UNIVERSITY OF
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A CORRELATION BETWEEN INJURY INCIDENCE, INJURY PREVALENCE AND BALANCE IN RUGBY PLAYERS.

Submitted in fulfilment of the degree: Masters in Physiotherapy.

Researcher: J. Ras (206504834)

Supervisor: Prof. T. Puckree

School of Physiotherapy, Sport Science and Optometry

Discipline: Physiotherapy, Westville Campus

ABSTRACT

Introduction: Rugby is a contact sport, and along with other contact sports there is general acceptance that there is a risk of sustaining an injury (Haseler, *et al*., 2010). Poor balance can cause injury, re-injury or other trauma. Prevention of injury is important to reduce the acute and long-term outcomes on health (Drawer and Fuller, 2002). Despite the popularity of the sport, few rigorous studies have been conducted to determine the relationships between injury and neuromuscular variables such as balance. Results from this study will provide a baseline for future balance testing, possible rehabilitation intervention strategies, injury prevention programmes, injury risk analysis, and other epidemiological studies.

Aim: This study determined and correlated injury prevalence, injury incidence and balance in rugby players. Balance is reflected as Sway Index (SI = static balance) and Limits of Stability (LoS = dynamic balance).

Methods: Quantitative and qualitative approaches using retrospective and prospective modes were used to achieve the aims and objectives of the study. The first part of the study looked at the pre-season data collected from first year Sharks Academy rugby players (retrospective). Part two, the prospective study was observational consisting of a cross sectional survey on injury prevalence, incidence and balance testing using a calibrated Biosway portable balance system. The balance tests allowed for the determination of 'Postural Stability' and 'Limits of Stability' (eyes open, firm surface, bipedal stance). The data was analysed using the Statistical Package for Social Sciences (SPSS version 19). Significance was set at 0.05 and confidence interval at 95%. Pre-season and post-season means of SI and LoS were compared using paired sample t-tests. Further analysis of the data was conducted using the Spearman’s correlation co-efficient. One-way Analysis of

Variance, Wilcoxon signed rank test and Kruskal-Wallis test were used, as well as further analysis included post hoc Bonferroni tests.

Results: The participation rate was 75.5%. The majority of participants were 18 years old (71.4%), white (71.4%) and spoke English (n=42) as home language. Injury was prevalent in 43% of players with the majority of players reporting 'no' injury (n=43) pre-season. Injury was sustained by 83% of players during the season. The players (41.6%) reported 'one' or 'more than one' (41.6%) injury. Number of injuries reported post-season (n=117) was three times higher than injuries pre-season. The body part most injured during the 2012 season was the knee (25%). Players have lost from 8 up to 28 days of rugby (37%) due to injuries in the season. Injury prevalence was 1.18 per player compared to injury incidence of 1.52 per player. The injury rate was 5.95 injuries per 1000 match playing hours in season. The SI increased significantly (p=0.034) by 15% in the medial/lateral direction post-season compared to pre-season, but still was within a good balance range (SI<0.48). The mean LoS direction control increased significantly (p=0.000) in all directions, especially in the forward direction (17%), post-season compared to pre-season, but remained poor (LOS<65%). Post-season backward/right LoS correlated significantly with injury prevalence (Spearman's rho=0.247; p=0.027), as well as injury incidence and limits of stability pre-test for forward/right direction (Spearman's rho=0.232; p=0.031). Risk factors for injury during the 2012 season included the scrum-half (14.8%) playing position, lack of protective equipment (69%) used during time of injury, right side (46%) of the body, pre-season gym activities (54%), in-season strength (23%) and fitness (23%), injuries during match (66%), in the 2nd half of the match (57%), during contact (67%), trauma (62%), re-occurrence of injury (29%), and rehabilitated injuries (69%).

Conclusion: The incidence of injury was higher than prevalence. The injury prevalence, injury incidence, and balance were determined. No correlation between incidence and prevalence was found, but correlation existed between incidence and prevalence with static and dynamic balance only in selected directions. Static balance as reflected by the SI decreased due to injuries sustained in season. Dynamic balance improved as reflected in the LOS.

