversion motion. Peroneal nerve-conduction velocity can be reduced especially between days four to eight post-injury but even up to 22 days post inversion ankle sprain there could be reductions of conduction velocity. The result of this is muscular atrophy and performance deficits as with any neurological damage (Mattacola and Dwyer, 2002).Any deficits in proprioception or neural damage will result in a relatively 'weaker' ankle at greater risk for injury.

2.3.3 FUNCTIONAL ASPECTS OF INSTABILITY

The patient with functional instability has deficits to ankle control in postural control tasks. This is explained in part by the fact that the somatosensory receptors are disrupted and this generates a decreased motor response to maintain postural equilibrium (Santos and Lui, 2008).

Impaired proprioceptive input that leads to impairment to postural control has been evident in injured individuals who struggle to position the foot at certain angles (Rothermel et al, 2004). There is no conclusive evidence of peroneal nerve palsy but impaired cutaneous sensation is sometimes present as well as decreased nerve conduction velocity (Hertel, 2002). There is also evidence supporting the fact that when there is functional instability present the athlete takes longer to stabilize in the medio-lateral direction (De Norhona et al, 2008). This can be explained by the relative increase in inversion prior to ground contact in these individuals (Delahunt et al, 2006). Subjective as well as instrumented evaluations of patients after injury have identified the functional

insufficiencies in patients with suspected instability. The 'ankle strategy' of postural control refers to alternate pronation and supination to stabilize the foot and maintain the body's centre of gravity above the base of support (Hertel, 2002). It has been shown that differences in postural control often recover to insignificant levels in the months after injury whether the athlete adheres to a structured rehabilitation program or not. There is however a significantly higher incidence of recurrence of injury in the athletes who do not adhere to a rehabilitation management program (Holme et al, 1999).

Neuromuscular firing patterns and strength have also been seen to be affected and might predict re-injury. There is evidence that the patterns are not only affected locally at the affected structure but as far up as the firing pattern of gluteus medius can be affected (Hertel, 2002). There are differing opinions with regards to muscle strength deficits and no conclusive evidence can be gathered from the literature as to causes of weakness, related to neural control or muscle injury and resultant atrophy (Hertel, 2002; De Norhona et al, 2008).
It is also evident that patients with functional ankle instability take longer to stabilize after a single-leg jump landing than normal individuals (Ross and Guskiewicz, 2004) and this might be one of the predisposing factors to reinjury.

2.4 MECHANISM OF INJURY TO THE ANKLE JOINT

Injury of the lateral ligament complex is mostly sustained when the ankle is forcibly plantar flexed and inverted as the centre of gravity passes over the ankle joint. The order of injury to individual ligaments is anterior talo-fibular followed by the calcaneo-fibular ligament and lastly the posterior talo-fibular ligament. The injury occurs when the force applied through the ankle exceeds the tensile limits of the dynamic link between the leg and the planted foot, which has to bear the brunt of the concentrated forces (Walker 2003). Most patients explain the injury as a rolling over the ankle with inversion, plantar flexion or internal rotation (DiGiovanni et al, 2004).

2.5 CLINICAL SIGNS AND SYMPTOMS OF LATERAL LIGAMENT INJURY

The clinical history of a tear, in most cases, has the athlete reporting a loud sound likened to a snap or tear, occurring after forced or uncontrolled inversion of the foot. The site and area of pain will give a good indication of structures involved, most commonly the anterior talo-fibular ligament. Marked swelling and bruising can be present and in most cases this is a good indication of the severity of the injury (Brukner and Khan, 2007; Boruta et al, 1990).

When there has been an injury to the lateral ligament complex the athlete often reports an inability or difficulty in weight bearing on the foot and ankle. The degree to which the instability affects the ability to bear weight can be a predictor of the severity of the injury. The ability to walk on the foot usually excludes a fracture, based on the Ottawa ankle rules, which will be discussed later in this review (Stiell et al, 1995). Inability to bear weight on the foot is generally indicative of a sprain of the ankle joint except where normal local sensation or control from the central nervous system has been altered, rather indicating more serious pathology. Although most patients can put weight on the leg the gait pattern will be altered. They might have a shortened stance phase and a Trendellenburg gait can even develop over time. If central control is affected by neural damage, weight bearing might not be possible. Foot position and control of the stance phase could be affected due to pain or compensatory mechanisms. Crutches or alternative supports may be required (Woods et al, 2003).

In cases with a partial tear, active movement might be limited due to pain, especially plantar flexion and inversion which will reproduce symptoms. Where there has been a complete tear increased range of motion with less pain can be expected (Petty and Moore, 2001).

Objective testing is required to support the subjective evidence of an injury. Most authors agree that mechanical stability can be judged by two tests; this includes the anterior drawer sign and the talar tilt test, which will be discussed in detail later. These two tests describe the integrity of the lateral ligament complex and the talar tilt test specifically assesses the calcaneofibular ligament (Brukner and Kahn, 2007; Petty and Moore, 2001; Magee, 1992).

2.6 MECHANICAL INSTABILITY

2.6.1 DEFINITION

Mechanical instability is defined as the increase in accessory movement (arthrokinematic motion that cannot voluntarily be produced, e.g. the glide and roll of the talus in the mortise); which translates into an enlarged neutral zone or a stability dysfunction (Motram and Comerford, 1998). The neutral zone is defined as the range of joint motion that is produced with minimal internal resistance of the collagen tissues around the joint (Panjabi, 1992). It is also described as movement within the normal tensile limits of joint excursion (Petty and Moore, 2001)

Mechanical instability is usually the result of a tear or lengthening of one of the ligamentous structures supporting the joint. Changes that take place include pathological laxity, impaired arthrokinematics, synovial changes and the development of degenerative joint disease. Residual mechanical instability suggests a non-optimal healing process. The assessment of mechanical integrity is generally explained in single plane motion but it must be remembered that triplanar movement takes place at the ankle joint. Keeping this in mind, effective clinical testing by qualified clinicians according to most authors is the best diagnostic tool available (Brukner and Kahn, 2007; Petty and Moore 2001; Trojian and McKeag, 1998).

Lateral ankle sprains occur most frequently due to excessive supination of the rear foot about an externally rotated leg soon after initial contact with the

ground during gait or with landing from a jump (Brukner and Khan, 2007; DiGiovanni et al, 2004). The inversion and internal rotation of the foot coupled with external tibial rotation results in ligamentous strain. Strain refers to a force exceeding the tensile strength of the soft tissue structures. Most commonly, the anterior talofibular ligament is affected during sprain and this stresses the remaining ligaments through rotational instability (Hertel, 2002; Hunter and Fortune, 2000).

To understand the effect that the deficit in ligamentous integrity has on the ankle one must also consider that it would be difficult to pinpoint one specific area due to the complexities of the ankle (Hertel, 2002). A ligament sprain, in almost all cases is accompanied by widespread soft tissue damage, including muscular constraints, retinaculum and joint capsule injuries (Brukner and Khan, 2007; Liu and Jason, 1994).

2.6.2 GRADING OF LATERAL ANKLE INJURIES

The grading system which is based on clinical assessment remains a very subjective grading and is clinician determined, based on the criteria set out for sport scientists (Trojian and McKeag, 1998) The Ottawa ankle rules are explained later in this chapter and based on this most clinicians will make a preliminary diagnosis from their clinical assessment.

Lateral ligament injuries are classified into three grades by identifying certain characteristics. Grade I is described as a minor tear or ligamentous stretch. There is minimal if any disruption of ligamentous integrity. When an inversion stress is applied, pain is experienced on the lateral border or inferior to the lateral malleolus. No sign of laxity or mechanical joint instability is noted. The patient can still walk quite comfortably. There is minimal swelling and mild tenderness on palpation. A grade I should still have a normal talar tilt and anterior drawer test and should be able to return to play within ten days (Brukner and Khan, 2007; Denegar and Miller, 2002; Van Dijk, 2002).

A grade II injury is painful with applied ligamentous stress. This can be achieved by straining the joint into inversion more markedly in a plantarflexed position. Laxity might be evident but there is still a distinguishable end feel. This is described as an injury where the anterior talofibular ligament is torn but the calcaneo-fibular ligament is still intact. These patients present with moderate swelling and tenderness. These patients should still be able to weight bear with moderate discomfort depending on the individual's pain threshold. When a grade II is sustained there is increased translation of the ankle joint with the anterior drawer test, but the talar tilt might still be negative. Expected return to sport can vary from two to four weeks (Brukner and Khan, 2007; Denegar and Miller, 2002).

For a lateral ankle injury to be graded as a grade III, it should present with gross laxity without a discernable end feel. A complete or large tear of the anterior talo-fibular and calcaneo-fibular ligaments are suspected. Swelling, bruising and marked localised tenderness can be expected. In most cases there is a complete disruption of the ligamentous integrity. These patients cannot weight bear on the affected ankle, due to the instability. Very often these patients have minimal pain due to the complete disruption of the integrity of the ligament, especially with the ligament stress tests where the fibres cannot strain any further (Brukner and Khan, 2007; Denegar and Miller, 2002).When there is a suspicion of a grade III injury both tests for mechanical integrity will be positive and with optimal rehabilitation return to sport can be expected anything from five to eight weeks after the injury (Trojian and McKeag, 1998). Surgical intervention might also be required and this will change expected outcomes (Samoto et al, 2007).

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History, clinical examination and x-rays are the only indicated investigations for acute ankle sprain. X-ray investigations are only indicated when criteria for the Ottawa-ankle rules are met or where the signs and symptoms do not subside with conservative management. This will be elucidated later in this chapter (Stiell et al, 1995; Stiell et al, 1993).

2.6.3 OUTCOME MEASURES AVAILABLE TO TEST MECHANICAL INSTABILITY

2.6.3.1. OBJECTIVE CLINICAL ASSESSMENT

There are two schools of thought, one supporting and the other negating objective clinical assessment. It has been reported in the literature that diligent clinical examination is sufficient to determine the diagnosis in the clinical setting and that even though stress view x-rays are the gold standard for determining ankle ligament injury they should not be done in the acute setting but rather once signs of chronicity are noted again supporting the use of accurate clinical assessment (Trojian and McKeag, 1998; Greenman 1995). Clinically the use of two tests specific to the ankle joint have been advocated namely the anterior drawer test and the talar tilt test. It must be considered that these are clinical interpretations by the clinician on ankle joint laxity. Laxity has been determined to be joint specific in the lower limb based on a study that was done to determine the relative laxity at the ankle and knee joint compared to generalized laxity or hyper mobility and it was found that laxity in the lower limb is mostly joint specific (Pearsall et al, 2006). To determine the outcomes for ankle ligament laxity the two tests used were the anterior drawer and talar tilt tests which give an indication of joint excursion restricted by the ligaments of the lateral complex (Pearsall et al, 2006).

A sensitivity of 84% and 95% specificity of the anterior drawer test when tested directly after the injury have been reported (Van Dijk et al, 1996; Spahn, 2003). The anterior drawer test assesses the integrity of the anterior talofibular ligament and initial reliability may be suspect within 48 hours of injury, but after five days from initial injury, a sensitivity of 86% and a specificity of 74% have been reported (Van Dijk et al, 1996). A second test, the talar tilt test has been said to be an effective indicator of injury to the calcaneofibular ligament showing increased adduction of the talus during inversion in 10 degrees of plantar flexion when the ligament is not intact (Magee, 1992).

Testing mechanical instability involves establishing the integrity of the lateral ligament complex. The clinical assessment includes the anterior drawer (transverse plane laxity) and talar tilt test (frontal plane laxity) which basically disregards the issues of rotary instability (Petty and Moore, 2001; Trojian and McKeag, 1998; Starkey and Ryan, 1996).

These mechanical tests have been used the literature to determine ankle ligament injury either in isolation or in combination with stress view x-rays. The following studies show how these tests were implemented and support the use of these clinical examinations in the study (Avci and Sayli, 1998; Starkey and Ryan, 1996; Freeman, 1965).

In a study to measure mechanical laxity, participants had partial or complete ruptures of the lateral ligaments of the ankle and were compared based on intervention received whether or not immobilized. The investigator measured mechanical laxity with talar tilt stress radiographs. A positive talar tilt was defined as an inversion tilt of the talus of 6° or more on the affected side when compared with the unaffected ankle (Freeman, 1965)

In another study anterior drawer was measured at two weeks and again at six weeks after an acute lateral ankle sprain. Classification of a grade III inversion ligament injury was required to be included in the study. Individuals were excluded if they had a history of chronic instability or fracture or current tenderness of the deltoid or syndesmotic ligaments. The authors stated that the anterior drawer test of the injured ankle was compared with that of the opposite, healthy ankle. The authors reported that 30% of participants had a positive anterior drawer test at two weeks after injury and 11% had a positive anterior drawer test at six weeks after injury (Avci and Sayli, 1998). This suggests that there was an improvement of the anterior drawer test six weeks after initial acute injury.

In another study, by Cetti,et al, 1984, the anterior drawer and talar tilt tests were applied at eight weeks and 24 weeks after acute ankle sprain and initial injury was determined with stress radiographs taking six degrees or greater as a

positive talar tilt test and three millimetre or more side to side differences as a positive anterior drawer test. The eight and 24 week interval testing was done only with clinical evaluation supporting the notion that clinical testing is sufficient to determine ligamentous laxity (Cetti et al, 1984).

Suggested mechanical investigations for standardized testing include the use of the anterior drawer test, talar tilt test, the side-to-side test, the Thompson's test, the squeeze test and external rotation stress test for complete evaluation of all structures around the ankle joint (Trojian and McKeag, 1998).

2.6.3.1.1 ANTERIOR DRAWER TEST

The anterior drawer test is designed to indicate the severity of injury to the anterior talo-fibular ligament. This is achieved by evaluating the amount of anterior glide of the talus to the tibia. It had been suggested earlier that performing the test with 10◦ of plantar flexion will improve the sensitivity (Johannsen, 1978), and this is supported by more recent literature (Petty and Moore, 2001). The knee should be flexed to at least 40◦ to ensure a relaxed gastrocnemius which can if contracted or in spasm lead to a false negative (Kovaleski et al, 2008;Brukner and Khan, 2007; Petty and Moore, 2001). A recent study suggests that positioning is important to isolate the ankle for testing. The ankle should be positioned in 10˚ of plantar flexion and the knee at 90˚. The argument being that in this position the most anterior laxity of the ankle will be achieved to better isolate the capsular and ligamentous structures of the ankle (Kovaleski et al, 2008).

A positive anterior drawer test has a sensitivity of 73% and a specificity of 97% (Van Dijk, 2002). When accompanied by a skin dimple during testing there is a high correlation of approximately 94%, with rupture of the lateral ligament complex. A positive anterior drawer test with pain on palpation and signs of haemorrhage has a 100% sensitivity and specificity of 77% (Van Dijk, 1994). To determine laxity the test must be done on the affected and unaffected side and then a comparison must be made.

2.6.3.1.2 TALAR TILT TEST

The talar tilt test determines the amount of inversion of the calcaneus when the tibia is stabilized. This again is a comparative test for side to side differences. This is only an adjunct to the anterior drawer test and is reported to be less reliable in predicting injury. The talar tilt test can be used to assess the integrity of the calcaneofibular ligament by inversion stress, but is an unreliable test for ligamentous rupture with poor interrater reliability (Van Dijk, et al, 1996). This test is normally seen as a supplementary test only. Most clinicians use both tests to determine ankle ligament integrity. (Kovaleski, 2008; Trojian and McKeag 1998).

The effectiveness of the talar tilt test is supported in the literature and findings suggest that the talar tilt test is accurate in detecting injury to the anterior talofibular and calcaneofibular ligament in 97% of cases and despite positive signs ranging from 0° – 23° it has been established that a 10˚ difference is sufficient to indicate a positive talar tilt test (Chrisman and Snook, 1969).

Both tests have false positives and negatives in patients with previous rupture or patients with physiological laxity of ligaments without injury. This again re-iterates the importance of comparing left to right as discussed with the anterior drawer test.

2.6.3.1.3 NON-RADIOLOGICAL INSTRUMENTED MEASURABLE METHODS

Efforts to produce a non-radiological, but measurable method to determine joint stability have been expensive and not clinically effective (Breitenseher et al, 1997; Kerkhoffs et al, 2002; Stiell, et al 1992). Different instruments have been suggested for determining ankle instability but none were shown conclusively to be an effective method to determine mechanical integrity (Spahn, 2003, Kovaleski et al, 2002, 1990, Alexander, 1998).

In Germany an instrument developed by Spahn; the ‘Ankle Meter”, is a device to measure the anterior drawer test in ankle sprain. The instrument consists of two plastic scales (heel and tibia) with an attached pointer which is adjustable through a screw-nut and a measuring border fixed on the surface of the tibial scale. The border contains a slit for gliding of the pointer to a graduator. Initial investigation revealed acceptable interrater reliability and the possible early detection of failed ligament healing in the early stages (Spahn, 2003). The authors raised questions with regards to the sample size, the effect of pain and possible inaccuracies during measurement and further research was suggested before it could be assumed that the ankle meter was an effective tool to determine ankle ligament instability. It was suggested that the anterior drawer test could be measured but again the need to assess the involved as well as uninvolved leg was reiterated (Spahn, 2003).

The Ankle Arthrometer as used in a study on cadavers was found to be an effective tool to measure ankle subtalar joint complex laxity by imposing controlled load to determine the inversion eversion ratios at the subtalar joint complex and anterior-posterior tibial motion displacement. This was a controlled laboratory study and ignored the aspects of active muscular guarding and neural control of the movement by live subjects (Kovaleski et al, 2002). The Arthrometer was initially introduced to determine it’s usefulness as an objective measure of joint excursion in uninjured subjects in dominant compared to non-dominant ankles. This does not show it’s efficacy to detect ankle instability in injured subjects though (Kovaleski et al, 1999)

Research in the field of podiatry has shown that standard measuring apparatus is not effective or reliable and that leaves a gap to determine a reliable and effective measure for mechanical instability, which is ethically acceptable (Alexander, 1998).

2.6.3.2 RADIOLOGICAL INVESTIGATIONS

X-rays are the first line of investigation for ankle sprain second only to clinical history and physical examination. The gold standard for determining ankle injury is stress radiography which has been used to quantify the amount of subtalar tilt and the anterior displacement of the calcaneus from the talus. However the validity of the test has been challenged as well (Nyska et al, 1992; Stiell et al, 1995). Stress views include inversion (or talar tilt) and the anterior drawer tests. The stress view x-rays of the affected side must then be compared with those of the uninvolved ankle for both tests. Variables in determining the reliability of these tests include the degree of patient relaxation and cooperation, the amount of force applied the angle of ankle flexion, and the amount of laxity on the uninvolved side. The anterior drawer test is performed with a lateral view of the ankle in the neutral position. An attempt is then made to manually translate the foot anteriorly with respect to the leg. Translation of the talus with respect to the tibia in the sagittal plane is measured. A measurement of more than three mm is considered a positive finding for an anterior talo-fibular ligament injury (Safran et al, 1999; Anderson, 1962), but up to five mm of anterior translation or greater is accepted as a likely anterior talo-fibular rupture by most sources. The talar tilt test is used more often than the anterior drawer test and is believed to be more reliable. A mortise or anterior-posterior view is used with the ankle held in a neutral position in 10˚ plantarflexion with an inversion stress applied to the foot. The assumption behind this test is that the contralateral ankle is normal. Studies have accepted positive test results as a stressed angle of 5-15° greater than the uninjured side (Safran et al, 1999). In 97% of cases a 10° or greater difference is accepted as clinically significant (Chrisman and Snook, 1969) and this is still accepted as the norm (Petty and Moore, 2001). This correlates with a torn anterior talo-fibular ligament and calcaneofibular ligament.

Imaging is not indicated in every case and to save costs the OTTAWA-ankle rules were created. The rule state that X-rays of the ankle are only indicated when the pain in the ankle is coupled with one of the following criteria. Firstly it is important to determine whether or not the person can bear weight on the

affected side either immediately after the injury or during the evaluation at the emergency unit. Secondly bone tenderness at the posterior edge for 0-6cm up or on the tip of either malleolus is seen as an indicator for investigations required (Stiell et al, 1995; Stiell et al, 1993).

X-rays for diagnostic purposes of the foot on the other hand are based on the following criteria when coupled with midmost pain. Again inability to bear weight on the affected limb and then assessment of bony tenderness at the base of the fifth metatarsal or the navicular is undertaken (Stiell et al, 1995; Stiell et al, 1993).

The Ottawa ankle rules have been a very effective tool to limit patient exposure to unnecessary radiation. The patient with general ankle sprain should not be sent for an X-ray unless supported by the Ottawa rules (Auleley et al, 1997). General practitioners and casualty departments use the guidelines as set out by the Ottawa-rules to decide upon the necessity of x-rays post ankle injury. In most cases due to the severity of the injury stress views are not asked for and these views are only done once the patient sees an orthopaedic surgeon or presents with persisting functional limitations and pain. The accepted norm for x-rays include anterior-posterior, lateral and mortise views (DiGiovanni, et al, 2004).

The meticulous description of investigations required is suggested because a recent Cochrane Review could not establish conclusive evidence for the use of surgical versus conservative management but it was evident that surgical intervention related to more functional deficits than the more conservative approach (Kerkhoffs et al, 2007). And even if surgery is not indicated to manage the injury effectively an accurate diagnosis is required (Kerkhoffs et al, 2007) more so not to miss the diagnosis of avulsion fracture that is sometimes missed (Haraguchi et al, 2007).

Ethical considerations for radiography contribute to the difficulty of finding an objective measurement in research. The problem encountered with stress radiography is the fact that normal as well as previously injured athletes have to

be exposed to radiation to have a true comparison. With the ethical considerations regarding radiography, researchers have to look at other mechanical tests to determine functional stability of the ankle joint (Spahn, 2003; Trojian and McKeag, 1998). The financial implications of radiological investigations must also be considered.