Keywords: rugby; balance; injury incidence; injury prevalence; Biosway

ATTESTATION

30 November 2012

I, Jaco Ras, acknowledge that in the research dissertation any ideas, or text that is not my own has been referenced and acknowledged.

Yours sincerely,

Jaco Ras

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I would like to thank my supervisor, family, and people whom assisted me with being able to complete this dissertation for the completion of the degree. Without everyone's assistance this achievement wouldn't have been possible.

Yours sincerely,

Jaco Ras

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CHAPTER 1

INTRODUCTION, PURPOSE AND SIGNIFICANCE

1.1. Introduction

Rugby is an international sport, ranked as one of the world's most popular team sports (Brooks and Kemp, 2008), second to soccer (Hughes and Ficker, 1994), and has a large fan base in South Africa. This popularity has resulted in the associated benefits gained from involvement and success at an elite or professional level (Barthgate, *et al*., 2002). The competitive nature of the sport and the potential loss of income due to injury, particularly at the higher levels, compel players to remain active in the sport (Barthgate, *et al.*, 2002). However, the risk of sustaining an injury in a rugby match appears to be higher than in many other sports due to the contact nature of the activities (Junge, *et al.*, 2004; Nicholl, *et al.*, 1995). In the study by Junge, *et al*. (2004) rugby players had 1.5 times more overuse and training injuries, as well as 2.7 times more match injuries than soccer players. Low or poor balance has been identified as a significant cause of injury in other sport, with lower limb injuries specifically ankle injuries most prevalent (Hrysomallis, *et al.*, 2007; McGuine, *et al*., 2000; Tropp, *et al*., 1984; Watson, 1999; Willems, *et al.*, 2005). No similar studies have been reported for rugby.

The contact nature of rugby predisposes players, particularly adolescents, to injury (Abernethy and MacAuley, 2003; Emery, 2003). In addition to age, playing positions have been associated with different injury profiles (Brooks and Kemp, 2011). Brooks, *et al.* (2005a; 2005c) showed that the incidence of injury during training is significantly lower than during matches regardless of the match level. The incidence

(Brooks, *et al*., 2005c) and days absent (risk) have also been linked to the type of rugby events, and the intensity of the contact situation (Brooks, *et al.*, 2008; Brooks and Kemp, 2011).

Brooks and Kemp (2011) showed that injury involving three body regions (shoulder, knee, and ankle) caused significant ($p<0.05$) absence from play in forwards. Back-line players' absence from play was attributed to injuries in the shoulder, hamstrings, and knees. The correlation of body parts injured to absence from play can assist in assessing and prioritising the need for injury-prevention strategies (Brooks and Kemp, 2011). In a few studies (Askling, *et al*., 2003; Bahr and Bahr, 1997; Mandelbaum, *et al*., 2005; Myklebust, *et al*., 2003; Olsen, *et al*., 2005; Soligard, *et al*., 2008; Verhagen, *et al*., 2004; Verral, *et al*., 2005) injury-prevention strategies in non-collision sport have showed successful results in reducing the incidence of injury to the lower limbs (hamstrings, knees and ankles). Injury prevention strategies such as exercises were used to improve proprioception (Askling, *et al*., 2003; Olsen, *et al*., 2005; Soligard, *et al*., 2008; Verral, *et al*., 2005), core stability (Akuthota and Nadler, 2004) and muscle strength (Bahr and Bahr, 1997; Mandelbaum, *et al*., 2005; Myklebust, *et al*., 2003; Soligard, *et al*., 2008; Verhagen, *et al*., 2004). The increasing emphasis on strengthening the core muscles not only to improve performance but also to reduce injuries has been welcomed by individuals participating in sports (Akuthota and Nadler, 2004; Drawer and Fuller, 2001). Core strength is described as the muscle control around the lumbar spine assisting functional stability (Akuthota and Nadler, 2004). An increase in core strength is suggested to improve static and dynamic stability.