Occasionally ultrasound has been advocated to investigate disruption of the lateral ligament complex of the ankle, changes in soft tissue can be observed and swelling visualized, but clear cut predictions cannot be made regarding the integrity of the ligament. CT-scan and MRI is not indicated in minor sprains, only where associated injury of the bony, osteochondral or tendinous or nervous system is suspected (DiGiovanni et al, 2004). A German study demonstrated MRI as being 100% accurate in diagnosing anterior talo-fibular ligament injuries. Interestingly this study also recommends MRI in the monitoring of conservatively treated ruptures (Kreitner et al, 1999). Using MRI to evaluate the talar tilt test has been proven reliable to detect complete double ligament rupture (ATFL and CFL) where the tilt was greater than 15 degrees compared to the uninjured side (Gaebler et al, 1997). Mostly CT and MRI are only done if the athlete or patient complains of persistent pain and instability despite the recent suggestion that MRI is playing an increasingly important role in detecting ankle injury, confirming diagnoses and predicting prognosis of ankle injury and associated complications and is seen as the modality of choice for evaluating ligamentous injury (Tham et al, 2008; Collins, 2008)

All of the above findings support the researcher's approach to use mechanical tests without confirmation of diagnosis through radiographic assessment. It is however evident that imaging is becoming increasingly important for the clinician to make an accurate diagnosis especially in athletes where persistent pain exists or recurrent injuries take place (Collins, 2008)

2.7 FUNCTIONAL INSTABILITY

2.7.1 DEFINITION

Functional instability is defined as the occurrence of recurrent ankle instability and the sensation of joint instability due to the contribution of proprioceptive, neuromuscular deficits and postural control (Hertel, 2002). In the past, it was loosely referred to as the giving way of the ankle compared to mechanically unstable ankles with an anatomical aetiology and even then it was reported that 40% of mechanical instabilities were subsequently deemed functionally unstable (Freeman, 1965).The ankle joint is stabilized by joint orientation, ligamentous restraints and muscular contraction controlled neurally, and therefore insult to any one of these components can lead to functional ankle instability. Earlier discussion on the anatomy and mechanical joint considerations has included each of the subsystems individually. The athlete often describes the problem as an intermittent 'giving way' of the ankle. Gait on uneven surfaces becomes challenging and a component of fear-avoidance is built in, where athletes are apprehensive regarding repeated episodes. Functional stability is controlled by balance and proprioception, which are both functions of central control. It is further complicated by residual mechanical laxity and strength deficits (Konradsen et al, 1998). For an ankle to be functionally stable it has to be able to adapt to the SAID-principle (specific adaptation to imposed demand) roughly translated into the patient being able to withstand the stresses placed on the tissue during the performance of activities required for the specific sport (Mattacola and Dwyer, 2002).

Previously it has been reported that patients with higher perceived instability showed signs of instability during functional performance more so than those with no perceived signs despite mechanical injury. It has also been shown that patients with similar reported deficits do not necessarily experience the same functional limitations (Buchanan et al, 2008).

2.7.2 PREDISPOSING FACTORS FOR FUNCTIONAL INSTABILITY

The exact aetiology of functional instability is unknown but has been described in a synopsis of predisposing factors as suggested by different authors (Bosien 1955; Freeman and Wyke 1967; Mattacola and Dwyer, 2002, Haraguchi et al, 2007). The possible reasons why functional instability occurs have existed for a while and were described as early as 1955.

- It is postulated that ligaments heal in a lengthened position due to scars filling the gap between the two torn ends (Mattacola and Dwyer, 2002; Denegar et al, 2002).
- Scar tissue is inherently weak and thus healed ligaments are also thought to be weaker (Mattacola and Dwyer, 2002)
- Persistent peroneal weakness especially described in the incompletely rehabilitated ankle (Bosien, 1955; Ashton-Miller et al, 1996)
- Hereditary hypermobility (Mattacola and Dwyer, 2002)
- Unrecognized disruption of the distal tibiofibular ligament which allows for increased tibio-fibular translation (Mattacola and Dwyer, 2002)
- Loss of proprioception of the foot related to injury of the mechanoreceptors and their afferent nerve fibres, impaired reflex stabilization and peroneal nerve dysfunction leading to delayed muscle response (Freeman and Wyke, 1967)
- The loss of relative absence of proprioception from hip and knee joint or relative signs of decreased postural control (Beynnon et al, 2002)

2.7.3 BALANCE AND PROPRIOCEPTION

It has been shown that the presence of ankle injury leads to sensorimotor deficits in athletes and that both feedforward and feedback mechanisms of control are altered. This is further qualified as alterations in conscious perception of afferent somatosensory information as input mechanism, reflex responses on a primitive level and with the output of efferent motor control (Hertel, 2008)

Balance or postural equilibrium depends on the ability of the afferent nervous system to determine the body's position relative to the ground assessing gravitational forces. For complete postural control, input from the vestibular, visual and somatosensory sources is required. The input information must then be analyzed and integrated by the central control system to determine the motor control required. The existence and importance of retraining the feed forward mechanism where the impending event is identified and muscular co-activation precedes the stimulus is required for normal kinetic control of motion (Hertel, 2008). This is in contrast with the feedback mechanism where re-establishing balance after an event challenging the system has occurred (Motram and Comerford, 1998).These two mechanisms present the components of proprioception.

Proprioception is sometimes referred to as the collection of sensations regarding joint movement (kinaesthesia) and joint position. Proprioceptors are found in joints relaying a message to the central nervous system regarding the position of the joint in space and related gravitational forces (Denegar and Miller, 2002). A very early definition of proprioception is that there are receptors that read neural inputs originating from structures around the joint including muscles and tendons (Sherrington, 1948). When mechanical stresses are applied, proprioceptors respond by generating neural impulses which are relayed to the central nervous system. Four types of receptors have been defined (Wyke, 1972). Type I respond to mechanical stress and have a low-threshold and slowly respond to external stress. These receptors are active in the joint whether it moves or not. Type II respond rapidly but still have a low threshold. These receptors only function momentarily at the onset of movement. Type III requires high-threshold stimuli to activate the mechanoreceptors which are only

active at the extremes of range of motion. Type IV play no part in an immobile joint and are only activated with deformation of major mechanical stress (Wyke, 1972). It is important for Type III and IV receptors to be active during activity especially with the load imposed during sporting activities where the sensory system has to assess and judge the different surfaces and ground contact and then has to adapt to it (Wyke, 1972).

More recently the somatosensory system has been described as being controlled by quick (mediating sensation of joint motion) and slow (relaying joint position and sensation) adapting mechanoreceptors, which can detect touch, pressure, pain, and joint motion and position (Taube et al, 2008). These receptors act as protectors for the ankle joint relaying information to protect the ankle. These mechanoreceptors will be suppressed after injury due to the presence of inflammation. Hertel, 2008 takes it further by referring to motorneuron excitability that has been reduced in subjects with chronic ankle instability which lead to reduced reaction time for peroneus and soleus but also more proximally the quadriceps and hamstrings have also been affected. There is no conclusive evidence to suggest that reflex reaction to inversion perturbation is reduced in the peroneus complex but it is suspected (Hertel, 2008). Muscle strength deficits are also attributed to the motorneuron pool excitability rather than actual damage to the muscle or tendon complex (Hertel, 2008).

The vestibular system, which responds to information from the vestibules and semicircular canals of the inner ear, helps to maintain overall body posture and balance. The visual system provides the central nervous system with visual cues for use as reference points in orienting the body in space. The somatosensory, visual and vestibular systems contribute to postural control and with acute injury there is deficits reported that recover quite quickly for the involved as well as the uninvolved leg with the latter improving much quicker. In the chronic ankle instability subjects marked differences in postural control was noted. There also seem to be a central mediation of postural control because it was evident that subjects who trained the injured ankle with rehabilitation had bilateral improvements in postural control tasks (Hertel. 2008).

The key role played by the somatosensory system helps to explain why some athletes tend to repeatedly injure certain joints. For example, when an athlete sprains an ankle, he/she usually damages not just the ankle ligaments but also the somatosensory system's mechanoreceptors which are dispersed throughout the ankle joint. As a result, kinaesthetic acuity for the ankle joint (the ability to detect ankle-joint movements) diminishes. As a result, the ankle remains relatively unstable long after the torn ligaments have healed. Naturally, researchers have been intrigued by the possibility that improved postural control might reduce the risk of injury - and even improve performance (Riemann, 2002). But each component is required to be intact, or in some way compensated for, before an ankle can be deemed functionally stable. There are two components to the assessment of functional instability. The first is static and the second dynamic postural control. The principle of functional balance testing rests on being able to measure the centre of balance and limits of postural sway to derive information regarding the sensorimotor systems involved in postural control (Mattacola and Dwyer, 2002). Proprioceptive feedback is crucial in the conscious and unconscious awareness of a joint or limb when dynamic movement occurs. Improved functional control is required for prevention and rehabilitation of ankle injuries (Ergen and Ulkar, 2008). Balance is decreased in individuals where time to stabilize upon ground reaction takes longer. This is evident in subjects with chronic ankle instability. The difference in response to perturbation may be indicative of central sensorimotor changes (Brown and Mynark, 2007). Spinal and supraspinal adaptations have been investigated and the use of balance training to improve postural control has been shown. There is also evidence to indicate that it can lead to increases in muscle power by improving motor performance through rehabilitative and preventative measures. This again underlines the plasticity of the sensorimotor system. (Taube et al, 2008, Hertel, 2008).

In a study by Hrysomallis et al, 2007 it was established that balance can be seen as a strong predictor of ankle and knee injuries and is regarded as a risk factor that can be modified with the correct management. This study also suggested that further studies be done to determine an optimal management plan for such injuries en the associated deficits (Hrysomallis et al, 2007).

2.7.3.1 OUTCOME MEASURES OF POSTURAL CONTROL

There are a multitude of tests available to determine static and dynamic control of postural sway and thus functional stability of the lower limb. These are often used to determine the functional and proprioceptive abilities of the ankle joint (Gribble et al, 2004; Susco et al, 2004; Friden et al 1989).

There are objective instrumented stabilometry tests available (Kinzey and Armstrong, 1998). In a study on Australian netball players, the FootTrak Motion Analysis System was used, to determine the angle of inversion of the calcaneus by using video equipment (Mashawari et al, 2003). In another study on netball players the NeuroCom Balance Master was used which measures force distribution during stance by using a force platform and a personal computer (Riemann et al, 1999). Good correlation between these and a clinical test, the Balance Error Scoring System (BESS) has been described (Riemann et al, 1999) and a similar test know as the Romberg position where the athlete is required to stand on one leg so the patient's ability to maintain the position can be assessed compared to the uninvolved side (Kawaguchi, 1999). The other non instrumented measure used, is length of time in equilibrium (Crotts et al, 1996). To determine dynamic control it has been suggested that the Star Excursion Balance Test (SEBT) be used (Olmsted et al, 2002). The advantages of using non instrumented measures is that expensive sophisticated equipment is not required although one must consider that these tests are much less sensitive and are only a subjective interpretation of the function of the whole kinetic chain during weight bearing and they do not only address the ankle joint (Olmsted et al, 2002). Other more dynamic assessments have been used to assess functional performance testing for participants with functional ankle instability namely the single-limb hopping test and single-limb hurdle test. The hopping test was shown to be an effective indicator of performance deficits and could also be used by clinicians as an assessment and treatment tool (Buchanan et al, 2008). There was also a high correlation found between subjects with reported functional ankle instability on a self-assessment questionnaire and the functional

stability tests for the single leg hopping test to the side and in a figure eight (Arnold et al, 2005).

2.7.3.1.1 STATIC POSTURAL CONTROL: BALANCE ERROR SCORING SYSTEM (BESS)

Static postural control is interpreted as the control required for maintaining postural control at rest. It is however suggested that the ability to maintain balance is decreased with exertion and not always related to stability of a specific joint's function (Susco et al, 2004).

Tests used in the literature for static control include the Balance Error Scoring System (BESS), (Riemann et al, 1999) and a computerized long force-platform sway measure of the Neurocom Smart Balance Master as well as the Chattanooga Balance machine (Troijan and McKeag, 2004). The results derived from clinical and computerized testing show good correlations between the two (Trojian and McKeag, 2004). Researchers have shown that postural control performance in single limb stance is related to risk of ankle sprain (Hertel et al, 2001).

The BESS was developed as a clinically objective assessment tool for the evaluation of postural-stability deficits after concussion. It was however shown that the test is both reliable and valid for head injured and healthy subjects in controlled laboratory environments (Riemann, et al, 1999; Susco et al, 2004). In previous studies the use of expensive computerized equipment has been advocated but similar results have been produced with moderate correlation between the NeuroCom Balance Master and the BESS (Yaggie, et al, 1999). As testing equipment is not available at the field-side, clinical tests are suggested as a more practical option (Riemann et al, 1999). The use of the BESS has been suggested in a study comparing different techniques for assessing balance but it must be clear that no one standing balance test whether functional or static can be used to isolate evaluation of solely the ankle joint (Guskiewicz and Perrin, 1996). As described earlier in this review the ankle is a

part of the whole kinetic chain and a deficit at any point in the chain would affect balance and ultimately postural control (Nyska et al, 2003; Riemann, 2002).

In a study on the effect of chronic ankle instability on postural control it could not be shown that injury to the ankle would be the sole causative factor affecting postural control and it is suggested that each individual must be assessed for possible contributions to postural instability (Riemann, 2002). It is evident though that the decreased afferent input through injury to mechanoreceptors can contribute to postural control deficits (Riemann, 2002).

The test is performed in three progressive stance positions with the difficulty rating increased: double leg, single leg and tandem stance. These are repeated on two different surfaces: firm and foam. The number of errors made by the subject in a period of 20 seconds is counted. If a subject made any errors the test is assumed as positive for the BESS. Errors include opening the eyes, lifting any part of the foot and stepping out of the stance position (Waterman et al, 2004)

2.7.3.1.2 DYNAMIC POSTURAL CONTROL: STAR EXCURSION BALANCE TEST (SEBT)

Dynamic postural control can be seen as the patients' ability to maintain balance while movement takes place and has been used to investigate the deficits in subjects with chronic ankle instability (Olmsted et al, 2002). Previously it has been used to investigate the lower extremity reach deficits in patients with chronic ankle instability and was shown to be an effective measure to determine reach deficits (Olmsted et al, 2002).

The suggested measure for dynamic postural control is the Star Excursion Balance Test (SEBT), which has been established as highly reliable and valid for both research and clinical purposes (Kinzey and Armstrong, 1998; Hertel et al, 2000; Gribble et al, 2004; Olmsted et al, 2002). The test is both meaningful and relevant to determine postural control. The SEBT appears to be sensitive in detecting reach deficits both between and within athletes with instabilities. It is

an effective means for determining reach deficits in subjects with possible functional instability. It is described as a functional test that quantifies lower extremity reach while challenging an individual's limits of stability (Olmsted et al, 2002). It must be noted that the SEBT is a dynamic assessment tool and tests the athlete's ability to maintain the centre of gravity over a stable base of support without losing balance while leaning or reaching activities are performed (Gribble et al, 2004). As with the BESS it must be emphasised that the test is not specific to determine only function at the ankle joint rather that it is a tool to assess postural control with associated incidental ankle findings

More recently the use of the dynamic postural stability index has also been advocated because it is seen as a sensitive measure of dynamic postural control and can detect the subtle differences between individuals with or without functional stability deficits (Wikstrom et al, 2007).

2.7.3.2 IMPLEMENTATION AND USE OF POSTURAL CONTROL

Return to competitive participation can only be effective once sport specific training has been done. For this to effectively take place the athlete must be able to stabilize joint motion through range of motion, thus control the excursion of the joint during normal movement. There are signs of central neural mediation of postural control described in the literature based on proprioceptive feedback. The recruitment of low frequency motor units will lead to tonic firing of the muscle which in turn stimulates local stabilizers to control the neutral position of the joint and aids in the postural holding associated with eccentric deceleration or resisting momentum (Grimby and Hannerz, 1976; Comerford 1997). This is supported by a study in which unilateral training increased bilateral postural control (Rothermel et al, 2004). By improving postural control of the unaffected limb there might be an overflow to the injured limb (Zöch et al, 2003). Effective rehabilitation strategies must be based on an understanding of the physiology of healing to prevent chronic ankle instability and to regain postural control and re-introduce the athlete to the sporting arena gradually. The most effective way to manage these patients is most certainly to prevent ankle injury in the first place. (Denegar and Miller, 2002).

While investigating the relationship between functional ankle instability and postural control it was found that the control of the ankle inversion position is affected where there is functional ankle instability. There are signs of decreased control in stance and time to recover from perturbation is longer in the ankle with functional instability (De Norhonha et al, 2008). In this study the 2.21 seconds was the mean recovery time in the instability group and 1.43 seconds in the external control group. The mean variability of the reference measure of instability for inversion was as follows: 2.0˚ for the instability group and 1.4˚ for the control group (De Noronha et al, 2008).

To get injured players back to competitive participation mechanical and functional factors have to be addressed and controlled and therefore standardized testing is required and will assist in effectively managing acute injuries and preventing chronic ankle instability.

It has been suggested that finding a standardized regime to evaluate and clinically monitor progress after acute ankle injury would be very useful to predict which athletes will be at risk of sustaining further injury or who have decreased functional stability (De Norhona et al, 2008; Denegar and Miller, 2002; Van Dijk et al, 1996).

2.8 CHRONIC INSTABILITY

2.8.1 MECHANICAL AND FUNCTIONAL FACTORS RELATING TO CHRONICITY

The stability of the ankle joint is affected after injury and pathomechanical changes occur which can lead to chronic ankle instability. The changes that occur include soft tissue changes in ligamentous structures, which heal with scar tissue (De Norhona et al, 2008).

Ligaments and tendons have the unique quality that collagen tissue is laid down in parallel bundles which forms a dense web of connective tissue designed to withstand crimping when loaded. Crimping is the ability of the tissue to withstand forces without unduly lengthening or eventually tearing. Normal connective tissue consists of minimal ground substance and scattered fibroblasts. When connective tissue is injured and tissue healing is in the repair phase there is re-epithelisation that leads to wound contraction and the reproduction of collagen. Build up and breakdown of collagen take place during the remodelling phase. The arrangement, orientation and aggregation of the newly grown tissue with existing tissue takes place in the remodelling phase with the formation of cross linkages that form adhesions. Where increased joint mobility is not addressed tissue repair is compromised and the torn ligaments heal in an elongated position if the talus remains anteriorly subluxed and repeatedly glides anteriorly. This result in hypermobility at the ankle joint in that direction with a compensatory decreased posterior glide, a compensatory hypomobility of dorsiflexion occurs. This in turn compromises the affected and surrounding joints (Denegar and Miller, 2002). When the joint is overloaded during the healing phase the healing process is compromised and the ligaments heal in lengthened positions. Where there is resultant hypomobility, due to the position mentioned earlier, the axis of rotation is changed. This leads to altered proprioceptive input to the central nervous system and a vicious cycle of instability may occur (De Vries et al, 2008; Denegar and Miller, 2002).

Because of the competitive nature of sport, a player is expected to return to sport as soon as possible and often the normal phases of healing post-injury are not observed. In the literature there is very little consensus about the time that is taken for a ligament to regain 85 – 95% of it's normal tensile strength and these figures ranges from 16 to 50 weeks (Woods et al, 2003; Houglum, 1992). Poor results after ankle sprain are also linked to intra-articular damage such as

chondral flaking, syndesmotic irritation as well as neural and musculotendinous damage. These are in most cases related to more severe ankle sprains (Sausser et al, 1983).

An earlier study showed that the anterior drawer and talar tilt tests were applied at eight weeks and 24 weeks after acute ankle sprain and initial injury was determined with stress radiographs taking 6˚ or greater as a positive talar tilt test and 3mm or more side to side differences as a positive anterior drawer test. The eight and 24 week interval testing was done only with clinical evaluation. The authors reported that approximately 12% of participants had a positive anterior drawer at eight weeks after injury. The number decreased to approximately 3% at six months after injury. Despite the small percentage of participants who had mechanical laxity as determined with manual stress tests, the authors reported that approximately 70% of participants had residual symptoms at eight weeks after injury; and 42%, at six months. Residual disability included functional instability, swelling, pain, abnormal gait, and tenderness (Cetti et al, 1984). Again this supports the fact that even though the athlete returned to sport there were still aspects of functional instability present which could predispose to future injury.

In the literature a distinct line is drawn between functional and mechanical instability but it is also postulated that they form a continuum of pathological contributions to chronic ankle instability (De Norhona et al, 2008, Riemann, 2002, Hertel, 2002)). Ligamentous injury leads to a mechanical stability deficit which in turn can lead to functional instability when there are repetitive challenges to the integrity of the ligament complex with inadequate healing time (Hertel, 2002). Certain predisposing factors to ankle injuries have been investigated and these include muscle tone abnormalities, proprioception problems and shortening of the capsule or tendinous structures which is thought to be due to inadequate sport specific training, specific for the activity to be performed. Changes in dynamic force distribution are evident in patients with chronic instability (Nyska, 2003). Provocative factors include accidents or trauma *(traumatic incidents overstraining the tensile limits of the joint)*, obesity *(the greater weight the greater the risk of injury)* and kinetic energy applied in excess of joint design limits *(force applied greater than the tensile limits of the*

joint during dynamic motion) (Foster, 2004). Other factors identified include gender, *(more laxity in females has been identified which might be related to hormones)*, height and weight distribution, limb dominance *(left or right)* and generalized laxity whether genetic or due to the need for joint excursion in certain sports such as dancing or gymnastics (Beynnon et al, 2002).

The line which represents a continuum between mechanical and functional instability that will lead to chronic ankle instability is supported by the study, by Hubbard and Hicks-Little, 2008. The study reported on two other studies where the use of stress radiographs and a manual stress examination to measure mechanical laxity after an ankle sprain were assessed. In the first study all patients in the study had a rupture of the anterior talo-fibular ligament alone or in combination with the calcaneo-fibular ligament. Rupture was verified arthrographically in all participants. The exact timeline when patients were examined was not reported. The role that recurrent injury may have played in the study is also unknown (Hubbard and Hicks-Little, 2008).

The second study objectively measured mechanical stability based on the manual anterior drawer test was used in yet another study. It was reported that all patients had a recent ankle sprain and had a ligament rupture verified by arthography. The manual anterior drawer test was performed to test mechanical laxity. To subjectively assess instability, participants were asked about residual symptoms, particularly a feeling of instability in the ankle, swelling, aching, pain on movement, and further sprains. A percentage of between 28 – 31% of participants still had a positive anterior drawer more than one year after the initial ankle sprain. Although most participants were symptom free at follow-up, 20% reported that their ankles felt unstable. Specifically, those participants reported that their ankles felt weaker and gave way (Hubbard and Hicks-Little, 2008).

Ankle sprains are often seen as recurrent injures and the literature shows this with percentages as high as between 56%, and 75% where players with a sprain reported previous injury to the lateral ligament complex of the ankle (Anandacoomarasamy and Barnsley, 2005; Woods et al, 2003; Nielsen, 1989). Most authors agree that an injury leads to re-injury and that this plays a role in

future athletic performance (Taube et al 2008, Woods, et al, 2003, Kawaguchi, 1999).

With injury there are alterations in the sensorimotor control system which affects the whole spectrum from conscious perception of the input from the somatosensory system, reflex reaction instituted by the body and efferent motor control deficits that are present. This again suggests that both the feedback and feed forward mechanisms of postural control is altered with ankle injury (Hertel, 2008).

There have been effective results shown with respect to the ankle and knee joint with the use of balance training to reduce postural control deficits and prevent future injury (De Norhona et al, 2008) Based on this the use of non-invasive electrophysiological imaging and imaging of the brain revealed that there is benefit in improvement of postural control with balance training to the extent that it improves postural control. This underlines the plastic nature of the sensorimotor system for spinal and supraspinal structures where adaptations to imposed demand can aid in injury prevention and improve athletic performance (Taube, 2008).

Subtalar joint motion has been investigated and it is evident that abnormal subtalar motion is linked to injury. Where there has been previous injury, subtalar laxity is often evident and when the subtalar ligaments do not control end range of pronation or supination the ankle is again at risk for further injury (Hertel et al, 1999).

The reaction time of a normal peroneal muscle occurs too slowly to control all movement, but there should be a degree of preparatory muscular activation from peroneus prior to ground contact with the foot. This is of cardinal importance for muscular control to protect the joint (Mattacola and Dwyer, 2002). The retraining of proprioception has also indicated a slower reaction time of the tibialis anterior and posterior which are inherently inverters of the foot thus protecting against further inversion during an ankle sprain (Kernozek et al, 2008).

Patients with chronic ankle instability have an altered gait pattern with longer duration of contact of the heel to central forefoot which indicates that weight transfer from heel strike to toe off is slowed down due to hesitation to transfer weight onto the forefoot. The delay in these patients towards the end of the stance phase is to ensure that the foot has enough time to stabilize. In most cases this is with the use of lateral shift of the centre of pressure. Increased lateral load of the foot in the stance phase could be due to reduced proprioceptive function and diminished peroneal strength, however further studies have shown that central / neurological control plays a greater part since there is no major difference between the injured and uninjured leg's strength (Nyska, et al, 2003).

2.9 PERCEIVED INSTABILITY: OUTCOME MEASURES

The following outcome measures were identified by Haywood et al, 2003. A study investigated through a structured review, the multi-outcomes measures for lateral ligament injury and established the most useful measures (Haywood et al, 2004).

Seven disease specific measures:

- Ankle Joint Functional Assessment Tool
- Clinical Trauma Severity Score
- Composite Inversion Injury Scale
- Kaikkonen Functional Scale (KFS)
- Karlsson Ankle Function Score (KAFS)
- Olerud and Molander Ankle Score (OMAS)
- Point System

(Haywood et al, 2004)

Two generic measures of health:

- McGill pain questionnaire
- Sickness Impact Profile

(Haywood et al, 2004).

The McGill pain questionnaire is a general questionnaire designed to determine the level of pain experienced and can be applied to any pain experience. The Sickness Impact Profile relates to the impact of a 'sickness' or injury on the person, thus the two generic tests are broad-based and non-specific for ankle injury. The conclusion was made that evidence supporting the use of five of the other tests is lacking and that they should be cautiously applied. The study by Haywood in 2004 does, however suggest that the Karlsson Ankle Functional Score and the Olerud and Molander questionnaire are the most promising where self- /patient-assessed evaluation of function is required (Haywood et al, 2004). The Olerud and Molander Ankle Score (OMAS) has been identified as an investigative tool previously used by other investigators and suggested by Olerud and Molander to make studies of ankle injury more comparable (Olerud and Molander, 1984; Rose et al, 2000).

The Olerud and Molander questionnaire has limited use for indicating subjective improvement in symptoms but it has been suggested that it can be effectively used to investigate the relationship between subjective and objective instability because the athlete can compare the self-evaluation questionnaire to the advice given by medical practitioners (Rose et al, 2000). In their study although significant improvement in objective tests and the Olerud and Molander questionnaire was shown there were still signs of Sway Index dysfunction which was tested through functional stability tests (Rose et al, 2000). This was evident for the injured and uninjured leg in the affected individual and raises the question of whether some individuals are predisposed by postural sway vulnerability (Rose et al, 2000). The use of the Olerud and Molander questionnaire is further supported by its effective use in some studies and it has been deemed reliable and valid in research (Rose et al, 2000). The

Olerud and Molander questionnaire firstly investigates the patient's clinical signs and symptoms including questions regarding pain, stiffness and swelling. The second part of the questionnaire is dedicated to determining the functional impact of the injury on the participant's ability to function in activities of daily life and sport. It also determines whether or not the participant requires external support in the form of taping or bracing, to function. The use of self-evaluation questionnaires are further supported by a study that assessed the dynamic postural stability deficits in subjects with self-reported ankle instability and it determined that the dynamic postural stability index was a sensitive measure of dynamic postural stability and was able to detect differences between functionally stable and unstable ankles (Wikstrom et al, 2007).

Another assessment tool, the foot and ankle ability measure (FAAM) has also been introduced as a self-assessment questionnaire to detect disability and dysfunction of the foot and ankle during activities of daily living and with sporting activities (Garcia et al. 2008).

2.10 MANAGEMENT OF ANKLE INJURIES

2.10.1 ACUTE STAGE

The acutely injured patient will present to general practitioners, casualty departments and more recently also physiotherapists and trauma assistants at field side, as first line practitioners and these patients have to be accurately assessed and correct management instituted. Once a decision has been made regarding further investigations based on the Ottawa ankle rules, diligent clinical examination must be done of all relevant structures (Fong et al, 2008; Petty and Moore, 2001).

Once it has been established that the nature of the injury does not require that further precautions be taken, the RICE- regime comprising of rest, ice, compression and elevation must be applied. In cases where weight bearing is affected the use of crutches or an external support may be advocated to protect

the ligaments and joint structures from any further damage (Van Dijk, 2002; Trojian and McKeag, 1998).

Once the acute inflammatory phase of healing has been addressed, functional rehabilitation needs to be undertaken. This might happen simultaneously depending on the severity of the injury and the symptoms experienced by the athlete or injured subject.

2.10.2 FUNCTIONAL MANAGEMENT PHASE

In the literature different approaches to rehabilitation have been suggested but it seems that a holistic functional rehabilitation regime renders the best outcomes. This is based on a 2002 Cochrane review that suggested that functional treatment seems the most appropriate management for acute ankle injuries but results have to be interpreted with caution because most trials are poorly reported and there were a variety of interventions evaluated. Assessing mechanical integrity was also not standardized in these trials (Kerkhoffs et al, 2002). There were results that indicated that early mobilization lead to earlier return to work and sports after surgical intervention (De Vries et al, 2008). There was low quality methodology in most of the studies covered by the review and therefore the evidence was not conclusive to support either conservative or surgical treatment (De Vries et al, 2008; Samoto et al, 2007).

To be functionally rehabilitated means that the athlete can return to competition. Return to competitive participation can only be effective once sport specific training has been done. For this to effectively take place the athlete must be able to stabilize joint motion through range of motion, thus control of the excursion of the joint during normal movement. There are signs of central neural mediation of postural control described in the literature based on proprioceptive feedback. The recruitment of low frequency motor units will lead to tonic firing of the muscle which in turn stimulates local stabilizers to control the neutral position of the joint and aids in the postural holding associated with eccentric

deceleration or resisting momentum (Grimby and Hannerz, 1976; Comerford 1997).

This is supported by a study in which unilateral training increased bilateral postural control (Rothermel et al, 2004). Researchers have shown that by improving postural control of the unaffected limb there might be an overflow to the injured limb (Zöch et al, 2003). There is also evidence to support the use of stochastic resonance stimulation which improved the centre of pressure measures in subjects with functional ankle instability after a six week training program and therefore lead to increased postural control (Ross et al, 2007).

Effective rehabilitation strategies must be based on an understanding of the physiology of healing to prevent chronic ankle instability and to reintroduce the fully rehabilitated athlete to active participation (Denegar and Miller, 2002). It has to be remembered the most effective management though is to prevent ankle injury in the first place (Denegar and Miller, 2002).

It has been suggested that finding a standardized regime to evaluate and clinically monitor progress after acute ankle injury would be very useful to predict which athletes will be at risk of sustaining further injury or who have decreased functional stability (De Norhona et al, 2008; Denegar and Miller, 2002; Van Dijk et al, 1996).

In the clinical setting it is up to the clinician to plan and then implement the rehabilitation programme. The following guidelines have been suggested:

- a comprehensive knowledge of the anatomy, physiology and biomechanics of the joint (Brukner and Khan, 2007).
- an understanding of how the locomotor system functions, specifically addressing the speed, acceleration, end of range stressors and mid-range control of motion so all mechanoreceptors are considered (Wyke, 1972)

- knowledge of the athlete's required functional needs (Brukner and Khan, 2007)
- addressing demands specifically related to the sport to which the athlete needs to return to (Molnar, 1988)
- effectively addressing sensorimotor deficits after acute ankle sprain (Hertel, 2008; Taube et al, 2008).

Based on the five points above any regimented rehabilitation programme can be developed. An important key to effective rehabilitation is establishing a baseline measurement of ankle function to be able to measure and document objective changes (Kawaguchi, 1999). The whole process is described in phases of healing, and rehabilitation should be based on the tensile strength of the healing tissue. The acute phase or acute inflammatory phase last from 48 – 72 hours and is focussed on limiting the amount of damage and protecting the injured tissue. The sub-acute phase lasts from day five after the injury to week six post-injury and only 15% of normal tensile strength is achieved during this phase and gradual loading is allowed. During this phase exercises should focus on regaining normal functional range of motion, decreasing swelling and inflammation, graduated return to full weight bearing, static resisted exercise to retain optimal strength. In this phase the focus should be on postural control exercises to avoid movement dysfunction and to address existing muscle imbalances which might have lead to the injury. Functional rehabilitation can be attempted after six weeks when the injured tissue has about 85% of its normal tensile strength and this phase can last up to two years (Hertel, 2008; McGuine and Keene, 2007; Mohammadi, 2007).

The functional rehabilitation included isometric, isotonic and isokinetic strengthening for open and closed chain, proprioception, balance retraining and stretching to ensure normal joint excursion (Brukner and Khan, 2007).

Stretching or regaining normal range of motion is required for normal locomotive activities. Where there are problems with relative flexibility, the body will adapt by predisposing another area to injury in order to regain

functional motion (Motram and Comerford, 1998). Secondary to flexibility is strength provided by the primary dynamic stabilizers for the joint. Here muscle strength, power and endurance are required for normal motor control (Davies, 1997). The concept of strength is based on concentric, eccentric, isotonic and isometric contraction of the controlling musculature and all these components must be addressed (Davies, 1997). Strengthening is based on the principles of: periodization, progression, overload, specificity and relative rest which allows a muscle to optimally function under loaded circumstances (Brukner and Khan, 2007; Davies 1997). Recently it has been showed that alterations in the afferent processes could affect the evertor's strength and timing of contraction and therefore the importance of proprioception is supported. The study by Santos and Lui, 2008 established deficit and non-deficit categories in functionally unstable ankles. There were definite balance and strength deficits in the injured group between the injured and non-injured ankle and also between players in the control group and those with functional ankle instability. Mechanical alterations were present in the functionally unstable ankle and can range from limited range of motion or joint laxity, proprioceptive deficit, muscular weakness, decreased balance to delayed neuromuscular reaction time (Santos and Liu, 2008). When there is functional ankle instability the medio-lateral stabilization is delayed. The somatosensory receptors are affected and this leads to a delayed motor response which in turn affects postural equilibrium. The results showed that there was a difference in performance of the single leg hop test for the stable and unstable groups in this study. The patients with instability took longer to recover than the stable group and had a greater variability of the reference measure for inversion (De Noronha et al, 2008). This supports retraining of feedback and feed forward mechanisms by improving proprioception and balance (Motram and Comerford, 1998). In a systematic review, by Zőch et al, 2003, it was revealed that the most effective program for rapid restoration of ankle movement, strength, endurance and proprioception is one that addresses each component individually. Disc training or balance retraining on a foam surface, for the ankle seemed to be the optimal exercise to improve proprioception and restore range of motion; the secondary support that seemed to be most efficient is taping or bracing to prevent injuries. The external support acts to control joint excursion. Strength deficits in both the injured and

uninjured leg can be improved by isokinetic training utilizing the cross-over effect of training (Zőch et al, 2003).

In a study on the supraspinal and spinal adaptations associated with balance training it was shown that in the past balance training was used to rehabilitate deficits in proprioception after injury (Taube et al, 2008). It also supported that the use of balance training to prevent injury is also advocated and it has also been shown that there might be improved motor control due to the input mechanisms to the central control system. It was evident that with balance training there were neurophysiologic changes that would ultimately influence the motor control. This study supports its use not only in athletes, but also the elderly and in injury prevention strategies (Taube et al, 2008).

Balance training has been showed to be effective in significantly reducing the risk of ankle injury in high school athletes playing soccer and basketball. A study to test this showed that the participants were divided into two groups where the first group only received conditioning exercises and the second was given a balance training program with great reduction in the incidence of ankle injuries in the balance retraining group (McGuine and Keene, 2006). A basketball-specific balance retraining program was also seen as effective to reduce acute ankle injuries in basketball players by using a wobble board for a home-based training program (Emery et al, 2007).

A study on soccer players by Ergen and Ulkar (2008) showed that balance training in effective in preventing ankle injuries. It is suggested that the athlete be managed by a comprehensive training programme that includes proprioceptive retraining to enhance functional joint stability for both prevention and management strategies (Ergen and Ulkar, 2008).

In another study, by Mohammadi (2007), on soccer players further supported the effectiveness of proprioceptive rehabilitation where it showed the effectiveness in a prevention study in soccer players compared to no intervention. The players who received proprioceptive input were however not

markedly improved from those who underwent a strength training program or were given orthotic support (Mohammadi, 2007).

In volleyball players there were significant reductions in ankle sprains for the players who had previous injury to the ankle once they were given a prescribed balance retraining program (Verhagen et al, 2004).

2.10.3 FUNCTIONAL MANAGEMENT OF ANKLE INJURIES IN RUGBY PLAYERS

Supports in the form of taping or bracing have been used with success in rugby union for the management of ankle injuries. It is suggested that the external support should be able to sustain forces between six and 56 kilograms for it to exceed the strength of the ligament. Tape cannot provide enough mechanical support but the proprioceptive effects may contribute to stability (Hume and Gerrard, 1998). Bracing has been shown to be effective in decreasing ankle inversion sprain and it has been suggested that the International Rugby Board should consider the use of ankle braces in rugby with stiff lateral components for protection (Hume and Gerrard, 1998). Effective bracing requires rehabilitation as well and should not be used in isolation. With bracing alone a relatively weak unstable ankle becomes progressively reliant on the support of the external device (Davies, 1997). Bracing however has definitely showed some benefit in reducing the incidence of recurrent ankle sprain in soccer players (Surve et al, 1994). In a comparative study the use of proprioceptive training, normal technical training or strength training and external supports were compared as to effectiveness and it was shown that there were benefit in all three approaches individually but there was no control group to compare this to (Stasinopoulos, 2004).

A structured warm-up program as part of training can significantly reduce acute severe injuries to the ankle and knee, reported at 50% reduction in the relative injury risk profile (Olsen et al, 2005). This structured program focused on exercises to

improve awareness and control of knees and ankles during standing, running, cutting, jumping, and landing. The regime consisted of balance and proprioceptive exercises including ball work wobble board and balance mat for warm up, exercises for specific sporting technique, balance and strength (Olsen et al, 2005). To finally refine rehabilitation a program for proprioception has to be included (Laskowski et al, 1997). The effectiveness of balance retraining has been underlined in a study on high school football players where inversion ankle sprain was reduced by 77% by a balance training intervention consisting of two phases namely pre-season including balancing on a foam stability mat for 5 minutes twice a day for a period of four weeks and in-season twice a week (McHugh et al, 2007).

The experienced clinician should be able to make an accurate diagnosis before instituting management and refer for specialist intervention if required. To make an accurate diagnosis, clinical reasoning should be based on a sound knowledge of the clinical presentation of lateral ankle injuries (Brukner and Khan, 2007). This is required to identify causative factors and to address these effectively.

2.11 THE IDENTIFICATION AND MANAGEMENT OF PREDISPOSING FACTORS

As mentioned earlier, the need for a national injury register for rugby injuries has been suggested to encourage effective management and injury prevention. Once injuries are identified a clinical picture can be created to enable clinicians to identify potential risk factors or establish a risk profile and effectively address the injured player (Holtzhauzen et al, 2006; Edgar et al, 1995).

Similar registers have been acquired in collegiate sports as explained in the section on incidence of injury (Harmer, 2008; Nelson et al, 2007; Hootman et al, 2007). In rugby two recent epidemiological studies were done in the UK (Sankey et al, 2008; Brooks and Kemp, 2008) and in South Africa a register was compiled during the Super Twelve competition to elucidate all rugby injuries (Hotzhauzen et al, 2007).

Such a register would make it possible to identify the injuries with high risk of incidence in rugby and allow making certain pre-season adaptations to avoid injury to be made as well as to protect the previously injured sites.

The existence of biomechanical factors should also be identified and addressed prior to the athlete participating in the season. When looking at the ankle the identification of the overpronated or oversupinated (rigid) foot; the foot with an abnormally everted calcaneus or cavus foot can aid in protecting the player from injury by managing the biomechanics through training and orthotic support. A simple balance evaluation can identify players with decreased postural control or functional instability and by addressing this before the season the athlete can be protected (Denegar and Miller, 2002).

2.12 CONCLUSION

This chapter included a comprehensive overview of the normal ankle joint. The effect of injury and possible abnormalities in anatomy and biomechanics which might predispose to future injury were discussed as pathomechanics. The key concepts of ankle instability were defined and a detailed description of outcome measures has been discussed as well as evidence advocating the use of various clinical tests.

The ankle joint and stability are managed differently by different medical professionals from the acute management in the casualty setting including the RICE – regime (Rest, Ice, Compression and Elevation) to surgical intervention by orthopaedic surgeons to rehabilitative therapeutic interventions by physiotherapists as well as orthotic support and bracing as advocated by podiatrists.

Relevant is the fact that ankle injuries occur particularly in the sporting population. These injuries if not managed effectively and expediently can lead to recurrence, which in turn can lead to chronic ankle instability. Where factors predicting chronic ankle instability are present, the sportsman will be adversely

affected, especially in sports where high loads are applied to the ankle and where change of direction is required, as in rugby.

There are differing opinions yet again with regards to assessment and management of lateral ankle ligament injuries. Diligent clinical testing by trained professionals should be advocated both for mechanical as well as functional instability. A correct diagnosis is required to institute an effective and comprehensive management plan for both the injury and the postural control deficits.

CHAPTER 3

3. METHOD

3.1 INTRODUCTION

This chapter includes a description of the design of the study, the selection of subjects, outcome measures and the statistical analyses that were used.

3.2 STUDY DESIGN

A cross sectional study design was used where all subjects were tested for perceived instability, exclusion criteria applied and all remaining subjects tested for positive signs of mechanical instability.

3.3 SUBJECTS

Subjects included all the players from the first team squads, from all the clubs in one region of the Gauteng Lions Rugby Union first division, namely the South Gauteng region.

All ten clubs in the region were invited to participate in the study however one club refused to participate and was thus not included.

A total of nine clubs out of the ten in the region participated in the study. Each squad included twenty players consisting of the fifteen players in the team and five reserves. Thus a total of 180 players were eligible for inclusion in the study.

3.3.1 INCLUSION CRITERIA

All players in the squad for the first teams were included in the study provided none had any of the exclusion criteria listed below.

3.3.2 EXCLUSION CRITERIA

- Previous surgery to the lateral ankle ligament complex or ankle joint
- Previous injury (within three months of the tests) of the lower extremity rendering the player out of active participation and therefore not currently playing.
- Patients with recently diagnosed concussion (within 1 month of the tests)
- Patients with ear infection, head cold or upper respiratory tract infection at the time of the study because this could affect the players' ability to balance.

3.4 ETHICAL CONSIDERATIONS

Ethical clearance was obtained ((Clearance Number: R14/49 (26-09-2005) – M050726); (See ethical clearance form Appendix E)), from the Committee for Research on Human Subjects at the University of the Witwatersrand.
Permission was given by the relevant authority on behalf of the Gauteng Lions Rugby Union to conduct the study. Consent was obtained from the management of each club and informed consent was obtained from coaches and players. (See Appendix C and D)

3.5 OUTCOME MEASURES

The tests used are divided into specific tests to determine the prevalence of ankle instability whether perceived, mechanical or functional and tests used to form a description of the clinical picture of players with ankle instability.

3.5.1 TESTS TO ESTABLISH PREVALENCE

1. Olerud and Molander questionnaire
2. Tests to determine mechanical integrity
    a. Anterior drawer test
    b. Talar tilt test / Stress inversion test
3. Test to determine functional instability: Balance error scoring system

3.5.2 TESTS USED TO DESCRIBE THE CLINICAL FINDINGS RELATED TO ANKLE INJURIES

1. Olerud and Molander questionnaire
2. Data questionnaire
3. Star excursion balance test

3.5.3 TESTS USED TO ESTABLISH PERCEIVED FUNCTIONAL LIMITATIONS

3.5.3.1 QUESTIONNAIRE

A questionnaire was developed to, establish demographic data, establish exclusion criteria and to establish possible factors that could create a clinical picture of players with mechanical and functional instability. This questionnaire was designed with input from coaches and medical personnel in the club rugby fraternity, to establish content validity (Partney and Watkins, 2000). (See appendix A)

The first section of the questionnaire was developed to establish the exclusion criteria. In the second section general information about the player was included namely position, occupation, time spent playing rugby at club level, age, height and weight. To compile the third section, an expert group of coaches and

medical personnel were consulted to develop questions that could establish a clinical picture of players with signs of instability and questions that could be used to determine risk factors as well as future suggestions for the management of these players in order to establish the content validity of the questionnaire.