Movement of the Centre of Gravity (CoG) and Centre of Pressure (CoP) have been used as indicators of postural control (Chaudhry, *et al.*, 2005; Koozekanani, *et al*., 1980; Koozekanani and Duerk, 1985; Shimba, 1984). Postural control is informed by proprioceptive, visual and vestibular inputs (Woollacott and Shumway-Cook, 2002). Sensory, motor and biomechanical inputs are important to react to stimuli from the environment causing a disturbed body position (Lee and Lishman, 1975; Nashner, 1993). Cognition and vision are involved in posture and controlling balance, and while vision helps to identify objects and their movement, it also feedback assists in 'object-to-object orientation' and with body position in the environment, providing visual proprioception (Shumway-Cook and Woollacott, 2001).

The central nervous system uses somatosensory, visual and vestibular input to maintain balance. Somatosensory input includes touch and proprioception, this feedback assisting the individual with positioning in space, body sway, and environmental changes (Chapman, *et al.*, 2008; Davids, *et al.*, 2003). The somatosensory system allows an individual's muscles to make continuous, automatic adjustments to maintain balance and avoid falls (Bouisset and Do, 2008). Visual inputs orientates the head as to assists the vestibular system to maintain balance. These above mentioned systems work together to maintain balance, and if any one of these systems is dysfunctional balance control is decreased (Guskiewicz, 2003).

As rugby consists of various combinations of running, changing direction, stopping, catching the ball while running, developing and holding scrummages, jumping in line-outs, kicking, collisions and tackles, the continuous and dynamic interplay of optimal static and dynamic balance is important. Static and dynamic balance can only be optimized by enhancing the core components of strength, flexibility, mobility, speed, vision and skill. The interaction between the components of balance and various lower limb strategies assist to maintain balance and body position during functional movement (Irrgang, *et al*., 1994).

A study of rugby related injury incidence and prevalence will assist in identifying anatomical sites commonly injured, as well as play positions vulnerability to injury during the game and during whatever event an injury occurs. Without a concomitant assessment of stability, it will not be possible to identify which components for example strength, visual acuity, flexibility, speed, agility and power needs to be addressed to ensure optimal performance in the game. The correlation between balance parameters and injury incidence and prevalence will provide more insight into the development of injury prevention strategies in rugby.

1.2. Problem statement

There are currently no studies internationally or in South Africa regarding the correlation between injury incidence, injury prevalence and balance in rugby players.

1.3. Aim

The aim of this study was to determine injury prevalence, incidence, and the balance in registered first year Sharks Academy rugby players, and to establish any correlation between the first two and the latter.

1.4. Objectives

The study set out to achieve the following objectives to establish:

1. The prevalence of injuries.
2. The incidence of injuries.
3. The anatomical sites most frequently injured.
4. The injury severity during the 2012 rugby season.
5. The injury rate during the 2012 rugby season.
4. The player’s static balance (sway index).
5. The player’s dynamic balance (limits of stability).
5. The correlation between incidence and prevalence with balance.
6. The risk factors for injury during the 2012 rugby season.

1.5. Operational definitions

The following definitions apply to this study:

Balance: Static balance (postural stability test) and some degree of dynamic balance (limits of stability test), as tested on the BioSway portable balance system (950-460/1). See literature review chapter (heading 2.4. Balance, pp. 41) for a detailed description.

Balance classification (Biodex, 2012a): The 'postural stability test' using the parameter sway index (standard deviation of the stability index). The ‘limits of stability test’ using a score out of one-hundred. See methods and procedures chapter (heading 3.8. Data analysis, pp. 69) for a detailed description.

Injury: (Fuller, et al., 2007a:329): “Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities."

Injury incidence: The total number of new injuries per population (1st year Sharks Academy rugby players) in a given time period (2012 rugby season). This will be expressed as injury rate, as well as percentages and numbers for correlation.