To ensure that the questionnaire was clear and easy to understand a pilot study was undertaken on a group of players not involved in the main study and changes made as suggested by the participants. The researcher was present during the answering of the questionnaire and players could ask questions if required to do so.

3.5.3.2 OLERUD AND MOLANDER QUESTIONNAIRE

The Olerud and Molander questionnaire includes a detailed previous history of injury to the ankle ligament, determining the state of self assessed functional instability of the ankle as perceived by players. It is thus a subjective measure of the ability of the ankle to handle functional expectations during a game (Appendix B).

It is a short questionnaire designed to asses the problems, to which the ankle injury may be directly related. The information obtained was combined with the data generated by the testing procedures. Each player was asked to complete the questionnaire by indicating which of the options was best suited to the specific functional problems experienced, if any. Each answer is scored separately to contribute to the clinical picture and then a percentage is calculated to determine the patients' perceived functional limitations (Rose, et al, 2000). The Olerud and Molander questionnaire is marked in increments of five and therefore any signs of perceived instability suggested by the player will have a score of equal to or less than 95%.

The Olerud and Molander questionnaire is further divided into sub-sections. The sub-analysis gives an indication of the prevalence of clinical signs and symptoms of instability including pain, swelling and stiffness. The prevalence of functional limitations was derived from the players' ability or inability to run,

jump, squat or climb stairs. It also indicates supports required including taping, bracing or crutches and the effect on activities of daily life. This is also used to describe the clinical picture of players with reported ankle problems.

3.5.4 MECHANICAL INSTABILITY

3.5.4.1. ANTERIOR DRAWER TEST

For the anterior drawer test the subject was asked to lie supine and the knee was then semi-flexed to 40˚. This position was achieved with the use of a goniometer; this was done to eliminate the stabilizing effect of a tight gastrocnemius muscle on the excursion of the joint. The researcher was positioned in front of the subject. The one hand stabilized the lower leg while the researcher cupped the calcaneus with the other hand. The researcher used the forearm, of the hand cupping the calcaneus to support the foot in 10˚of plantar flexion. The foot position was again established by measuring with a goniometer. The test was performed by the researcher with the subject instructed to relax and to allow the researcher to move the ankle. The action performed was an anterior displacement or forward pull of the talus and calcaneus while the other hand stabilized the tibia with a constant force (Trojian and McKeag, 1998; Petty and Moore, 1996).

The anterior drawer test was deemed positive if the talus glided or slid anteriorly from under the ankle mortise. In certain cases where an audible clunk was heard the suspected instability was supported by the indication of talar subluxation which indicates greater excursion of the talus and thus instability. The literature mentions that patients might experience pain over the anterior aspect of the ankle joint during testing and this is possibly in part due to the impingement of the anterior synovium or the retinaculum, which in itself is not indicative of ankle ligamentous injury. (Trojian and McKeag, 1998). The researcher performed the anterior drawer test on all players.

3.5.4.2 TALAR TILT TEST / INVERSION STRESS TEST

For the talar tilt test the patient was positioned supine with the researcher sitting facing the patient. The test was performed by the researcher holding the calcaneus with one hand while the foot was positioned in the neutral position. The other hand was used to stabilize the lower leg, again around the distal tibio-fibular region. The researcher palpated the calcaneo-fibular ligament, with one finger to feel the gapping if present. The hand stabilizing the calcaneus applied an inversion stress by rolling the calcaneus inwards to cause talar tilt (Vinger and Hoerner, 1982; Starkey and Ryan, 1996).

The talar tilt test was deemed positive in the presence of excessive tilting or gapping or if the patient experienced pain while performing the test. A test is deemed positive if tilting or gapping greater than 3 – 5 mm is recorded, measured with a tape measure (Trojian and McKeag, 1998).The researcher performed the talar tilt tests on all players (Vinger and Hoerner, 1982; Starkey and Ryan, 1996).

3.5.5 FUNCTIONAL INSTABILITY

3.5.5.1 BALANCE ERROR SCORING SYSTEM (BESS)

The Balance Error Scoring System (BESS) is a test where the standing balance of a player is tested statically while trying to maintain a stable base of support under different testing conditions. For the purposes of this study two testing conditions on two different surfaces were used, namely single leg stance for left and right leg, on two different surfaces namely a firm surface (stable flat surface) and a foam surface (a foam block) On a firm surface control should be better, the foam surface supplies an added component that the player has to manage to maintain balance. Initially the player had to maintain his balance with his eyes open and was then asked to repeat the test but this time closing his eyes. The reason for closing the eyes is to remove the focus gained from visua

input to control balance
Single leg stance was performed as described standing on the dominant leg with the contra-lateral leg held in 30˚ of hip flexion and 90˚ of knee flexion (ranges were measured by a goniometer) and the foot held approximately 15 cm off the ground. (Dominance was established in the demographic questionnaire).

Each stance was performed firstly on a firm surface and repeated on a medium density foam block. The test was performed with the player standing in the required position for 20 seconds. The subject was asked to close his eyes and place his hands on his iliac crests, while maintaining the appropriate stance. If the subject fell out of position he had to return to the position as quickly as possible. When having the eyes closed the player could open his eyes and keep them open until balance was regained before closing the eyes again. The researcher, standing three metres away then recorded the amount of errors made by each subject during the test. A test was deemed positive if the player made a mistake and was graded according to the amount of mistakes made during the 20 second period.

Prior to performing the test the subject was instructed, shown and given an opportunity to practice the stance position. The reliability and validity of the above test was discussed in the literature review in chapter two (Susco et al, 2004).

3.5.5.2 STAR EXCURSION BALANCE TEST (SEBT)

The challenge of this test lies in maintaining a unilateral stable base of support while reaching in four directions with the opposite leg. The test was performed with the subject standing at the centre of a grid placed on the floor with four lines extending at 90˚ angles from the centre of the grid. A standard grid was made and used on each testing occasion. A verbal and visual demonstration of the procedure was given and then the subject was tested. The subject was instructed to keep his hands on his hips. The subject was required to lightly touch the furthest point on the line with the most distal part of the foot; this was done to ensure stability was achieved through adequate neuromuscular control

of the stance leg. The subject then had to return to the starting position. The examiner measured the reach after every repetition with a tape measure.

If the subject lost control of the stance leg and lost his balance or if the player could not control the reach foot position, it was deemed a failed SEBT and the subject was functionally unstable for this specific test. Losing control included not touching the line with the reach foot while maintaining weight bearing on the stance leg, lifting the stance foot from the centre of the grid, or losing balance at any point in the procedure. If a player was limited by pain and could not complete the test it was taken as a positive test for ankle instability and was included as a functionally unstable ankle. Prior to performing the test the subject was instructed, shown and given an opportunity to practice the stance position with corrections from the researcher. The reliability and validity of the test was discussed in chapter two (Gribble et al, 2004; Hertel et al, 2000).

3.6 PROCEDURE

3.6.1 PILOT STUDY PROCEDURE

The pilot study was performed to establish the clarity and reliability of the self assessment questionnaire including demographic data and the Olerud and Molander questionnaire as well as the clinical tests for mechanical instability. Mechanical tests were done to establish the inter- and intrarater reliability for the anterior drawer and talar tilt tests by having the researcher and an assistant physiotherapist test the players and compare results from these tests to establish interrater reliability. Interrater reliability was tested so that one tester, namely the researcher would be considered reliable and would be able to conduct all the tests. Interrater reliability was established by using the researcher and an assistant to assess the two mechanical tests on 14 players from a team not involved in the main study on the same day in two separate testing rooms so that they were blinded to the results scored by the other. The researcher tested a player and then the player went to the other room where the assistant tested the player until all 14 players had been tested. The researcher then repeated the tests

four days later in the same manner blinded to the initial results, to establish intrarater reliability. Good intrarater reliability confirms that the researcher would at any given time record similar results for the same player.

The pilot study was performed on the players of the second team of Alberton Rugby Club. The players completed the demographic questionnaire as well as the Olerud and Molander questionnaire on two separate occasions, four days apart to ensure test-retest reliability of the questionnaires.

The results of the pilot study are presented in Chapter 4

3.6.2 MAIN STUDY PROCEDURE

Each club in the South Gauteng region was asked to participate in the study by telephonically approaching the chairperson of the club. Information regarding the testing procedures was sent to the clubs via e-mail as well as the player and club consent forms. The researcher then pre-set a date and time to do the testing. Players were shown to a room where the testing apparatus had been set up. Informed consent was obtained from each player before participation. To determine perceived instability each player was then asked to complete the demographic data questionnaire and the Olerud and Molander questionnaire. After completion of the questionnaire the exclusion criteria were established before mechanical testing took place. The researcher tested the mechanical stability of both ankles of each player through the talar tilt and anterior drawer tests as previously described for the pilot study. The functional stability was assessed through the Star Excursion Balance Test and Balance Error Scoring System as described earlier.

3.6.3 STATISTICAL ANALYSIS

The data were captured in an Excel Spreadsheet and was then imported into Stata Release 10 statistical software for data analysis. The statistical analyses were performed on the data to determine the prevalence and establish a possible clinical presentation of ankle instability in club rugby players in the South Gauteng region.

The prevalence of mechanical and functional instability was presented as a percentage of the whole sample and reflects the number of existing cases of a disorder relative to the total population at a given point in time and is calculated as follows:

Prevalence = number of existing cases observed in the whole study sample at a given point in time / total number of subjects in the study sample and is described as a percentage (Portney and Watkins, 2002).

Prevalence of the symptoms was alluded to by the Olerud and Molander questionnaire and was determined and the association with previous ankle injury assessed using the odds ratio (OR) along with the 95% confidence interval and p-value to describe the presence of perceived signs of ankle instability in the population. The odds ratio can be defined as the odds of a clinical sign as depicted in the Olerud and Molander questionnaire if the subject reported previous ankle injury / those with no reported previous injury. This states that a subject has a specific percentage chance to experience a specific clinical sign after sustaining an injury.

The prevalence of mechanical and functional signs of ankle instability based on the mechanical and functional tests applied was determined.

The Chi-square test was used to compare the difference in clinical signs of mechanical ankle instability between the group who had never had any an ankle injury and the group who reported a previous ankle injury. Similarly the Chi-

square test was used to compare the differences in clinical signs of functional ankle instability between the group who had never had an ankle injury and the group who had a previous ankle injury. The results of the Chi-square test were confirmed by the Fisher's exact test.

Odds ratios for the risk of developing any of the features suggested in the Olerud and Molander questionnaire was included.

The different reaching distances and the total distance left and right sides, in the Star Excursion Balance Test, were compared using the paired t-test. The left and right sides of, the unstable and stable ankles, as derived from the mechanical testing were compared with respect to reach distances using the two-sample t test. Furthermore players with and those without previous injury were also compared.

All testing was done at the $p = 0.05$ level of significance.

CHAPTER 4

4. RESULTS

4.1 PILOT STUDY

4.1.1 TEST-RETEST RELIABILITY OF THE DATA COLLECTION QUESTIONNAIRES

The pilot study was used to determine the clarity of the two questionnaires. The Olerud and Molander questionnaire has been used in previous studies however no test-retest reliability scores were available. A test-retest reliability of greater than 90% was achieved as will be illustrated. The demographic questionnaire rendered similar results at 93.3%. The only change that occurred was because one player sustained an injury and therefore reported differently on the two questionnaires. The results of the pilot study revealed that parts of the data questionnaire had to be adapted for clarity. Appendix A.1 includes the initial questionnaire with the sections to be changed highlighted and Appendix A.2 has the questionnaire as used in the study for comparison. The questions that needed to be adapted included:

- the area of previous injury which was open ended with no choice, this was subsequently changed to eight areas frequently injured in the lower quadrant
- injury management where it had to be explained what a podiatrist and orthopaedic surgeon were, were verbally explained when the questionnaires were handed out to participants.
- phrasing of certain questions was changed e.g. for the questions pertaining to medication two options were added, one of no medication used because not all players required medication and one of chronic medication used daily for pain. There were also more

options added to the rehabilitation question as illustrated in Appendix A

- boxes were added where choices had to be made so that only a tick in the correct box was required.

Table 4.1 is an illustration of the test-retest reliability of the demographic and Olerud and Molander questionnaires as tested on two different occasions by the researcher.

Table 4.1: Test-retest reliability of the data collection questionnaires

TESTING OCCASION		**TEST DAY 1**	**TEST DAY 2**
QUESTIONNAIRE	**DEMOGRAPHIC QUESTIONNAIRE**	15 completed forms	15 completed forms 14 forms with the same results
	OLERUD AND MOLANDER	15 completed forms	15 completed forms 14 forms with the same results
TEST-RETEST RELIABILITY		**93.3%**	

The reason for the one form being different is the inclusion of one of the players who sustained an injury in the four days from the initial completion of the questionnaire to the second test day. Thus 100% test-retest reliability can be assumed if the one player was not included.

4.1.2 INTERRATER RELIABILITY

An interrater reliability of 100% was established with the researcher and the assistant physiotherapist agreeing on all subjects for both mechanical tests performed; namely the anterior drawer test (ADT) and the talar tilt test (TTT). Fourteen players were included in the pilot study from the fifteen who completed the questionnaires. One person was excluded due to a previous ankle fracture. Table 4.2 below illustrates results of the intterater reliability tests done by the two researchers. A (+) sign indicates positive results and a (-) sign a negative result.

Table 4.2: Interrater reliability

	TESTS	**ADT (+)**	**ADT (-)**	**TTT (+)**	**TTT (-)**
T E S T E R	**RESEARCHER 1**	6	8	4	10
	RESEARCHER 2	6	8	4	10
	INTERRATER RELIABILITY (%)	100%	100%	100%	100%

Based on the above interrater reliability achieved, both the anterior drawer and talar tilt tests were included. The interrater reliability suggests that similar results would have been reported by different physiotherapists performing the

tests. Therefore a single examiner, namely the researcher performing the tests was deemed to be adequate.

4.1.3 INTRARATER RELIABILITY

Intrarater reliability was confirmed by the researcher repeating the mechanical tests on the above subjects four days later. The same results were obtained for thirteen subjects. One subject sustained an acute ankle injury during a practice session and tested positive for the anterior drawer test which had been negative in the initial testing. Intrarater reliability was also 100% excluding the subject with the altered status of the ankle. These results are shown in Table 4.3.

TABLE 4.3: Intrarater reliability (illustrating positive tests)

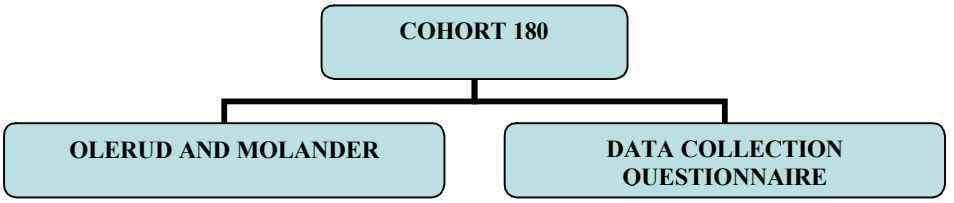
		EXAMINER – DAY 1		**EXAMINER – DAY 2**	
T E S T	**SIDE**	L	R	L	R
	ADT	6	8	6	9
	TTT	5	6	5	7
	INTRARATER RELIABILITY			100%	93%

With the one change from the player injured in the four days between testing, being ignored the intrarater reliability would also be 100%. The intrarater reliability supports the notion that one therapist would at any given time have recorded similar results for the same player.

4.2 THE MAIN STUDY

The aims of the study were twofold. Firstly to determine the prevalence of ankle instability in club rugby players using different testing conditions namely; perceived, mechanical and functional test, and secondly to describe the clinical picture of players with positive tests.

4.2.1 FLOW DIAGRAM TO ILLUSTRATE THE CHANGE IN SAMPLE SIZE THROUGHOUT THE STUDY



EXCLUSION CRITERIA:

1. Previous surgery to the ankle {14 excluded}
2. Injury to the lower limb rendering player out of active participation {11 excluded}
3. Patients with diagnosed concussion within 1 month {8 excluded}
4. Patients with ear infection, head cold or upper respiratory tract infection {10 excluded}

180 – 43 = 137

137 PLAYERS

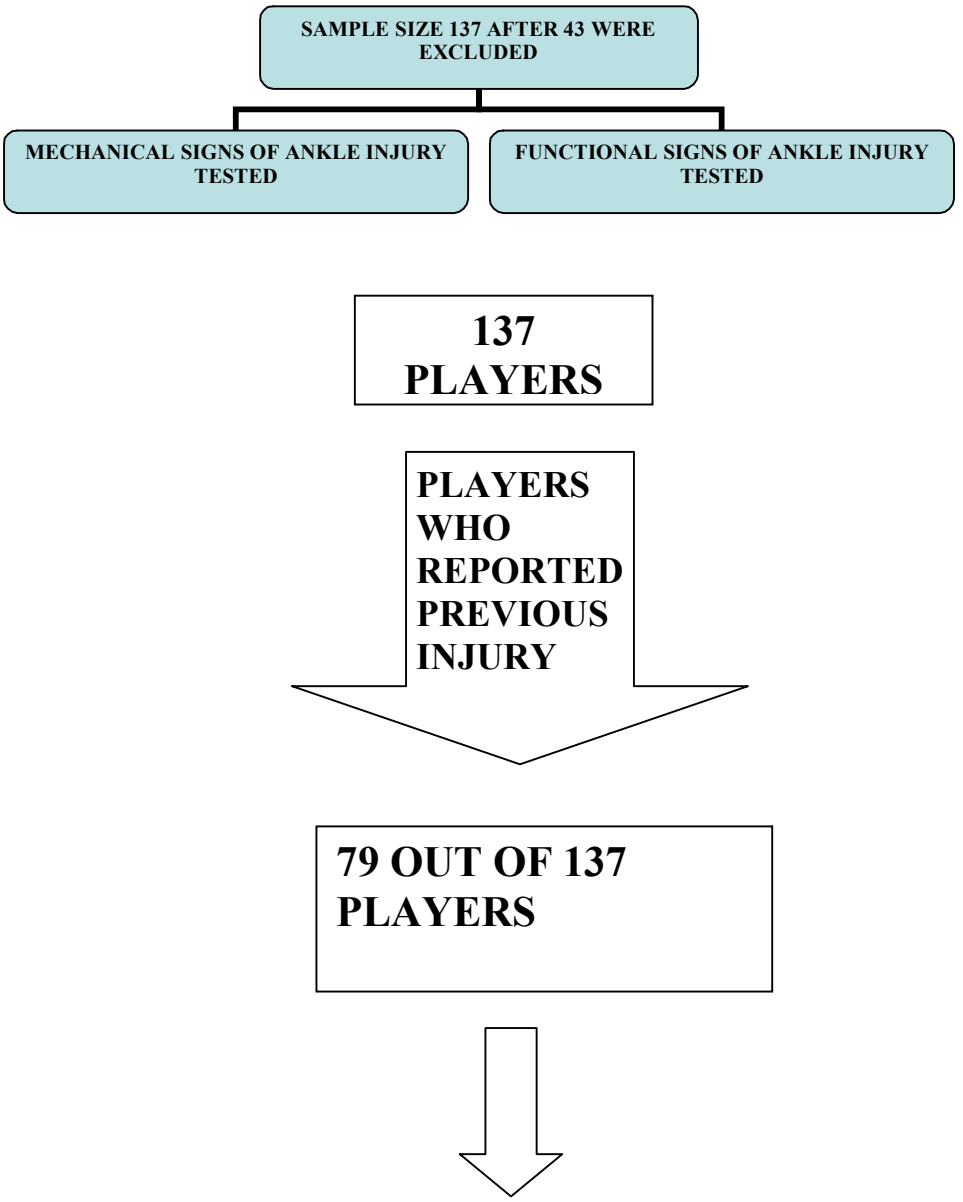


FIGURE 4.1 FLOWDIAGRAM TO ILLUSTRATE CHANGE IN SAMPLE SIZE THROUGHOUT THE STUDY

4.2.2 DEMOGRAPHICS OF THE SAMPLE

The sample consisted of 180 players who completed the demographic as well as the Olerud and Molander questionnaires. The 180 players were made up of 20 players per team in 9 of the 10 teams in the South Gauteng region as explained in Chapter 1.

4.2.2.1 DEMOGRAPHIC DATA

Table 4.4 illustrates the demographic data related to age, height and weight of the sample

Table 4.4: Age, height and weight of sample (n = 137)

PARAMETER PARAMETER	RANGE		MEAN (±SD)
	MINIMUM	MAXIMUM	
AGE	16 years	43 years	24 years (±4.7)
HEIGHT	156 cm	204 cm	181.5 cm (±7)
WEIGHT	60 kg	130 kg	93.6 kg (±14)

Age, height and weight distribution in the sample varies. Age from adolescent to earlier forties, weight from 60 to 130kg and height from 156cm to 204cm.

Table 4.5: Occupation and position (n= 137)

PARAMETER	SEDENTARY	PHYSICAL
OCCUPATION	**51.8% (71)**	**48.2 % (66)**
PARAMETER	**FORWARDS**	**BACKLINE**
POSITION	**53.3% (73)**	**46.7 % (64)**

In table 4.5 the occupations were divided into sedentary referring to corporate or office bound players and physical referred to those players who performed physical labour as part of their duties.

Forwards refer to positions one through eight and backline are the positions from scrumhalf to fullback.

4.2.3 THE PREVALENCE OF POSITIVE CLINICAL SIGNS OF ANKLE INSTABILITY

To establish the prevalence of ankle instability in club rugby players, three different aspects were addressed:

- clinical signs of perceived ankle instability derived from the Olerud and Molander questionnaire
- clinical signs of mechanical ankle instability using two objective clinical tests, namely the anterior drawer test and talar tilt test which establishes integrity of the lateral ligament complex
- clinical signs of functional ankle instability using the Balance Error Scoring system

4.2.3.1 THE PREVALENCE OF PERCEIVED ANKLE INSTABILITY

4.2.3.1.1 THE OLERUD AND MOLANDER QUESTIONNAIRE

A total of 180 players completed the questionnaires. The whole group was asked to complete the questionnaires and after this the exclusion criteria were applied and the sample size for further tests is thus different. An example of the scoring of the Olerud and Molander questionnaire can be seen in Appendix A. The results are illustrated in Table 4.6.

Table 4.6: The results of the Olerud and Molander questionnaire (n=137)

RESULTS	O + M Score	N= 137 (Percentage)
No perceived instability	100%	77(56%)
Perceived instability	< 95%	60(44%)

In the 137 players who were included in the study, 44% reported some signs or symptoms of instability as rated by the Olerud and Molander questionnaire.

This is only a broad indication of any clinical sign of instability and the Olerud and Molander Questionnaire was divided into sub-sections to further clarify the clinical picture.

4.2.3.1.2 SUB-ANALYSIS OF OLERUD AND MOLANDER QUESTIONNAIRE

Table 4.6 illustrates the sub-analysis of the Olerud and Molander questionnaire. This is used to describe the clinical signs and symptoms present in players with self-reported ankle problems.

Table 4.7: Results of the sub-analysis of the Olerud and Molander questionnaire (n=137)

PARAMETER	PERCEIVED PROBLEM (n = 137)
PAIN	38 (27.8%)
STIFFNESS	40 (29.2%)
SWELLING	20 (14.6 %)
STAIRS	16 (11.7%)
RUNNING	6 (4.4%)
JUMPING	8 (5.8 %)
SQUATTING	9 (6.6%)
SUPPORTS	23 (16.8%)
ACTIVITIES OF DAILY LIFE	11 (8%)

Pain (28%), stiffness (29%) and swelling (15%) were the most prevalent clinical signs and 17% of players reported that they required some kind of external support.

4.2.3.1.2 SUMMARY OF THE PREVALENCE OF CLINICAL SIGNS OF PERCEIVED ANKLE INSTABILITY

The final amount of players with perceived instability is **60/137 (44%)**, according to the Olerud and Molander questionnaire.

4.2.3.2 THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL INSTABILITY

To determine the prevalence of clinical signs of mechanical instability the anterior drawer test and talar tilt tests were used. These tests were only applied to players after the exclusion criteria had been applied and therefore the sample

size decreased to 137 from the initial 180. The percentage of players who showed signs of instability is illustrated in Table 4.8a

Table 4.8a: The prevalence of clinical signs of mechanical ankle instability (n=137)

POSITIVE OR NO CLINICAL SIGNS OF MECHANICAL INSTABILITY	**NUMBER OF PLAYERS**	**PERCENTAGE**
Number of players **with** positive clinical signs of mechanical ankle instability	60	43.8%
Number of players **with no** clinical signs of mechanical ankle instability	77	56.2%

The results in table 4.8a indicate that 60 players out of the total of 137 had some mechanical insult to the ankle irrespective of side of injury or ligamentous structure injured. This indicates the prevalence of clinical signs of mechanical instability.

4.2.3.2.1 SUMMARY OF THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY

Based on the mechanical tests, namely the anterior drawer and talar tilt tests the overall prevalence for positive clinical signs of ankle instability if **60/137 (43.8%)**.

4.3.2.2.2 SUBGROUPS OF MECHANICAL PREVALENCE

These results are now analyzed into subgroups in table 4.8b

Table 4.8b: The prevalence of clinical signs of mechanical ankle instability to summarize tests used side to side differences (n=137)

SIDE	TEST	PREVALENCE N (%)	95% CONFIDENC INTERVAL
LEFT	Anterior Drawer Test	31(22.6 %)	15.9 - 30.6%
	Talar Tilt Test	28(20.4 %)	14.0 – 28.2%
	TTT + ADT	25(18.2%)	14.00 – 22.2%
	ADT + TTT + Both	34(24.8%)	17.9 – 33.6%
RIGHT	Anterior Drawer Test	23(16.8 %)	10.9 - 24.1%
	Talar Tilt Test	23(16.8 %)	10.9 – 24.1 %
	ADT + TTT	20(14.6%)	10.4 – 18.0%
	ADT + TTT+ Both	26(18.9%)	14.5% - 23.0%
ONE SIDE ONLY -either left or right	ANY POSITIVE CLINICAL SIGN	45 (32.8%)	25.0 – 36.8%
BOTH SIDES	ANY POSITIVE CLINICAL SIGN	8 (5.8%)	3.4 – 8.8%%
LEFT	BOTH TESTS POSITIVE	25 (18.2%)	14.0 – 22.5%
RIGHT	BOTH TESTS POSITIVE	20 (14.6%)	10.4 – 16.8%
LEFT AND RIGHT	BOTH TESTS POSITIVE	53 (38.7%)	30.0 – 47.0%
LEFT AND RIGHT AND BOTH	ANY POSITIVE CLINICAL SIGN	60 (43.8%)	35.1 – 51.0%

Out of a total of 137 players 43.8% had positive tests for clinical signs of mechanical ankle instability irrespective of side of injury or ligament injured. When side to side differences are considered, the left had a higher percentage of 25% compared to the 19% reported for the right hand side.

4.3.2.2.3 THE COMPARISON BETWEEN PREVIOUSLY INJURED SUBJECTS AND THOSE WITH NO PREVIOUS MENTION OF INJURY

Table 4.9 illustrates the comparison between two sub-groups in the study. The one is the group who had a previous injury and the second group is the one who has never had any injury to the ankle joint.

Table 4.9a: The comparison between previous ankle injury and no reported previous ankle injury (n=137)

RESULTS	PREVIOUS ANKLE INJURY	NO REPORTED PREVIOUS ANKLE INJURY
	79 (57.7%)	58 (42.3%)

Table 4.9b: The prevalence of clinical signs of mechanical ankle instability (n = 137) divided into those with and those without previous injury

MECHANICAL TEST	**PREVALENCE - previous ankle injury**	**PREVALENCE – no previous ankle injury**	**p-VALUE : Chi-square**
ADT – Left	31.7% (25/79)	10.3% (6/58)	0.003 *
ADT – Right	24.1% (19/79)	6.9% (4/58)	0.01 *
TTT – Left	30.4% (24/79)	6.9% (4/58)	0.001 *
TTT- Right	21.5% (17 /79)	10.3% (6/58)	0.08 *
Combined Tests – Left	35.4% (28/79)	10.3% (6/58)	0.001 *
Combined Tests – Right	25.3% (20/79)	10.3% (6/58)	0.03 *

Combined Test – Left and Right	60.7% (48/79)	17.2% (5/58)	0.00 *

There were significant differences between the two groups for all but one of the tests; for the TTT-right which can at 0.08 be seen as marginally significant. This is based on the continuum below.

0 <SIGNIFICANT> **0.05** < MARGINALLY SIGNIFICANT > **0.1** < NOT SIGNIFICANT

FIGURE 4.2 ILLUSTRATION OF SPECTRUM OF SIGNIFICANCE

Table 4.9c: The prevalence of clinical signs of mechanical instability (n=137) divided into those with and those without previous injury for the players with a mechanical insult

MECHANICAL TEST	PREVALENCE - previous ankle injury	PREVALENCE – no previous ankle injury	p-VALUE : Chi-square
ADT – Left	80.6% (25/31)	19.4% (6/31)	0.007*
ADT – Right	82.6% (19/23)	17.4% (4/23)	0.01*
TTT – Left	85.7% (24/28)	14.3% (4/28)	0.001*
TTT- Right	73.9% (17 /23)	26.1% (6/23)	0.07*
Combined Tests – Left	82.4% (28/34)	17.6% (6/34)	0.002*
Combined Tests – Right	76.9% (20/26)	23.1% (6/26)	0.03*
Combined Test – Left and Right	80% (48/60)	20% (5/60)	0.000*

All the above percentages are above 70% for players who have a recollection of a previous injury to the ankle joint and who returned positive results for either

the anterior drawer or talar tilt tests. There are significant differences between all tests except for the TTT on the right which is marginally significant.

4.2.3.3 THE PREVALENCE OF CLINICAL SIGNS OF FUNCTIONAL ANKLE INSTABILITY

4.2.3.3.1. BALANCE ERROR SCORING SYSTEM

The prevalence of clinical signs of functional ankle instability for players is depicted in Table 4.10. This was based upon the results of the balance error scoring system

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Table 4.10: The prevalence of positive clinical signs of balance deficits relating to functional ankle instability (n=137)

SIDE	STANCE SURFACE	PREVALENCE OF FUNCTIONAL INSTABILITY: positive signs of instability/137(%)	95 % - CONFIDENCE INTERVAL
Left	**Firm – eyes open**	13 (9.5%)	5.1% - 15.7%
	Firm – eyes closed	88 (64.2%)	55.6% - 72.2%
	Foam – eyes open	65 (47.5%)	38.8% - 56.1%
	Foam – eyes closed	132 (96.4%)	91.6% - 98.8%
Right	**Firm – eyes open**	13 (9.5%)	5.1% - 15.7%
	Firm – eyes closed	76 (55.5%)	46.7% - 63.9%
	Foam – eyes open	66 (48.2%)	39.6% - 56.9%
	Foam – eyes closed	134 (97.8%)	93.7% - 99.5%

The more difficult the testing conditions are, the higher the prevalence of functional instability or decreased postural control. The highest percentages of

functional instability were found with the test performed on an unstable surface with the eyes closed, for the right leg (97.8%) and for the left leg (96.4 %).
The subjects were divided into those with previous injury and those without. This is illustrated in table 4.11

Table 4.11a: The prevalence of clinical signs of functional ankle instability as a comparison between uninjured and previously injured ankles (n=137)

SIDE	FUNCTIONAL TEST	NO PREVIOUS ANKLE INJURY	PREVIOUS ANKLE INJURY	p-VALUE
LEFT	Firm – eyes open	3/13 (2.3%)	10/13 (76.9%)	0.16
	Firm – eyes closed	32/88 (36.4%)	56/88 (63.6%)	0.04*
	Foam – eyes open	29/65 (44.6%)	36/65 (55.4%)	0.54
	Foam – eyes closed	56/132 (42.4%)	76/132 (57.6%)	0.17
RIGHT	Firm – eyes open	4/ 13(3.1%)	9/13 (69.2%)	0.32
	Firm – eyes closed	29/76 (38.2%)	47/76 (61.8%)	0.12
	Foam – eyes open	28/66 (42.4%)	38/66 (57.6%)	0.37
	Foam – eyes closed	57/134 (42.5%)	77/134 (57.5%)	0.17

The results in table 4.11a were only marginally significant for one test namely the test where a participant stood on the left leg on a firm surface with the eyes closed. This test is not a good indicator of ankle function and ankle injury, but more likely assesses the whole kinetic chain. It was also evident that there were minimal differences between the players with previous ankle injury and those without. This could be related to the increased difficulty of maintaining balance as a function of postural control rather than ankle instability.

Refer to table 4.9a for the players with reported previous ankle injury

In table 4.11a the percentages of players who recalled previous injury to the ankle were depicted for all the players with positive clinical signs of functional ankle instability. Here the percentages are much lower and can be ascribed to the sensitivity of the test. It is important to note that the balance error scoring system tests the whole kinetic chain not only the ankle joint.

4.2.3.3.2 PERCEIVED ANKLE INSTABILITY VERSUS OBJECTIVE ANKLE INSTABILITY

The table below depicts the number of players with perceived ankle instability with:

1. Positive clinical signs of mechanical instability
2. Positive clinical signs of functional instability

Table 4.12: The number of players with and without perceived instability who has positive clinical signs of ankle instability for mechanical and functional tests.

Positive clinical signs of mechanical instability with perceived instability	Positive clinical signs of mechanical instability with no perceived instability	Positive clinical signs of functional instability with perceived instability	Positive clinical signs of functional instability with no perceived instability
35/60 (58.3%)	21/53 (39.6%)	60/60 (100%)	0/77 (0%)

4.2.3.4 THE PREVALENCE OF CONCURRENT CLINICAL SIGNS OF MECHANICAL AND FUNCTIONAL ANKLE INSTABILITY

4.2.3.4.1. BALANCE ERROR SCORING SYSTEM

The prevalence of concurrent positive clinical signs of ankle instability for both mechanical and functional factors of ankle instability was established by dividing players with clinical signs of functional ankle instability into two groups; those with clinical signs of mechanical injury and those who showed no clinical signs of mechanical injury as tested by the anterior drawer and talar tilt tests. Table 4.13a illustrates the results. These tests were based on the 137 players included in the study.

Table 4.13a: Table to illustrate changes in the number of subjects for the group with and those without clinical signs of mechanical instability (n = 137)

TOTAL NUMBER OF PLAYERS INCLUDED	PLAYERS WITH MECHANICAL SIGNS OF INSTABILITY	PLAYERS WITHOUT MECHANICAL SIGNS OF INSTABILITY
N = 137	N = 60	n = 77
L = 137	L = 34	L = 103
R = 137	R = 26	R = 111

The above values are relevant for Table 4.13b where prevalence of concurrent clinical signs of mechanical and functional instability is depicted.

Table 4.13b: The prevalence of concurrent clinical signs of mechanical and functional instability using the balance error scoring system

SIDE	STANCE SURFACE	NEGATIVE SIGNS OF MECHANICAL ANKLE INSTABILITYn/total (%)	POSITIVE SIGNS OF MECHANICAL ANKLE INSTABILITYn/total (%)	p-VALUE
LEFT	**Firm – eyes open**	8/13 (61.5)	5/ 13(38.5%)	0.73
	Firm – eyes closed	62/88 (70.5%)	26/88 (29.5%)	0.001*
	Foam – eyes open	47/65 (72.3%)	18/65 (27.7%)	0.004*
	Foam – eyes closed	100/132 (75.8%)	32/132 (24.2%)	0.001*
RIGHT	**Firm – eyes open**	8/13 (61.5%)	5/13 (38.5%)	0.73
	Firm – eyes closed	58/76 (76.3%)	18/76 (23.7%)	0.002*
	Foam – eyes open	55/66 (83.3%)	11/66 (16.7%)	0.001*
	Foam – eyes closed	109/134 (81.3%)	25/134 (18.7%)	0.001*

For the balance error scoring system there were significant p-values for all but two tests, standing on a firm surface on the right and left leg with the eyes open. There is a significant difference between those with and those without mechanical ankle injury.

Each testing condition is more difficult or challenging than the one before. This explains the higher percentages of positive clinical signs of functional instability for more difficult positions. This supports the notion that this is not only an ankle test but tests the whole kinetic chain for postural control and any deficit in the kinetic chain might contribute to a player's inability to perform well in this test.
In Table 4.13c the above is further analyzed into two groups those who reported previous injury compared to those who reported no previous injury.

Table 4.13c: The prevalence of concurrent clinical signs of mechanical and functional instability as a comparison between uninjured and previously injured ankles

		NO CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY (L = 103; R = 111)			WITH CLINICAL SIGNS OF MECHANICAL ANKLE INSTABILITY (L = 34; R = 26)		
SIDE	TEST POSITION	NO PREVIOUS INJURY	PREVIOUS INJURY	p-VALUE	NO PREVIOUS INJURY	PREVIOUS INJURY	p-VALUE
LEFT	Firm – e/o	1/8 (12.5%)	7/8 (87.5%)	0.18	2/5 (40%)	3/5(60%)	1.00
	Firm – e/c	27/62 (43.5%)	35/62 (56.5%)	0.43	5/26 (19.2%)	21/26 (80.8%)	0.01*
	Foam – e/o	25/47(53.2 %)	22/47 (46.8%)	0.86	4/18 (22.2%)	14/18 (77.8%)	0.08*
	Foam – e/c	51/100 (51%)	49/100(49 %)	0.90	5/32 (15.6%)	27/32(84.4 %)	0.001*
RIGHT	Firm – e/o	2/8 (25%)	6/8 (75%)	0.38	2/5 (40%)	3/5(60%)	1.00
	Firm – e/c	25/58 (43.1%)	33/58 (56.9%)	0.39	4/18 (22.2%)	14/18 (77.8%)	0.08*
	Foam – e/o	26/55(47.3 %)	29/55 (53.7%)	0.87	2/11 (18.2%)	9/11 (81.8%)	0.13
	Foam – e/c	51/109 (46.8%)	58/109 (53.2%)	0.64	6/25 (24%)	19/25 (76%)	0.05*

No significant changes were seen for this differentiation for the comparison between those with and those without previous injury for the group with no clinical signs of mechanical ankle instability. On the other hand the group that had clinical signs of mechanical ankle instability showed certain significant differences for the comparison between those with and those without previously reported ankle injury. There were marginal to significant differences for players with clinical signs of mechanical instability for standing on the left leg with the eyes closed on a firm surface and with

the eyes open and closed on a foam surface. On the right there were only marginally significant results on a firm and foam surface with the eyes closed. Furthermore the results in this table support the reasoning that the Balance Error Scoring System does not isolate the ankle joint and the results can not be related to the ankle joint specifically.

4.2.4 CLINICAL FINDINGS ASSOCIATED WITH ANKLE INJURIES IN CLUB RUGBY PLAYERS

4.2.4.1 PREVIOUS INJURY IN THE LOWER QUARTER AND PREVIOUS ANKLE INJURY

Table 4.14 illustrates the prevalence of previous injury in the lower quarter excluding the ankle compared to the perceived prevalence of ankle injuries in club rugby players. Here the lower quarter refers to lower back and pelvis, hip, knee, groin, hamstring, quadriceps and calf muscle. It includes both past and present injuries. This is a clear indication of the players' subjective view of their ankles compared to the rest of the kinetic chain of the lower quarter.

Table 4.14: Injury reports in the lower quarter excluding the ankle, and injury reported of the ankle (n = 137)

RESULTS	LOWER QUARTER	ANKLE INJURY
	63 (45.9%)	79 (57.7%)

Fifty eight percent of the players reported an ankle injury in their career, compared to 46% who reported other injuries in the lower quarter. The rest of the data in this section is based upon the 79 players who reported an ankle injury and subsequently n = 79

4.2.4.2 SIDE AND SITE OF ANKLE INJURY

Table 4.15 illustrates the side to side difference in ankle injuries both past and present

Table 4.15: Side and site of injured ankle (n = 79)

LEFT ANKLE	RIGHT ANKLE	DOMINANT SIDE	NON-DOMINANT SIDE	BOTH SIDES
30 (37.9%)	39 (49.4%)	42 (53.2%)	27 (34.2%)	10(12.7%))

The groups were divided into side: left or right and site referring to dominance. There were more injuries on the right and when site was established, it referred to the dominance; it was more often the dominant rather than non-dominant side that was injured.

4.2.4.3 TIME SIDELINED BY INJURY AND TIME TAKEN TO RECOVER

Table 4.16 illustrates the effect that the injury had on the player in:

- time sidelined: not sidelined at all, days (2 – 7 days after acute injury), weeks (4-6 weeks allowed for healing) or months (3-6 months)
- time taken to recover: days (2 – 7 days post acute injury), weeks (4 -6 weeks intermediate phase of rehabilitation), months (3-6 months post injury), never fully recovered
- time spend on the field of play post-injury: a full game (80 minutes), one half (40 minutes) or still on the bench not participating in games yet.

Table 4.16: Time and the ankle injury (n = 79)

TIME SIDELINED	FREQUENCY (Percentage)
NOT SIDELINED	16 (20.3%)
DAYS	16 (20.3%)
WEEKS	33 (41.8%)
MONTHS	14 (17.7%)
TIME TAKEN TO RECOVER	FREQUENCY (Percentage)
DAYS	40 (50.6%)
WEEKS	25 (31.6%)
MONTHS	4 (5.1%)
NEVER FULLY RECOVERED	10 (12.7%)
TIME SPENT ON THE FIELD	FREQUENCY (Percentage)
FULL GAME	72 (91.1%)
ONLY ONE HALF	5 (6.3 %)
BENCH ONLY	2 (2.5 %)

Thirteen percent of players reported that they never recovered but more than 90% of players had returned to full participation in rugby after the ankle injury including the 13% who has not recovered. Forty four percent of players returned to training and participation in matches after being sidelined for a few weeks. This is less than the time for optimal healing of six weeks that should be observed for soft tissue healing. Twenty one percent returned within days after the injury.

2.4.4 INJURY MANAGEMENT

For return to sport an injury has to be managed and Table 4.17.1 and Table 4.17.2 illustrate how players manage their injuries

Table 4.17a: Management of ankle injury and investigations required (n= 79)

INVESTIGATIONS REQUIRED	**FREQUENCY (PERCENTAGE)**
No investigations done	39 (55.7%)
X-rays	24 (34.3%)
Ultrasound	2 (2.9%)
MRI	2 (2.9%)
CT-Scan	3 (4.3%)
INJURY MANAGEMENT	**FREQUENCY (PERCENTAGE)**
Self	29 (41.4%)
Physiotherapist	31 (44.3%)
Biokineticist	2 (2.9%)
Orthopaedic surgeon	2 (2.9%)
Podiatrist	3 (4.3%)
General practitioner	2 (2.9%)

Table 4.17b: Management of ankle injury – use of medication (n= 79)

USE OF MEDICATION	NOTHING	ANTI-INFLAMMATORY	PAIN KILLER	BOTH
CURRENT	56 (70.9%)	12 (15.2%)	3 (3.8%)	8 (10.1%)
AT TIME OF INJURY	48 (60.8%)	18 (22.8%)	10 (12.7%)	3(3.8%)

The percentage of players using both anti-inflammatories and painkillers are higher for current use than use after the initial injury. Forty four percent of players reported having been to a physiotherapist for treatment and the second highest, 42% managed these injuries themselves. Most players did not have any investigations post-injury and second to that only X-rays seemed to have been done fairly regularly with 34% of injured players having x-rays taken with or without stress views.

4.2.3.5 EFFECT OF ANKLE INJURY ON PERFORMANCE OF SUBJECTS

In table 4.18 below the effect of the injury on the athlete's performance is illustrated

Table 4.18: The effect of ankle injury on the subjects perception of performance (n = 79)

EFFECT	PERCENTAGE AND FREQUENCY
No effect	37 (46.8%)
Speed	13 (16.5%)
Power	4 (5.1%)
Agility	8 (10.1%)
Speed and Power	1 (1.3 %)
Speed and Agility	9 (11.4%)
Power and Agility	4 (5.1%)
Speed, Power and Agility	3 (3.8 %)

Forty seven percent of players reported that the injury had had no effect on their ability to perform at their level of participation, although 16.5% reported a decrease in

speed and 10% reported limitations of agility. When combined a total of 53% stated some effect on their performance.