Injury rate: The amount of injuries per participant per one-thousand exposure hours in matches.

Injury prevalence: The total number of injuries in the population pre-season, divided by the number of individuals in the population.

Injury severity: The time missed from sport participation, training practice or match because of injury (in days). See literature review for a detailed description (pp. 14).

Pre-season: Testing prior to the start of official season training (February 2012).

Post-season: Testing after the 2012 rugby season (September 2012).

Rugby players: First year registered male Sharks Academy rugby players in Durban, KwaZulu-Natal.

1.6. Significance

Rugby is a contact sport, and along with other contact sports there is general acceptance that there is a risk of sustaining an injury (Haseler, *et al*., 2010). Establishing a correlation between injury incidence, injury prevalence and balance in rugby players will help the rugby community to identify common musculo-skeletal injuries and develop preventative and therapeutic interventions (Brooks, *et al*., 2008). The significance of testing balance and correlating it to injury incidence and prevalence will assist a needs analysis if balance-specific training programmes must be implemented in the future rehabilitation, training and gym programmes to reduce injuries.

Undertaking the study on first year Sharks Academy rugby players will allow the group used in the study to see the benefits of the study in the remaining two years of their internship when various preventative and therapeutic interventions will be implemented to reduce the number of injuries. Results of the study on these first year Sharks Academy rugby players will provide the possibility for future studies on the same group in their second and third year of their three year study programme.

Injuries have economic consequences through direct medical costs of treatment and rehabilitation, and indirect costs including parents taking leave to help the injured family member (Abernethy and MacAuley, 2003). Reducing the incidence or prevalence of injuries will therefore also decrease the economic effect. Injury may also decrease self-esteem, social participation, teamwork and fitness and increase stress levels (Ekeland, *et al*., 2004), all of which are important for personal growth of the individual. The study will assist with improving research evidence regarding balance, injury incidence and injury prevalence in rugby for South Africa and internationally. It has the potential for establishing support networks or associations which will assist in future studies for junior rugby players at academies.

1.7. <u>Summary</u>

This introduction, purpose and significance have provided a brief overview of the study, as well as the importance to the various stake holders. Rugby has a risk of injuries due to the contact nature of the sport. The study will assist the rugby playing community, management and medical staff to get a measure of the relationship between injury prevalence, injury incidence and balance to implement plans to assist with management of the players. The outline of the thesis with regards to the study is discussed next.

1.8. <u>Outline of the thesis (other chapters)</u>

The study is reported in the following remaining chapters: Chapter two provides a critical overview of literature regarding rugby, injury related to rugby, possible risk factors for injury, balance, validity and reliability of instrumentation, factors affecting balance, sport and balance, and finally the research question or hypotheses for our study will be asked. The research hypotheses are presented at the end of the literature review, because literature informs the hypothesis formation about the possible study outcomes.

Chapter three presents the study methods used, including a description of the study design, population, sample strategy and size, variables measured, procedure of the study, data analysis and ethical issues addressed.

Chapter four presents the results in text, tables and graphs. In this chapter the participating population is characterised followed by the presentation of the data both in raw and statistical terms.

Chapter five discusses the findings in relation to the local and international literature. Through an indepth interrogation of the results, gaps are also identified. The results are discussed in relation to the hypotheses of the study. The identified gaps allow for the development of recommendations after limitations have been noted. The latter is covered in Chapter 6.

The final Chapter six provides conclusions to the study, firmly comparing the aims and objectives with the actual findings. This allows for concise formulations of the limitations of the study and recommendations for the future. The final chapter is followed by a list of references and supporting documentation labelled as appendices in the text.

CHAPTER 2

LITERATURE REVIEW

2.1. Introduction

This chapter provides an overview of three main issues namely rugby, injuries and postural balance, with relevant issues with the latter two in particular being explored in detail. In the literature review, some of the literature is dated, and includes those from other sporting codes, because of the gap in the recent literature on rugby. At the end of the literature review the research question for this study will be addressed. A comprehensive review of the literature was conducted by undertaking an electronic online search using Google Scholar search engine, the University of KwaZulu-Natal Libraries databases such as Academic Research Library, Academic Search Complete, Medline (via PubMed), Science Direct, Cochrane reviews, Pedro and Medline via EBSCOhost research databases. In addition the SUMMON engine allowed further access to published literature on the topic.