4.2.4.6 ODDS RATIOS RELATED TO THE CLINICAL FINDINGS OF THE OLERUD AND MOLANDER QUESTIONNAIRE

The Olerud and Molander questionnaires results were also compared to the players with reported previous ankle injury and the risk of developing any of the clinical signs after an initial injury is noted.

Table 4.19: Previous ankle injury as risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire

OLERUD AND MOLANDER SUB-CATEGORY	ODDS RATIO (OR)	95%-CONFIDENCE INTERVAL	p-VALUE
PAIN	4.59	(1.83;11.55)	0.001*
STIFFNESS	4.28	(1.73;10.58)	0.002*
SWELLING	4.91	(1.35;17.87)	0.016*
STAIRS	6.68	(1.33;33.53)	0.021*
RUNNING	1.84	(0.34;9.87)	0.477
JUMPING	2.23	(0.43;11.50)	0.339
SQUATTING	1.29	(0.29;5.70)	0.741
SUPPORTS	4.16	(1.32;13.16)	0.015*
ACTIVITIES OF DAILY LIVING *(1)*	8.02	(0.99;65.09)	0.051*

The odds ratio above indicates the likelihood of a subject with previous ankle injury to report or experience any of the above clinical signs, symptoms or functional deficits of ankle instability. This means that players with previous ankle injury are more than four times likely to have pain, stiffness and swelling. They are more than

six times likely to experience difficulty in climbing stairs and four times more likely to use supports. Finally they are possibly more than eight times more likely to have difficulty in activities of daily living.(see explanation below).

(1) Wide 95%- confidence interval due to the nature of the data, i.e. only one subject did not have a previous ankle injury among those who experience problems with activities of daily living.

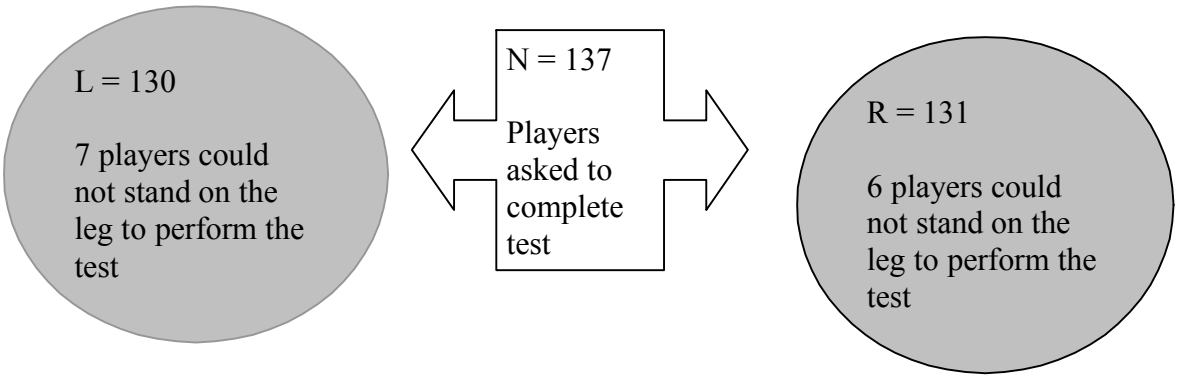
4.2.4.7 STAR EXCURSION BALANCE TEST

4.2.4.7.1 THE STAR EXCURSION BALANCE TEST FOR THE ANKLES WITH AND THOSE WITHOUT CLINICAL SIGNS OF MECHANICAL INSTABILITY

The Star Excursion Balance Test in this case depicts reach distances for left and right leg while comparing ankles clinical signs of mechanical instability to those without, as illustrated in Table 4.19.

The analysis is then further carried into comparing those individuals with previous ankle injury to players who have not sustained previous injury. This analysis is depicted in Table 4.20.

Of the 137 players who were asked to do the functional stability tests the following figure 4.2 illustrates the changes in Table 4.19 and Table 4.20 for the n-values



4.3 CHANGE OF SAMPLE SIZE (n) FOR THE STAR EXCURSION BALANCE TEST

Here some players could not perform the test because of inability to stand, weight bear and control the leg in space and against gravity not explaining the failure to stand on the leg.

Table 4.20: The Star excursion balance test for subjects with and those without clinical signs of mechanical instability

SIDE	DIRECTION OF REACH	MEAN(SD) – REACH DISTANCE (-)	MEAN(SD) – REACH DISTANCE (+)	N : ((-); (+))	p-VALUE
LEFT	ANTERIOR	95.3 (±15.4)	88.1 (±15.2)	130 (98;32)	0.02 *
	POSTERIOR	76.8 (±18.9)	74.0 (±19.5)	130 (98;32)	0.5
	SAME SIDE AS STANCE LEG	60.1 (±17.22)	54.56 (±18.8)	130 (98;32)	0.1
	OPPOSITE FROM STANCE LEG	87.4 (±16.4)	79.3 (±19.0)	130 (98;32)	0.02 *
	SUM OF REACH DISTANCES	319.5 (±52.2)	296.0 (±52.4)	130 (98;32)	0.03 *
RIGHT	ANTERIOR	92.9 (±16.0)	91.5 (±13.9)	131 (105;26)	0.7
	POSTERIOR	75.4 (±18.2)	73.1 (±20.0)	131 (105;26)	0.6
	SAME SIDE AS STANCE LEG	56.8 (±17.5)	51.5 (±17.3)	131 (105;26)	0.2
	OPPOSITE FROM STANCE LEG	87.1(±17.2)	86.0 (±17.0)	131 (105;26)	0.8
	SUM OF REACH DISTANCES	312.3 (±53.3)	302.1 (±48.85)	131 (105; 26)	0.4

From this table, significant differences between the (-), the ankle without clinical signs of ankle instability and the (+), the ankle with clinical signs of mechanical instability were found for the left with reaching anteriorly ($p = 0.02$), across the left leg to the left ($p = 0.02$) and also for the sum of the reach distances of the left hand side ($p = 0.03$). The players with clinical signs of mechanical instability on the left hand side could not reach the same mean distances as players without clinical signs of mechanical instability of their ankles.

4.2.3.7.2 THE STAR EXCURSION BALANCE TEST FOR THE ANKLES WITH AND THOSE WITHOUT MENTION OF PREVIOUS INJURY

The data gained from the Start Excursion balance test was again used but this time the comparison was made between previously injured and non-injured subjects. Results are depicted in Table 4.21

Table 4.21: The Star excursion balance test for subjects with or without previous ankle injury

SIDE	DIRECTION OF REACH	MEAN(SD) – REACH DISTANCE NO PREVIOUS INJURY	MEAN(SD) – REACH DISTANCE PREVIOUS INJURY	N : (NO PREVIOUS INJURY ; PREVIOUS INJURY	p-VALUE
LEFT	**ANTERIOR**	95.7 (±15.8)	92.3 (±16.3)	130 (51;79)	0.11
	POSTERIOR	77.2(±19.1)	75.9 (±19.2)	130 (51;79)	0.35
	SAME SIDE AS STANCE LEG	59.8 (±18.9)	58.2 (±15.5)	130 (51;79)	0.31
	OPPOSITE FROM STANCE LEG	87.2 (±21.0)	84.3 (±13.5)	130 (51;79)	0.17
	SUM OF REACH DISTANCES	319.8 (±57.6)	302.9 (±59.6)	130 (51;79)	0.07 *
RIGHT	**ANTERIOR**	94.6 (±16.5)	91.4 (±15.2)	131 (52;79)	0.1
	POSTERIOR	75.5 (±18.8)	74.9 (±18.4)	131 (52;79)	0.4
	SAME SIDE AS STANCE LEG	53.7 (±18.0)	57.2 (±16.3)	131 (52;79)	0.8
	OPPOSITE FROM STANCE LEG	87.4(±18.3)	86.8 (±16.3)	131 (52;79)	0.4
	SUM OF REACH DISTANCES	311.3 (±54.1)	302.4 (±70.8)	131 (52; 79)	0.2

In Table 4.20 there is only one marginally significant value for the sum of reach distances standing on the left leg. This again re-iterates that the ankle is not the only joint in the kinetic chain that needs to be considered or that there is no difference in a subject's ability to perform the test, irrespective of injury to the ankle.

4.3 CONCLUSION

The results of the study have been given in this section for the following:

Prevalence of the following:

1. Clinical signs of perceived ankle instability : 47% for the Olerud and Molander questionnaire and 51% for self-reported ankle injury
2. Clinical signs of mechanical ankle instability: 39% when laterality is ignored
3. Clinical signs of functional ankle instability: varied values based on the difficulty of the testing position
4. Clinical signs of concurrent mechanical and functional ankle instability: varied values based on the difficulty of the testing position

The comparison between injured and uninjured subjects was made for the clinical signs of mechanical and functional as well as the concurrent clinical signs of mechanical and functional ankle instability. For mechanical and functional clinical signs of ankle instability the presence of previous injury was related to clinical signs of the aforementioned.

The odds-ratios for previous ankle injury were determined to establish previous ankle injury as a risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire.

Finally clinical findings relating to ankle injuries were described for different factors including the side and dominance, investigations done and management instituted effect on player's ability and their return to the game. Results of the Star Excursion Balance Test revealed no significant differences between injured and uninjured subjects possibly due to the fact that it views the whole kinetic chain and not only the ankle joint in isolation..

CHAPTER 5

5. DISCUSSION

5.1 INTRODUCTION

This chapter includes a discussion of the results as described in chapter four. The prevalence of clinical signs of ankle instability in club rugby players is discussed for perceived, mechanical and functional deficits including a comparison between players who have had previous ankle injuries and those who did not report any previous injury to the ankle. The clinical findings related to ankle injuries in club rugby players in the Golden Lions South Gauteng region are also described.

5.2 THE PREVALENCE OF CLINICAL SIGNS OF PERCEIVED INSTABILITY

The 47% of players who reported some signs of instability is higher than the prevalence discussed in the literature, 10 – 30% (Zöch, et al, 2003; Garric, 1997). It must be remembered that this is a subjective evaluation by the player of the perceived status of the ankle. It is not inferred that these injuries were sustained as a result of playing rugby. There is also a very broad spectrum of questions included in the Olerud and Molander questionnaire that can be associated with ankle injury but the Olerud and Molander questionnaire was specifically designed to make research by different groups into ankle injuries more comparable whether sporting related, occupational or even in the military (Hertel, 2008; Rose et al, 2000). Documentation indicating the presence of any one of the signs or symptoms was taken to be a sign of a functional control deficit (Rose et al, 2000). Therefore this may have resulted in the high prevalence of perceived instability. The questionnaire is further divided into two sections which will now be discussed.

The first section of the questionnaire consists of the physical signs and symptoms and results reported here range from 15% – 29%, and these results are much closer to results as reported in the literature which range from 10 – 30% (Zöch, et al, 2003; Trojian and McKeag, 1998; Garric, 1997). The subsections include pain (27.8%), stiffness (29.2%) and swelling (14.6%). It is interesting that despite the reports of physical signs of ankle injury some of these players were still actively participating in practice sessions and games. This raises the question of whether they are predisposed to future injury due to inadequate healing time, management and rehabilitation. The literature reports an initial healing time as 4 – 6 weeks for orientation, aggregation and arrangement of soft tissue. In this phase normal function is possible but the athlete is still vulnerable to re-injury. Over a period of six months to two years the final tissue changes will still take place (Denegar and Miller, 2002; Zöch et al, 2003). Rehabilitation is the key to effective and successful return to sport. Acute management should include anti-inflammatory modalities and exercises to maintain range of motion. Once initial tissue healing has been observed, strength and proprioception has to be addressed and then a graduated return to sport must be supervised (Arnold and Docherty, 2004). The experienced clinician should also identify the internal and external precursors for future injury including biomechanical abnormalities, footwear and the need for bracing or taping (Zöch et al, 2003; Denegar and Miller 2002; Beynnon et al, 2002).

The functional limitations included four problems that are of particular interest to the rugby fraternity because all the maneuvers are used regularly on the field and in training. The following percentages of perceived problems were reported: running (4.4%), jumping (5.8%), stairs (11.7%) and squatting (6.6%). These players experienced problems with basic training techniques which suggest that they should not be participating in games and practices. The low percentages here can be ascribed to the stoic nature of the sportsman, the body's adaptation to limitation and the fact that these players want to continue playing the game (Hertel, 2008). Where the translation of a joint is not controlled there will be a long term negative impact on tissue structure and degeneration of the ankle and subtalar joint with the possible onset of early osteo-arthritis (Hertel, 2008; Denegar and Miller, 2002). If the continuum from acute ankle sprain with mechanical deficit to functional instability and then chronic instability is applied as earlier discussed, the ankle with perceived

instability may eventually end up categorized as chronic instability, this being a sure precursor for early degenerative arthritic changes (Gribble et al, 2004; Mattacola and Dwyer, 2002).

Seventeen percent of players reported the use of some sort of support with the highest percentage of the subjects reporting the need for strapping or bracing rather than the use of crutches. There seem to be conflicting ideas in the literature with regards to the use of taping and bracing. The need for taping and bracing is described as rehabilitative and protective. It is used to limit movements which might strain the structures that are healing and allow movement in the desired direction (Mohammadi, 2007; Surve et al, 1994). The use has been questioned by certain authors (Hume and Gerrard, 1998), who argue that this will lead to weakness of the supporting musculature and others that report only minimal effectiveness of bracing to restrict weight bearing inversion injuries in netball players (Mashawari et al, 2003). In clinical practice it certainly seems that there is some benefit to the use of taping and bracing (Wikstrom et al, 2006). There is no conclusive evidence to advocate the use of any specific external support for clinical efficacy or cost-effectiveness (Kerkhoffs et al, 2002).Team physicians in some of the top teams in the world report that their players are strapped as a precautionary measure to prevent injury (Wikstrom et al, 2006; Davies, 1997; Surve et al, 1994). Effective bracing requires preparation through rehabilitation and bracing is only indicated as part of a comprehensive treatment approach and is not suggested as the only management strategy (Davies, 1997). Soft and semi-rigid braces do not improve postural control but assist with the attenuation of vertical forces (Wikstrom et al, 2006). A study on soccer players did mention a fivefold reduction in the incidence of recurrent ankle sprains in soccer players who used the Sport-Stirrup orthosis (Surve et al, 1994). However reports from rugby players suggest that they feel safer with an external constraint and taping and bracing have been shown to have good effect to decrease ankle injuries and also have minimal effect on the performance of a subject (Sankey et al, 2008; Hume and Gerrard, 1998). Whether this is merely a placebo effect remains to be shown (Wikstrom et al, 2006).

From a rehabilitation point of view it is suggested that if an external constraint can be used to control motion it may be possible to prevent injury or recurrences through rehabilitation of postural control and muscular rehabilitation which are the anatomical

structures to regain stability the ankle (Kawaguchi, 1999). Failure of conservative management of the ankle has lead to the statement that any athlete who has had a significant lateral ligament injury should use protective strapping or bracing for any future participation in sport (Brukner and Khan, 2007; Davies, 1997). When looking at the ankle and subtalar joints and the muscular support it is evident that the joint is not crossed by any muscle and that support is only given by the tendons passing across the joint and ligamentous constraints (Moore, 1992). There is also not one single tendon attached to the talus, the only bone in the human body where there is no insertion point for a muscle or tendon. It may be that the anatomical features of the ankle (the bony congruency and ligamentous support are essentially the two restraining factors and if this is lost the joint is even more vulnerable to injury), relatively predisposes the joint to injury and the case for taping and bracing can possibly be made (Moore, 1992).

Twelve percent of players reported difficulty in performing activities of daily life due to their ankle injuries. Daily life is affected by the presence of clinical signs such as pain and stiffness which limits participation in certain activities. This is further linked to inability to climb stairs, run and jump which are all related to normal function in daily life. There were also a few of these players who had physical occupational duties which might have been more difficult to perform. This is an issue of concern as a certain percentage may suffer from chronic pain syndromes, early onset of osteo-arthritis and eventually gait disturbances which could well affect the rest of the kinetic chain including knee, hip and lumbar spine (Brukner and Khan, 2007; Motram and Comerford, 1998; Davies 1997).

5.3 THE PREVALENCE OF CLINICAL SIGNS OF MECHANICAL INSTABILITY

A seventeen percent prevalence of mechanical instability was seen for both the anterior drawer and talar tilt tests on the right hand side. For the left, the results were slightly different with the anterior drawer test being 23% and talar tilt test 20%. The different values for the left leg can be ascribed to the sensitivity of the talar tilt test to

determine injury to the calcaneo-fibular ligament where the anterior drawer test is more specific for the anterior talo-fibular ligament this would have been true for the right hand side as well. . It is deduced that more players injured the anterior talo-fibular ligament in isolation and this is supported in the literature (Trojian and McKeag, 1998; Hartley, 1995). The prevalence of mechanical instability in the subjects used for this study is slightly higher (43.8%) to what has been reported in the literature for ankle injuries in sport, 10 – 30% (Zöch et al, 2003), and relatively higher than the reported prevalence for ankle injuries in rugby players at nine to 15% (Sankey et al; Trojian and McKeag, 1998). To discuss this one must consider the traumatic impact experienced in the game of rugby to explain the higher prevalence reported in this study and consider the level at which the game is played, i.e. club, provincial or national. At a higher level injuries are usually managed by a multi-disciplinary medical team which might decrease the prevalence of injury with correct rehabilitation or identification of risk factors and pre-injury intervention. Club rugby players are rarely managed at the club and have to attend physiotherapy at their own cost. High reliance is placed on bracing instead of rehabilitation to ensure participation (Brooks and Kemp, 2008; Davies, 1997).

When laterality is ignored this percentage is even greater than when comparing left side to right side. Forty four percent of players had a problem with determined mechanical deficit on the left, right or even bilaterally. The prevalence of injury in club rugby players relates back to predisposing factors, rigors of the game, poor injury management, decreased postural control and wrong training methods (Brooks and Kemp, 2008). Clint Redhead, who was the physiotherapist to the recent World Cup winning South African rugby team verbally reported during a South African Sports Medicine Association presentation at the Morningside Medi Clinic that the preparation for this event started three years previously and that when a professional team prepares for international participation the season is divided into three phases. The first being the pre-season phase which includes screening for possible predisposing factors and conditioning training. Second, the season itself where injuries are managed and treated in a conservative fashion to enable return to sport when the player is conditioned and when healing time has been observed. The third and final session includes post-season management where niggling injuries and biomechanical factors are addressed. This is supported by the literature (Hunter and

Fortune, 2000; Brukner and Khan, 2007). In the build up to the 2007 Rugby World Cup the sports physicians involved felt that the players were being over-utilized and not being given sufficient time to recover from niggling injuries and a study was undertaken to indicate the incidence of injuries in the Super Twelve competition to show that these players needed more time to recover (Holtzhauzen et al, 2006). The dangers of the tackle were again underlined and there were mostly minor injuries of which chronic overuse injuries were mostly seen. Suggestions made then included that training in tackling and rucking techniques was important and that rules should be enforced to reduce risk of injury (Holtzhauzen et al, 2006). The management plan above is optimal at club rugby level but is not always applied to players at club rugby level where certain teams do not have an attending sports physician or physiotherapist and only a fortunate few will be able to afford private management by appropriate practitioners (Gabbet, 2004). The study did not determine if all ankle injuries sustained was purely due to rugby injuries and only states that there were injuries in the group of players.

The analysis were taken further and there were significant differences as expected for both the talar tilt test and anterior drawer test irrespective of laterality between the group who mentioned previous injury and the ones who had never experienced any previous injury. This again shows that there might be residual mechanical laxity after return to participation in sport or that the patients with some sort of mechanical deficit is more likely to sustain injuries. It asks the question of whether these players return to play too soon or whether they are not fully rehabilitated when they return to the game (Holtzhauzen et al, 2006; Garraway et al, 2000). This underlies the principle supporting clinical testing to establish ankle injury with mechanical deficits (Trojian and McKeag, 1998). This is also advocated in a study by Sankey et al in 2008 where grade I and II ankle injuries were accurately diagnosed based on clinical tests and where only more severe injuries required radiological investigations (Sankey et al, 2008). As expected there was a higher prevalence of mechanical deficits in rugby players with self-reported previous injury to the ankle. The use of self-reporting is supported by a recent article where it is suggested that the presence of previous injury and reduced function can be predictors of new injuries based on a player's self-reporting using a questionnaire (Steffen et al, 2008).

The evidence of presence of mechanical laxity in patients who reported previous injury to the ankle all rendered high percentages above 74% as would be expected.

5.4 PREVALENCE OF CLINICAL SIGNS OF FUNCTIONAL ANKLE INSTABILITY

A high percentage of players struggled to perform the more difficult balance testing positions (eyes closed or using the foam surface). Ninety six percent of players for the left leg and 98% of players for the right leg made mistakes on the balance error scoring system with their eyes closed on an unstable surface. When one considers that visual input is taken out of the somatosensory equation of proprioception, vestibular and visual input and that the proprioceptors are exposed to an unstable foam block and constantly have to adapt to the surface this is certainly the most difficult of the stance positions. This however mimics what is happening during a game. The visual input is not used for postural control, rather for assessing the information on the field. The grassy turf of a rugby field is not always even, and the foot must adapt to the ground with every step and contend with impacts from different directions during rucks, mauls and tackles.

On a stable surface with decreased visual input 64% (left) and 56% (right) were deemed functionally unstable. As soon as a player closed his eyes even when standing on a stable surface there were signs of instability. This is again probably pointing to the importance of visual input to the central nervous system to control the body in space (Ergen and Ulkar, 2008).

On an unstable surface with visual input the percentages dropped to 48% (left) and 48% (right) who showed signs of inability to control the ankle in space statically and this doesn't even consider the impact of movement on the ankle because it is only a static balance test. Perturbation is applied through the constant change in the foot position on the unstable surface. The test does not include the player's ability to read the surface or adapt to it during the stance phase and simultaneously allow the other foot to clear the ground and propel the body forward during dynamic movement. It

has been shown that players with reported functional ankle instability do take longer to stabilize after ground contact in a land from a single leg jump which assesses functional control (Ross and Guskiewicz, 2004). The more challenging the balance perturbation with progression of the test the greater the positive signs for instability as shown by the test for the combination of decreased visual input on an unstable surface where 96% on the left and 98% on the right showed functional signs of instability. For the balance error scoring system one must consider that the whole kinetic chain must be considered and a deficit anywhere in the chain could affect results What is evident from the results is that as the difficulty in stance surface increases as it is changed from firm to foam and with changes in visual input the results are poorer.

There is no consideration whether or not there is some sort of mechanical insult to the ankle ligament and thus this does not distinguish between players with positive mechanical signs of ankle instability namely torn or stretched ligamentous structures or those with no mechanical deficits. This might indicate that the lack of static postural control could be a precursor to injury as much as the after effect of it. This will be looked at further in the next section where concurrent mechanical and functional instability is discussed. This is not an isolated test for ankle instability but for static postural control so an insult to any one of the joints in the lower limb kinetic chain might result in positive signs for instability (Kawaguchi, 1999). Since the kinetic chain functions as a unit to produces movement and carry the weight of the body one cannot isolate the proprioceptive input from one joint to another.

The analysis was again taken further by dividing the group into those with and those without previous mention of ankle injury. There were only one significant difference and that was for players standing on a stable surface with the eyes closed on the left leg. This is a possible indication that the predisposing functional deficits could lead to future injury rather than injury contributing to the functional deficit upon balance testing. These results also ignore injury to the lower back, spine, hip and knee which might be the contributing factors to the decreased postural control affecting balance and proprioception, rather than the ankle itself. In players with positive clinical signs of functional ankle instability the percentages varied from 55% to 69%, which is less than the confirmed percentages for mechanical instability but again is expected

considering that the test is not specific to the ankle joint and includes the affects from the rest of the kinetic chain. The results were not very significant for the comparison

This also raises the question of the possibility of the presence of decreased postural control being the predisposing factor to injury (at the ankle and other parts of the kinetic chain) and not necessarily the result of a mechanical insult to the proprioceptors (Gribble et al, 2004). This will be further illustrated in the following paragraph where concurrent functional and mechanical problems are discussed.

5.5 THE PREVALENCE OF CONCURRENT CLINICAL SIGNS OF FUNCTIONAL AND MECHANICAL ANKLE INSTABILITY

For the balance error scoring system there were only two significant p-values, one on the right and one for standing on the left leg. The increased difficulty of each testing condition must be considered for the results showed. This explains the higher percentages for more difficult positions. This supports the notion that this is not only an ankle test but tests the whole kinetic chain for postural control and any deficit in the kinetic chain might contribute to a player's inability to perform well in this test (Susco et al, 2004).

From this it can possibly be concluded that standing on the right leg on a firm surface the players with clinical signs of mechanical disruption was only marginally significant and those with eyes open on a firm surface for the left leg compared to those without any mechanical signs of instability of the ankle.

For the rest of the results, eyes opened or closed on a stable or unstable surface, there were no significant differences between players with mechanical insult compared to players with no previous mechanical insult to the ankle. Two factors can be considered here to explain this. As referred to previously the ankle cannot be isolated by the balance error scoring system and injury to the rest of the kinetic chain must be considered as a contributory factor

(Kawaguchi, 1999). In this study only a quick subjective screening was done to establish contributions from the rest of the kinetic chain. The results might have been influenced by the presence of injury to the knee, hip or even centrally by irritation of the exiting nerve roots from the lumbar spine. The lack of significant differences between the injured and uninjured ankle can also indicate that mechanical instability is not necessarily an indicator of functional instability as measured by the balance error scoring system. It might actually be seen as a predictor of the possible lack of postural control mediated by the central nervous system (Taube et al, 2008).

The analysis was again applied to players who mentioned previous injuries to the ankle and those who have not and the findings were again that there were only marginally significant differences for players with clinical signs of mechanical ankle instability in the comparison between the group with previously mentioned ankle injury and those with no previous injuries. For all the other positions there were no significant differences. This indicates that there might be underlying proprioceptive deficits that might be present before injury and subsequently be the predisposing factors to injury.

5.6 FUNCTIONAL INSTABILITY AS A COMPONENT OF POSTURAL CONTROL AND BALANCE

A recent change in the management of sports injuries, in the United Kingdom, Australia and New Zealand has come from research indicating that the lack of postural control due to lifestyle and habitual postures resulting in muscle imbalances might be the precursor to functional instability (Comerford and Mottram, 1998; Richardson and Jull, 1995; Lee, 1996; O'Sullivan et al, 1997). Other determined intrinsic factors include forefoot varus and overpronation (Sanky et al, 2008) Most of the research has been done on the lower back and shoulder joints but can be applied to the rest of the kinetic chain. For years rehabilitative therapists have managed only the involved joint but from this recent research the emphasis has changed. A group of physiotherapist in the United Kingdom have started a group called "Kinetic Control"

and they apply specific tests to assess the translation of the joint to assess the presence of stiffness (restrictions) or hypermobility (gives) and then to rehabilitate the dysfunction in the kinetic chain or central control deficit and not only the localized problem, with good effect (Comerford and Mottram, 1998). Considering the results from this study, that there is not necessarily a specific mechanical injury to the ankle joint that relates to functional stability deficits, it indicates that decreased postural control for the functional stability tests might be the culprit. This supports the notion to manage postural control deficits by screening for 'gives' and 'restriction' and to control joint excursion throughout range of motion to prevent injury. The sporting population is more exposed to risk of injury and if pre-season screening can identify problems in postural control these can be addressed to prevent those injuries related to lack of postural control (Kaminski et al, 2003). It was shown that fatigue and chronic ankle instability can lead to postural control deficits and the opposite can also be true that existing postural control deficits might influence the stability of the ankle joint (Gribble et al, 2004).

This also supports the importance of a holistic approach to the patient that can be implemented to prevent injury and as an injury management tool rather than resorting only to localized management of the involved joint. This brings rehabilitation back to considering periodization and control from the core to the periphery (Brukner and Khan, 2007; Van Dijk, 2002). Postural control or kinetic control has been suggested as fundamental to neuromusculoskeletal rehabilitation, by different authors (O'Sullivan et al, 1997; Motram and Comerford, 1998). This refers to gaining control over the base of movement and then the peripheral joints. When one considers normal biomechanics of forward motion, each joint in the lower limb kinetic chain must be intact and translation movement controlled. When there is an abnormality anywhere in the chain it will have to be compensated for somewhere else in the chain (O'Sullivan et al, 1997; Motram and Comerford, 1998). There are basic control and adaptation mechanisms with balance training leading to neurophysiological adaptations and improved motor control. Emphasis is placed on the plasticity of the sensorimotor system relating to spinal and supraspinal structures which improve motor performance especially muscle power (Taube et al, 2008).

Traditional believes were that with acute ankle injury there was damage to afferent sense receptors with resultant proprioceptive deficits which lead to recurrent giving way of the ankle and slower response time for the peroneus to active to protect the joint (Freeman and Wyke, 1967; Freeman, 1965). The initial model was described in terms of feedback from the articular proprioceptors to the central nervous system. This however does not consider alpha motor neuron pool excitability and feed forward supported by the gamma motor neuron system. It has been showed in the literature that proprioception is affected irrespective of the presence of clinical signs of mechanical instability after any ankle injury (Konradsen et al, 1998). It has also been shown that individuals with chronic ankle instability looses a sense of position and upon ground contact the foot position is not optimal to transfer weight and has a suppressed ability to sense force but despite this one cannot only regard afferent input; the somatosensory and central nervous system effects must also be considered (Hertel, 2008).

In physiotherapy the work of Motram and Comerford, 1998; O'Sullivan et al, 1997; Vleeming, 1997 Richardson and Jull, 1995; Sahrman, 1993 and Panjabi, 1992 suggest that most overuse injuries can be prevented and managed by addressing movement dysfunction locally (at the injured joint) and globally from the core to the periphery. Spinal and supraspinal adaptations have also recently been investigated by Taube, 2008 and Santos and Lui, 2008. Functional control of movement is the use of low force continuous muscle activity in all positions of joint range and in all directions of joint motion. The specific stabilizing muscle is activated locally to control translatory joint motion acting as a support and protector of the joint. This is particularly important in mid-range or the so-called neutral position of the joint where capsular and ligamentous support is minimal and even more so when the primary constraints have been injured as is the case with the mechanically unstable ankle. The second level of control required is through range control and this is supplied by the global stabilizers.

When movement is not controlled by local and global stabilizers it can be described as a movement dysfunction. Poor movement habits or postural control might inhibit the global stability muscles leading to stiffness or shortening of global mobilising musculature because they in turn have to fulfil the role of the stabilizer. This leads to

imbalances in the global stability system with resultant loss of global control leading to what is called “gives” and “restrictions” (Motram and Comerford, 1998). A give is defined as uncontrolled movement in one direction, in the case of the mechanically unstable ankle the resultant increased inversion and calcaneal adduction is seen as a “give” into inversion. A restriction is normally what is found in the opposite direction to maintain a degree of relative stability. In the ankle joint the medial structures will compensate with possible limited calcaneal abduction and ankle eversion. Direction specific mechanical stress and strain of the joint, soft tissue and neural structures will lead to cumulative micro-inflammation (Comerford and Mottram, 1998).

This is often seen in cases of the overpronated or supinated foot where the result is pain and pathology (Hertel, 2002).This leads to a cycle of continued imbalance of the global stability system with further overload of already strained tissues, degenerative changes in the movement system and ultimately motor control deficit of the local stability system. All of the above eventually leads to a higher risk for recurrence. The injured ankle when not managed can have the following changes to compensate for lateral ligament instability; either forming a rigid cavus foot with splinting of muscles to control the instability or overpronation or early pronation in the stance phase of gait. This keeps the lateral structures in a shortened position requiring higher levels of muscular co-activation to compensate for joint laxity to maintain optimal joint alignment (Riemann, 2002). This is where it is seen that any instability cannot be viewed in isolation and that it is often the sum total of a number of injuries resulting in micro trauma that ends in the clinically unstable ankle (Riemann, 2002).

This does not exclude the presence of mechanical instability through trauma, with resultant complete rupture of the ligamentous structure. It just suggests that when the healing process has taken place the functional components have to be addressed before the player returns to competitive participation. (Motram and Comerford 1998; O’Sullivan et al, 1997; Sahrmann, 1993).

Players in this study showed signs of the lack of these components. In certain cases movement dysfunction was obvious as shown by the static Balance Error Scoring System and the dynamic Star Excursion Balance Test that will be discussed in the next section. Management of players at club rugby level should be more holistic. The

club rugby scene forms the base from which provincial players and then the national team are selected so these players should be managed to protect them from injury and to prevent recurrences from their initial injury.

One thing that is clear is that there are certain alterations in feedback and feed forward mechanisms after ankle sprain but it has not been clearly shown if this is merely local to the ligamentous structure or based on spinal or supraspinal effects (Hertel, 2008).

5.7 THE CLINICAL FINDINGS RELATED TO ANKLE INJURY

5.7.1 GEOGRAPHICAL AND DEMOGRAPHICAL DATA

Gauteng Lions Club Rugby consists of 10 clubs covering a vast area from North West Province and Gauteng. These players come from a wide geographical area and from diverse backgrounds. The group includes students, professionals and players from a more physical occupational environment. Experience ranges from players who have played rugby at this level for ten years to players who have only just started playing rugby at club level. It was difficult to group players according to the demographic or geographic data and these influences were not addressed in this study. The clubs have major differences in financial aid, player remuneration, training equipment, playing fields and other resources such as medical professionals available to the club. These can also play a role in predicting the clinical picture. Only two clubs had access to full time physiotherapy management, while four of the clubs had physiotherapists only for strapping and games, and three clubs had no professional medical assistants. The information above was reported on by the contact person at the clubs.

In this sample the average age was 24 but ranged from 16 – 43 years of age. The average is normal for club rugby because the feeding ground for clubs is post-matric players; but the two extremes should be considered. Players of 16 years cannot be mature enough to compete against their older counterparts and the risk of serious injury is possible but was not shown in this study. This is supported by school's rugby

rules limiting the minimum and maximum age of players playing at open level. As players age, their level of fitness and other risks must be considered as they could play a part in injuries (Gabbet, 2004). Player's heights ranged from 156cm to 204cm. The weights ranged from 60kg to 130kg.

5.7.2 PREVALENCE OF INJURIES

Forty six percent of the players included in the study reported injuries elsewhere in the lower quadrant in comparison to 58% who reported ankle injuries. The ankle injuries reported, ranged from a slight sprain to complete ligamentous rupture of the ankle or even fractures. This can partially explain the results of the Balance Error Scoring System where injuries elsewhere must be considered when assessing proprioceptive deficits because the ankle is a component of a whole kinetic chain. It is again a higher prevalence of reported ankle injury compared to injury anywhere else in the lower quadrant, and in comparison to the literature where only 10 – 30% of injuries are reported (Zöch et al, 2003). This perceived prevalence could be higher because it was only a player perceived prevalence and was not supported by the mechanical testing in the study.

A total of 79 players reported an injury of the ankle joint, either previous or current. Ten of the 79 reported bilateral injuries while 38% reported injury of the left and 49% reported right sided injury. This in comparison to the mechanical injury results of 25% left and 19% right although it must be remembered that the questionnaire did not distinguish between different levels of injury and whether or not the mechanical deficit had healed. A true comparison is however not entirely possible because the subjective questionnaire did not specifically refer to grade or severity of injury and an injury could range from a slight sprain to severe ligamentous rupture. The side of injury relates closely to the dominance where the dominant side was reported in 53% of cases as the most injured side. A higher prevalence is reported here for ankle injuries in club rugby players than is reported in the literature for ankle injuries in sport (Zoch et al, 2003; Garric, 1997).

5.7.3 TIMELINES FOR RECOVERY

The literature suggests that optimal healing takes places within four to six weeks from the time of injury with adequate rehabilitation. The experienced clinician should guide the player in his return to sport to ensure maximal strength, proprioception and preparation of sport specific exercises (Brukner and Kahn, 2007; Van Dijk, 2002). Fifty one percent of players felt that they only needed a few days to recover from the injury where 32% reported a few weeks of recovery time. Only 5% of the players observed the recovery time as suggested in the literature (Petty and Moore, 2001). This may be considered as one of the reasons for the recurrence of injury. These players often return to play with niggling injuries because they fear losing their place in the team while they are observing healing time. This is particularly important because players are not contracted, and they are only remunerated for games played and observing recovery time results in a loss of income, this is purely anecdotal in discussion with the coaches and management at the clubs and is only speculative. Therefore they return to play as soon as possible rather than within the medically accepted period. The statistic that raises concern is that 13% of players currently on the field felt that their injury had not recovered sufficiently. This can be a predictor for future injury, chronic ankle instability and an indicator of poor rehabilitation (Hertel, 2008).

In this study 20% reported not having been sidelined after the injury and returned to play, whereas 20% rested for a few days and resumed playing. Forty two percent did not participate for at least four weeks. None of the players contributing to these figures observed the six week period of optimal tissue healing and functional rehabilitation. A total of 18% took a few months before their return to active participation. The questionnaire did not consider the severity of injury but it is evident that certain players returned to play without any form of rehabilitation or injury management, a total of 42% self managed their injuries. The players who returned early mentioned the importance of participation for remuneration; pressure from coaches and teams; and not realizing how serious the injury was. A large percentage

was never properly managed before return to sport and this might have predisposed them to future injury.

Ninety one percent of players returned to a full 80 minutes of play. When considering the previous statistics there are players still hampered by ankle injuries playing a full game of rugby. Three percent were still on the bench following injury and struggling to make a full return to sport in part related to their absence giving opportunity to another player who might then make the position their own or the coach not being happy with the functional status of the player for return to sport. Six percent of players were only involved in forty minutes or one half of the game. Coaches are often reluctant to bring these players back and so use them as impact players in the second half or only for the first half until they've regained full match fitness (Holtzhauzen et al, 2006).

5.7.4 INJURY MANAGEMENT STRATEGIES

Initially 39% of the 79 players who reported injury used medication compared to 29% who were still using medication for ankle pain or swelling at the time of completing the questionnaire . This indicates that there are a lower percentage of players who experienced pain and swelling and still required medication. Twenty three percent of the sample initially used anti-inflammatories but 15% still used anti-inflammatories before or after a game to reduce pain and inflammation. If one considers the number of players who have returned to full participation the use of medication is hardly surprising. This again indicates inadequate healing time and recurrent or persistent inflammatory response due to joint irritation. This is cause for concern because anti-inflammatories mask the body's natural protective pain response. Acute severe pain was managed with painkillers in 13% of the injuries. Four percent experienced pain of chronic nature and still required painkillers. There were 10% who used a combination of painkillers and anti-inflammatories at the time of the study. This may mean that a player is using medication to decrease his pain to be able to participate with possible resultant re-injury because the body's natural protection mechanism namely pain is subdued. These players will probably be labeled the 'difficult ankle' group who

reports persistent pain and discomfort, because they are constantly causing more irritation to already injured structures (Petty and Moore, 2001).

The players who were still using medication to manage their condition should be assessed by an experienced clinician and sooner rather than later a management plan needs to be instituted. The players will require management of pain and inflammation before the rehabilitation process is started. The benefits of rehabilitation have been shown in the literature to reduce pain, manage instability and prevent recurrence (Van Dijk, 2002). The gold standard for management if proper rehabilitation of the ankle injury has failed is the use of radio isotopic bone scan. This can be used to determine injury which is hard to clinically confirm with diagnostic tests including stress fracture, avascular necrosis or tendon avulsion. More recently arthroscopic investigations have also been suggested and once it has been confirmed further management can be instituted (Brukner and Khan, 2007; Kerkhoffs et al, 2007).

A high percentage of players, 42%, self-managed their injury with no intervention from any medical practitioner. This could be one of the reasons why healing time and guidelines for return to sport were not observed. A high percentage, 44%, had at some stage been assessed and managed by a physiotherapist. This possibly indicates the failure of physiotherapy as a management strategy, non-compliance of players to suggested intervention or inadequate rehabilitation due to financial constraints. The results here also suggest that symptomatic treatment leads to a quick decrease in pain and the inflammatory response but full rehabilitation is rarely completed before return to sport because from the player's perspective recovery has taken place. From an intervention perspective proper rehabilitation requires injury management of six weeks and then rehabilitation and periodization before return to sport is possible (Brukner and Khan, 2007). This might explain the high failure rate of conservative intervention. What was also not established in this study was the type of physiotherapy and management done. The literature does however suggest that physiotherapists adhere to the clinical guidelines for management and intervention in the application of an ankle injury management plan (Van der Wees et al, 2007) Only a few of the players presented to general practitioners, orthopaedic surgeons, podiatrists or biokineticists.

The question arises when regarding post-injury and management outcomes whether they were fully rehabilitated and how many of these players fulfilled the *'back to sport criteria'* before returning to games and full sport participation. There should be a good relationship between player, coach and clinician to manage a player successfully. The player must be informed with regards to the injury, the time required to heal, the rehabilitation required and self-management strategies in the acute phase. For physiotherapy to succeed the physiotherapist must contract with the player and the coach and a conservative approach tend to yield much better outcomes (Van Dijk, 2002). Physiotherapy is still the primary intervention and the challenge for physiotherapists is to address all components of the neuro-musculoskeletal system and manage these players properly. A suggested post-injury management plan is included in Appendix F based on the literature review.

When this study was initiated an objective, quantifiable measure was required to determine the integrity of the lateral ligament of the ankle. The gold standard for this is stress view radiography (Stiell, 1995). Due to ethical considerations this was not possible and comparing previous investigations was not useful because only 30 % of injured players had x-rays done. The low percentage of investigations done could be related to the use of a set of guidelines, the OTTAWA-ankle rules which was discussed in the literature review (Stiell et al, 1995). Stress views are not indicated in the acute setting and most players have only had a standard x-ray to rule out any bony pathology. Two players had MRI-scans performed and three had CT-scanning to assist in making a diagnosis. All the above investigations are only a diagnostic tool and once a fracture is excluded injury management should be instituted based on the findings of diligent clinical examination.

5.7.5 EFFECT OF INJURY

Although 47% of the sample reported that the injury had no effect on their performance; speed, power and agility were affected singly or in combinations in 53% of the players. These players are the ones who could be predisposed to future injury and may not always be able to compete at their pre-injury level. When an injury hampers the speed, agility or power of players they cannot perform well. Since club

rugby is seen as the breeding ground for provincial and national players these players require top level performances to be able to step up a level. The challenge for the physiotherapist managing ankle injuries is to regain peak performance levels in the club rugby player (Van Dijk, 2002). This means addressing the whole kinetic chain from the local injury to postural control to create a stable base for movement (Mottram and Comerford, 1998; O Sullivan et al 1997.

5.7.6 ODDS RATIOS RELATING TO THE CLINICAL FINDINGS OF THE OLERUD AND MOLANDER QUESTIONNAIRE

There were significant p-values noted for the following categories of the Olerud and Molander questionnaire: pain, stiffness, swelling, stairs, and the use of supports and the effect on activities of daily living. The players with previous ankle injury have a greater risk of experiencing any of these clinical signs at any given point in time.

Pain is a known inhibitor for muscle function and control and can therefore suppress the protective mechanism of the ankle (Hertel, 2008). The presence of swelling has been documented as one of the reasons for the suppression of proprioceptive, afferent input (Konradson en al, 1998). Stiffness forces the change into foot positioning during ground contact which again predisposes to further injury. All of the above signs and symptoms underline the fact that the presence of a previous injury to the ankle irrespective of cause or severity can influence or predispose the athlete or rugby player to future injury as suggested by the use of self-reporting (Steffen et al, 2008).

When considering functional activities the players with clinical signs of ankle instability will struggle to climb stairs and the injury will affect their daily lives and lead to the use of taping and bracing to enhance stability around the ankle for functional activities and return to sport.

5.7.7 PERFORMANCE DEFICITS AS INDICATED BY THE STAR EXCURSION BALANCE TEST

There were only marginally significant changes for the Star Excursion balance test for players with clinical signs of mechanical instability compared to players with no clinical signs of mechanical instability and this only for the left leg. When players with self-reported previous injury were compared to those with no previous injury the results were pretty similar.