Key words used include academy, adolescent, athlete, balance, Bio-Sway, club, correlation, football, incidence, injury, international, limits of stability, posture, postural stability, prevalence, proprioception, risk factor, rugby, sport, sway index, and South-Africa. Secondary sources were obtained from the reference sections of the relevant articles as listed in the references. The relevant literature has been interrogated and a critical analysis is presented below.

2.2. Rugby

Rugby is an international sport ranking second in participation to soccer (Hughes and Fricker, 1994; Junge, *et al.*, 2004). Over three-and-a-half million people, in more than one-hundred-and-seventeen member unions representing countries on five continents play rugby, making it one of the world's most popular participation team sports (International Rugby Board, 2012c; International Rugby Board, 2012d). The International Rugby Board (IRB) reported that over one million children in England played rugby in schools and clubs in the 2008 and 2009 season (International Rugby Board, 2011e). Gain in popularity of rugby resulted in financial rewards for involvement in and success at an elite or professional level (Barthgate, *et al.*, 2002).

The main objective of rugby is to score more points than the opposing team, the primary aim of rugby conditioning is enhance rugby performance and secondary aim is preventing injuries (International Rugby Board, 2011a). There are 15 players in a rugby team with different playing positions. This various playing positions in rugby may predispose players to injuries (Brooks and Kemp, 2011). There are seven forward playing positions namely: the loose-head prop, hooker, tight-head prop, second-rows or locks (two), blind-side flanker, open-side flanker. Additionally there is a playing position called the eight-man or number eight. The back-line has five positions namely: scrum-half, flyhalf, centres (two), wingers (two) and the full-back (Brooks and Kemp, 2011). Each of these playing positions has various responsibilities within the game, and therefore carries the potential for a variety of injuries.

As a contact sport, there is general acceptance that there is a risk of sustaining an injury (Haseler, *et al*., 2010), these being the main cause of injury in adolescents (Abernethy and MacAuley, 2003; Emery, 2003), with age being identified as a non-modifiable risk factor (Haseler, *et al*., 2010). Due to the number of injuries sustained in rugby, sports medicine practitioners and other professionals have also showed an interest in player safety (Hughes and Fricker, 1994). Injury definition, possible risk factors, injury severity and rate, types of classification, and possible risk factors are elaborated on below.

2.3. <u>Injury</u>

Injury definitions vary and include describing whether the player could continue the game (Barthgate, *et al.*, 2002), miss the following game (Best, *et al.*, 2005), miss training or matches for more than 24 hours (Brooks and Kemp, 2011), need medical attention (Yang, *et al.*, 2005), or a combination of these (Webster, *et al.*, 1999). In the study by Abernethy and Bleakley (2007:628) injury was defined as injury rate (per participant, per 1000 exposures or per 1000 exposure hours) and injury severity (time missed from sport participation, training practice or match because of injury). In the majority of studies reviewed (Emery, *et al*., 2005; Heidt, *et al*., 2000; Junge, *et al*., 2002; McIntosh and McCrory, 2001; Olsen, *et al*., 2005) participants that miss one or more days of participation in sport were described as sustaining an injury. The following definition of ‘‘injury’’ was accepted by the IRB according to Fuller, *et al*. (2007a:329) and used in this study: "Any physical complaint, which was caused by a transfer of energy that exceeded the body’s ability to maintain its structural and/or functional integrity, that was sustained by a player during a rugby match or rugby training, irrespective of the need for medical attention or time-loss from rugby activities.