These results again underline that performance deficits in the lower limb cannot be attributed to a single joint and that the coordinated function of the whole lower kinetic chain needs to be intact. Obvious contributions have been seen from the proximal joints in the chain and it cannot be said that the afferent local receptors are the only contributors because of central neuromuscular effects (Hertel, 2008; Gribble et al, 2004; Bullock-Saxton, 1994)

5.7.8 CONCLUSION

Players at club level in the South Gauteng region present with three main problems singly or in combination:

- Perceived clinical signs and symptoms of lateral ankle instability
- Clinical signs of mechanical ankle instability
- Clinical signs of functional ankle instability in the presence of absence of ankle injury whether reported on or of mechanical nature.

5.8 CLINICAL RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

5.8.1 CLINICAL RECOMMENDATIONS

Considering the results of this study and the clinical picture derived from the results, a clinical recommendation is to develop a standardized, comprehensive management plan that could improve post-injury results and lead to graduated return to sport for these athletes. In addition the compilation of a pre-season screening tool to detect biomechanical abnormalities and postural control deficits should be considered.

Each club was informed of the status of the players tested and based on the literature review suggestions were made and given to the club's sports physician for further management to be instituted.

5.8.2 SUGGESTIONS FOR FUTURE RESEARCH

Based on the investigations done in this study the development of a pre-season screening tool can be advocated using tests as used in this study. This can be used to determine predisposing factors for recurrent injuries or to determine current injury status. Future studies could look at implementing the screening tool and using data to set up a management plan for these players.

In this study it has been shown that there is a high prevalence of ankle injuries in Club Rugby players and this re-iterates the importance of the development of a holistic management plan to reduce and control ankle injuries in Club Rugby players. Future research might include setting up a relevant plan, implementing this plan and then testing the prevalence thereafter with the idea to reduce perceived, mechanical and functional parameters of lateral ankle instability.

5.9 LIMITATIONS OF THIS STUDY

The lack of a sedentary control group to make comparisons between rugby players and non-sportsmen was a limitation of this study and can be considered in future studies.

The balance tests used, namely the SEBT and BESS are both subjective tests but again effective, valid and reliable data have been produced and thus supported the use of these tests in the study. A further limitation of the use of the balance tests is that they are not localized only to the ankle and will be influenced by injury anywhere in the kinetic chain.

This study was limited by the ethical considerations and indications for x-rays which are the gold standard investigations to confirm the mechanical integrity of the lateral ligament of the ankle. However diligent clinical assessment has been advocated in the literature as effective, reliable and valid to determine lateral ankle ligament integrity after an injury.

CHAPTER 6

6. CONCLUSION

The aims of this study were to determine the prevalence of clinical signs of ankle instability for perceived, mechanical and functional factors of stability and to relate the clinical findings of ankle injuries in club rugby players in South Gauteng.

In answer to the objectives the following can be concluded:

The prevalence of clinical signs of perceived ankle instability in club rugby players in Gauteng was derived from the Olerud and Molander questionnaire and is 47%; from players self-assessment 58% reported an injury to the ankle in their lives. These are higher than figures reported in the literature.

The prevalence of clinical signs of mechanical ankle instability irrespective of laterality is 44% and is slightly higher than figures reported in the literature. There are significant differences between those with and those without reported previous injury.

The prevalence of clinical signs of functional ankle instability for the Balance Error Scoring System ranged from 44.8% to 93.8%, the great difference here is due to the different stance surfaces and difficulty in performing the tests. This is suggestive of the fact that postural control rather than functional ankle instability could be the precursor of injury or re-injury. There were no really significant differences for the comparison of the group with reported injury to the ankle to those with no report of previous ankle injury.

The prevalence of concurrent clinical signs of mechanical and functional instability did not yield significant results. This supported the notion that mechanical instability is not necessarily a precursor for functional instability but possibly the effect of decreased postural control that might predispose to injury. There were also only

clinically significant differences between the group with mention of previous injury and the one where no previous injury to the ankle was reported for players with an existing clinical signs of mechanical instability.

Odds-ratios to elucidate the presence of previous ankle injury as a risk factor for the clinical signs, symptoms and functional capabilities of the Olerud and Molander questionnaire revealed between a four to nine times likelihood for a person with previous ankle injury to experience pain, stiffness, swelling and difficulty with climbing stairs and requiring the use of some support for the ankle.

The clinical findings related to ankle injuries in club rugby players can be summarized as a single component or combination of factors including perceived, mechanical and functional signs of instability.

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APPENDIX A.1: DATA QUESTIONNAIRE USED IN THE PILOT STUDY

NAME:	**AGE:**
WEIGHT:	**HEIGHT:**
OCCUPATION:	**POSITION:**
YEARS PLAYED AT THIS LEVEL:	**1 2 5 10**
PREVIOUS INJURY IN THE LOWER BODY QUADRANT OTHER THAN ANKLE : (IF YES STATE AREA OF INJURY) **N0 YES**	**LOWER BACK HIP KNEE ANKLE HAMSTRING QUADRICEPS CALF MUSCLE PELVIS**
PREVIOUS ANKLE INJURY: **YES NO**	**SIDE OF INJURY: (ankle)** **RIGHT LEFT**
SITE OF INJURY: (ankle) **DOMINANT NON-DOMINANT**	**TIME SIDELINED BY INJURY: (ankle)** **DAYS WEEKS MONTHS**
CURRENT USE OF MEDICATION: (for your ankle) **ANTI-INFLAMMATORY PAINKILLER**	**MEDICATION REQUIRED DURING PERIOD OF INJURY:(ankle)** **ANTI-INFLAMMATORY PAINKILLER**
IF USING MEDICATION INDICATE WHEN (for your ankle): **BEFORE GAME DURING GAME AFTER GAME**	**DATE OF INJURY: (ankle)**
TIME TAKEN TO RECOVER: (ankle) **WEEK MONTH SEASON NEVER FULLY RECOVERED**	**REHABILITATION: (ankle)** **NONE PHYSIO BIOKINETICS**
HOW HAS THE ANKLE INJURY AFFECTED YOUR PERFOMANCE? **DECREASED :** **SPEED POWER AGILITY**	**SINCE THE INJURY HOW MUCH TIME DO U SPEND IN THE GAME?** **FULL (80 mins) BENCH** **HALF (40 mins)**
PREVIOUS SURGERY TO ANKLE	**YES NO**

APPENDIX A.2: DATA QUESTIONNAIRE

NAME:	**AGE:**
WEIGHT:	**HEIGHT:**
OCCUPATION:	**POSITION PLAYED:**
YEARS PLAYED AT THIS LEVEL: 1 □ 2 □ 5 □ 10 □	**PREVIOUS SURGERY TO THE ANKLE?** YES □ NO □
FLU, HEAD COLD OR EAR INFECTION: (Currently) NO □ YES □	**RECENT CONCUSSION:** (Sidelining you from the game within 1 month) NO □ YES □
PREVIOUS INJURY IN THE LOWER BODY QUADRANT OTHER THAN ANKLE : (Last 3 months sidelining you from the game) (IF YES STATE AREA OF INJURY) N0 □ YES □	**AREA OF INJURY**: LOWER BACK □ HIP □ KNEE□ ANKLE □ HAMSTRING □ QUADRICEPS □ CALF MUSCLE □ PELVIS □
PREVIOUS ANKLE INJURY: YES □ NO □	**DATE OF INJURY:** _____
SIDE OF INJURY: RIGHT □ LEFT □	**SITE OF INJURY:** DOMINANT □ NON-DOMINANT □
TIME SIDELINED BY INJURY: DAYS□ WEEKS □ MONTHS□	**MEDICATION REQUIRED DURING PERIOD OF INJURY:** NONE □ ANTI- INFLAMMATORY □ PAINKILLER □
CURRENT USE OF MEDICATION: NONE □ ANTI-INFLAMMATORY □ PAINKILLER □	**WHEN DO YOU USE MEDICATION:** NEVER □ PRIOR TO GAME □ AFTER GAME □ DAILY FOR CHRONIC PAIN □
TIME TAKEN TO RECOVER: WEEK □ MONTH □ SEASON□ NEVER FULLY RECOVERED □	**INJURY MANAGEMENT:** SELF □ PHYSIOTHERAPIST □ ORTHOPAEDIC SURGEON □ BIOKINETICS □ PODIATRIST □
INVESTIGATIONS REQUIRED: X-RAYS □ULTRASOUND □ MRI □ CT-SCAN □	**HOW HAS THE ANKLE INJURY AFFECTED YOUR GAME?** DECREASED : SPEED □ POWER□ AGILITY□
HOW MUCH TIME DO YOU SPEND ON THE FIELD? FULL □ BENCH □ HALF □	THANK YOU FOR COMPLETING THE QUESTIONNAIRE!

APPENDIX B.1: OLERUD AND MOLANDER QUESTIONNAIRE

Please indicate if you experience any of the following signs or symptoms and tick to the appropriate degree

PARAMETER	DEGREE	TICK
1. PAIN	NONE	25
	WALKING ON UNEVEN SURFACES	20
	WALKING ON EVEN SURFACES	10
	WALKING INDOORS	5
	CONSTANT AND SEVERE	0
2. STIFFNESS	NONE	10
	STIFFNESS	0
3. SWELLING	NONE	10
	ONLY EVENINGS	5
	CONSTANT	0
4. STAIRS	NO PROBLEMS	10
	IMPAIRED	5
	IMPOSSIBLE	0
5. RUNNING	POSSIBLE	5
	IMPOSSIBLE	0
6. JUMPING	POSSIBLE	5
	IMPOSSIBLE	0
7. SQUATTING	NO PROBLEM	5
	IMPOSSIBLE	0
8. SUPPORTS	NONE	10
	TAPING / STRAPPING	5
	STICK / CRUTCH	0
9. DAILY LIFE	SAME AS BEFORE INJURY	20
	LOSS OF TEMPO	15
	CHANGE OF OCCUPATION DUE TO INJURY	10
	SEVERELY IMPAIRED WORK CAPACITY	5

(Rose, Lee, et al, 2000)

The Olerud and Molander questionnaire were scored as follows. Each player would be able to get a score of 100 if there were no problems identified relating to ankle injury. The final column of the Olerud and Molander is not included in the questionnaire handed out to players and in Appendix B.2 there is an example of a questionnaire as completed by one of the players where after the scoring was done.

APPENDIX B.2 EXAMPLE OF COMPLETED QUESTIONNAIRE

APPENDIX C: INFORMATION AND INFORMED CONSENT LETTER

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

Dear _____

I am Eloize Mellet, a Masters student in the Department of Physiotherapy at the University of the Witwatersrand and I'm investigating the prevalence of ankle instability of club rugby players in the South Gauteng region.

Research in other sports has indicated that ankle injury is one of the most common injuries in the sporting fraternity with a very high recurrence rate. Clinically it has been evident that rugby players are also at risk and often experiences instability or giving way of the ankle. Your cooperation in this study will help us to establish how real a problem this is.

What is expected from you?

Your club falls within the South Gauteng region and has given us permission to continue with the study. You are invited to complete the questionnaires that will be handed out. The first is a general questionnaire to determine whether or not you have had an ankle injury and the extent of the injury will then be further highlighted in the subsequent questions. The first four questions determine your further participation in the study. The second questionnaire is called Olerud and Molander and all questions pertain to your ankle. I will explain the

questionnaires and how to go about your answers. Your ligaments will then be tested with two tests to determine if they are intact. Balance will also be assessed. The testing procedures will take approximately a half an hour to complete.

There is no obvious chance of danger or injury to you through the testing procedures and you may decide at any time to withdraw from the study. All information will be kept strictly confidential and your anonymity is assured.

You will not directly or immediately benefit from this study but it is my hope that the evidence gained will be used to set up a pre-season screening protocol (including the tests performed in the study) to avoid recurrent ankle injuries which leads to instability.

If you have any queries they can be forwarded to Eloize Mellet at contact number 082 321 7739.

If you are happy to participate in the study and for data obtained to be used in this research product please sign the attached consent form. If you decide not to participate be assured that you will not be prejudiced in any way.

With thanks

Eloize Mellet

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

CONSENT FORM

I, _____ AGREE TO PARTICIPATE IN THE STUDY AND ALLOW THE RESEARCHER TO USE DATA OBTAINED THROUGH THE QUESTIONNAIRE AND TESTING PROCEDURES. I HAVE READ THE INFORMATION SHEET AND I AM SATISFIED THAT THERE ARE NO DANGERS INVOLVED IN THE STUDY. I UNDERSTAND THAT DETAILS OF MY RESULTS WILL BE CONFIDENTIAL AND THAT I WILL NOT BE PREJUDICED IN ANY WAY.

NAME: _____

SIGNATURE: _____

DATE: _____

APPENDIX D: LETTERS OF CONSENT TO SOUTH AFRICAN RUGBY UNION, GAUTENG LIONS RUGBY UNION AND CLUBS

10/03/2007

THE SOUTH AFRICAN RUGBY FOOTBALL UNION

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and I would like to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from SARU and would appreciate it if you could complete and sign this letter.

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research on behalf of SARU.

Name: _____

Date: _____

Signature: _____

10/03/2007

THE GAUTENG LIONS RUGBY UNION

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and I would like to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from GLRU and would appreciate it if you could complete and sign this letter.

With thanks

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research on behalf of GLRU.

Name: _____

Date: _____

Signature: _____

28-06-2006

_____

To Whom It May Concern:

My name is Eloize Mellet and I am a Masters student in physiotherapy at the University of the Witwatersrand. I am doing a study to determine the prevalence of functional ankle instability in rugby players and have selected to do the study on rugby players in the South Gauteng region.

I would like to conduct this study with consent from the management of your club and would appreciate it if you could complete and sign this letter. I have obtained consent from SARU and GLRU to conduct this study.

Included with this letter you will find the suggested protocol, which explains the aims and objectives of the study.

I will contact you to determine what will be a suitable time for the research to be conducted if you agree to it.

Yours sincerely

Eloize Mellet

The undersigned, _____, herewith supports the proposed research project and allows the researcher to continue the research; on behalf of the club.

Name: _____

Date: _____

Signature: _____

APPENDIX E: ETHICAL CLEARANCE FORM

APPENDIX F: SUGGESTED MANAGEMENT PLAN

1. Sound clinical assessment
2. Instituting anti-inflammatory measures to reduce pain, swelling and inflammation in the acute phase; including ultrasound, cryo- and heat therapy and interferential.
3. Once the acute phase has been observed active painfree motion should be initiated to regain and maintain normal range of motion. Healing tissue must be protected in this stage either limiting weight bearing or using external supports
4. Once the initial phases of healing has been observed rehabilitation must start including:
    a. Range of motion exercises to regain range of motion and maintain available ranges
    b. Strength training
    c. Localized stabilisation exercises
    d. Global postural control
    e. Balance and proprioception
5. Return to sport rehabilitation will include sport specific drills, change of direction-control and plyometrics.

(Based on management as suggested in: Ergen and Ulkar, 2008; Sankey et al, 2008; Brukner and Khan, 2007; Van der Wees et al, 2007; McGuine and Keene, 2006; Surve et al, 1994)

APPENDIX G: DATA COLLECTION SHEET FOR OBJECTIVE TESTS

NAME	
NUMBER	
LEGLENGTH (L)	**LEGLENGTH ®**
REACH DISTANCE (L) **ANTERIOR** **POSTERIOR** **LEFT** **RIGHT**	**REACH DISTANCE ®** **ANTERIOR** **POSTERIOR** **LEFT** **RIGHT**
STANDING FIRM (EYES OPEN) **BOTH LEGS** **LEFT LEG** **RIGHT LEG**	**STANDING FIRM (EYES CLOSED)** **BOTH LEGS** **LEFT LEG** **RIGHT LEG**
STANDING FOAM (EYES OPEN) **BOTH LEGS** **LEFT LEG** **RIGHT LEG**	**STANDING FOAM (EYES CLOSED)** **BOTH LEGS** **LEFT LEG** **RIGHT LEG**
ANTERIOR DRAWER TEST (L)	**ANTERIOR DRAWER TEST ®**
TALAR TILT TEST (L)	**TALAR TILT ®**

APPENDIX H: LETTER TO CLUBS - REPORT BACK ON RESULTS

THE PREVALENCE OF CLINICAL SIGNS OF ANKLE INSTABILITY IN PREVIOUSLY INJURED AND UNINJURED ANKLES OF CLUB RUGBY PLAYERS IN SOUTH GAUTENG

13-05-2009

Dear Madam / Sir

Re: Master's Study – Ankle Injuries in Club Rugby Players

Herewith, I express gratitude for your willingness to participate in the study to determine the prevalence of clinical signs of ankle instability in rugby players at Club Rugby level.

The results of the study have shown that there is a high prevalence of clinical signs of ankle instability in the following categories:

- Perceived instability referring to a player's self evaluation of his ankle function was determined at 47% of players in the South Gauteng region.
- Mechanical instability referring to specific tests for ligament integrity rendered results of 39% of the players in the South Gauteng region with some mechanical deficit
- Functional tests varied for different testing surfaces and the key finding based on this was that players had difficulty with balance and proprioceptive tests and as suspected the more difficult the testing position the more problematic performance of the test was.

Furthermore the likelihood of certain signs being present after ankle injury was determined and the following were the most evident:

- Pain
- Swelling
- Stiffness
- The use of ankle supports: bracing and taping

This is important to note because the players who reported this was after an initial injury and all these factors indicate possible susceptibility to future injury.

There were also signs of insufficient injury management and early return to play which again rendered these players more susceptible to future injury.

I suggest that you share the above with the attending physician or physiotherapist for further management. If you require further assistance in this regard feel free to contact me for advice and treatment suggestions from the latest literature. The study and results are available for your perusal if so required.

Your co-operation and contribution to the study is appreciated.

Yours Sincerely

Eloize Mellet
B.Sc. Physiotherapy (UOFS)

APPENDIX I: PHOTOGRAPHS OF MECHANICAL AND FUNCTIONAL TESTS AS PERFORMED IN THE STUDY

1. THE ANTERIOR DRAWER TEST



PHOTOGRAPH I.1 GONIOMETER USED TO DETERMINE KNEE POSITION AT 40ó OF KNEE FLEXION



PHOTOGRAPH I.2 GONIOMETER USED TO POSITION ANKLE AT 10ó OF PLANTAR FLEXION



PHOTOGRAPH I.3 PERFORMANCE OF THE ANTERIOR DRAWER TEST

2. TALAR TILT TEST

Position for the test is determined as in Photgraph I.1 and I.2 and the test performed as below



PHOTOGRAPH I.4 PERFORMANCE OF THE TALAR TILT TEST

3. THE BALANCE ERROR SCORING SYSTEM



PHOTOGRAPH I.5 EYES OPEN AND CLOSED STANDING ON A FIRM SURFACE



PHOTOGRAPH I.6 EYES OPEN AND CLOSED STANDING ON A FOAM SURFACE

4. THE STAR EXCURSION BALANCE TEST

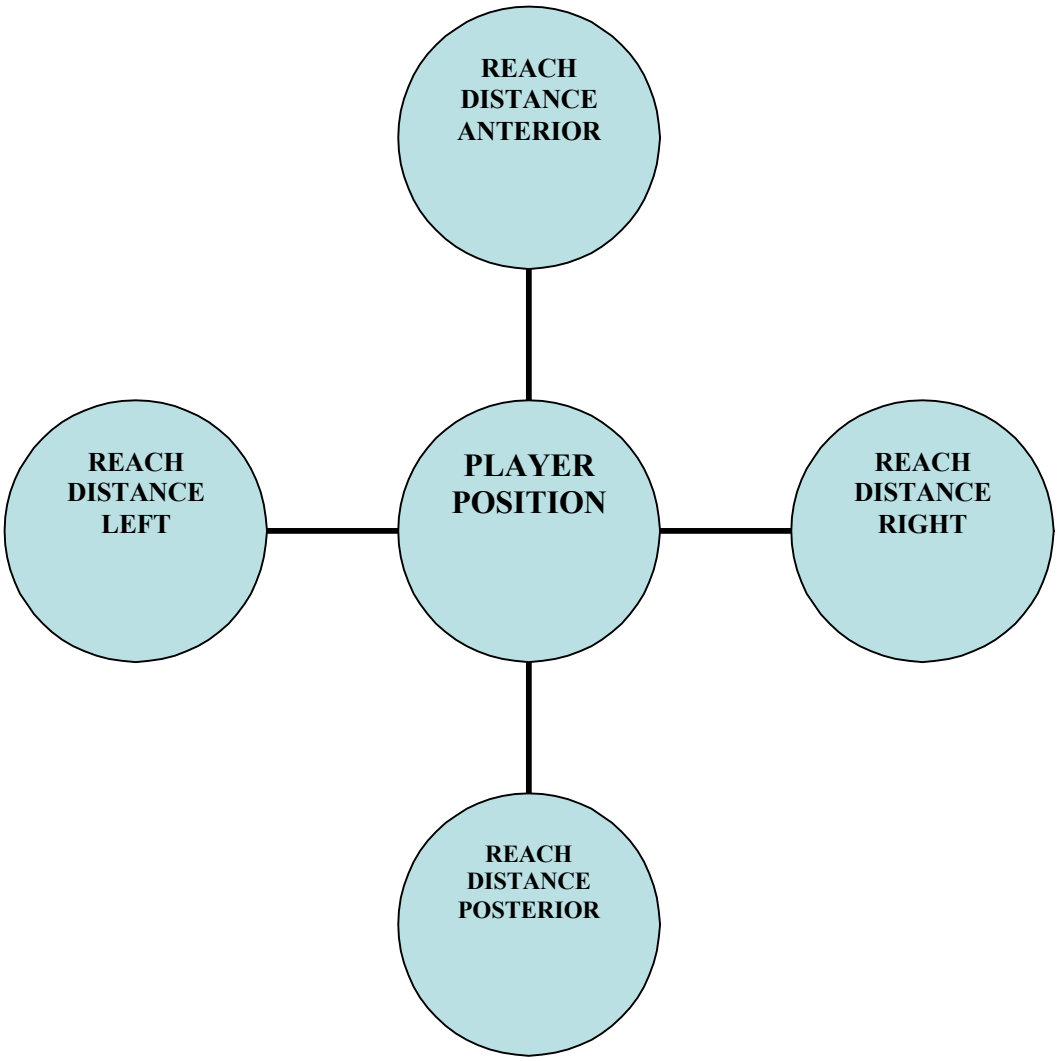


FIGURE I.1 DEPICTING GRID FOR STANCE POSITION