2.3.1. Recurrent injury

The IRB accepts an injury as recurrent if it occurs at the same body part, is the same type of injury as previously injured, and occurs after a player's return to full participation from that injury (Fuller, *et al*., 2007a). An injury that occurs within two months of a player's return to full participation is called an 'early recurrence'; when it occurs two to twelve months after a player's return to full participation, it is called 'late recurrence'; and when it occurs more than twelve months after a player's return to full participation it is called 'delayed recurrence' (Fuller, *et al*., 2007a). With professionalism and greater incentives to play, more time will be spent at training and players are more likely to play with chronic or recurring injuries to keep these incentives (Barthgate, *et al*., 2002). Recurring injuries or chronic instability is due to mechanical and functional insufficiency as stated by Hertel (2002). The mechanical problems are degenerative changes, synovial changes, arthro-kinematic restrictions, and pathological laxity. The functional problems are impaired proprioception, impaired neuromuscular control, strength deficits, and impaired postural control (Hertel, 2002). Decisions about prevention strategies will be informed by the occurrence of previous injuries of the same type at the same site. The risk of injury is discussed next, followed by injury severity and injury rate.

2.3.2. Risk of injury

The risk of injury occurs regardless of the sports code, but seems to be higher in contact sports such as rugby, primarily due to high physical trauma experienced during the game between players (Junge, *et al,* 2004; Nicholl, *et al*., 1995). Rugby has a high risk of new injuries among 16-25 year olds (Abernethy and MacAuley 2003; Nicholl, *et al.*, 1995), and in rare cases, can result in catastrophic injury (Quarrie, *et al*., 2002). Injury risk is calculated as a percentage of the number of injuries to the number of training or match exposure in hours (Bahr and Bahr, 1997), and is also determined by the number of days of absence caused by injury per exposure time (in hours). This is a product of incidence and severity of injury, and a good measurement of the impact of injuries (Brooks and Fuller, 2006; Drawer and Fuller, 2002).

2.3.3. <u>Injury severity</u>

There are a number of definitions regarding the severity of injury with studies before 2007 defining the severity with the number of matches (Barthgate, *et al.*, 2002; Best, *et al.*, 2005) or weeks missed (Targett, 1998) rather than days missed from matches or practice due to injury (Abernethy and Bleakley, 2007; Brooks and Kemp 2011). The IRB consensus statement described by Fuller, *et al.* (2007a) has provided one definition which should be used to enable different studies can be compared and contrasted. Fuller, et al. (2007a) define injury severity as: "The number of days that have elapsed from the date of injury to the date of the player's return to full participation in team training and availability for match selection." Injuries can be grouped according to severity, as slight (0-1 day), minimal (2-3 days), mild (4-7 days), moderate (8-28 days), severe (>28 days), ‘‘career-ending’’ and ‘‘non-fatal catastrophic injuries’’ (Brooks and Kemp, 2011; Fuller, *et al*., 2007a). Severity of injury can also be stratified by age groups, with Haseler, *et al*. (2010) showing that younger players have fewer severe injuries than older players. Severity of injury has also been associated with anatomical areas to draw focus to certain body parts.

2.3.4. <u>Injury rate</u>

Abernethy and Bleakley (2007:628) define injury rate "per participant, per one-thousand exposures or exposure hours." Few studies have considered injury rates in elite or professional rugby players. Barthgate, *et al*. (2002) showed that Australia's international rugby team has a high rate of injuries (69 injuries per 1000 match playing hours), while in South Africa, Jakoet and Noakes (1998) showed that in the Rugby World Cup (RWC) in 1995, the injury rate was 30-43 injuries per 1000 match playing hours. A comparison of injury rates at senior male recreational level varied from 13.95 per 1000 match playing hours to 53 injuries per 1000 match playing hours (Garraway and Macleod, 1995; Seward, *et al*., 1993). In schoolboys injuries varied from 7 injuries per 1000 match playing hours to 27.5 injuries per 1000 match playing hours (Durie and Munroe, 2000; Roux, *et al*., 1987). A study of injury rates in senior female rugby players show 25.5 injuries per 1000 match playing hours (Carson, *et al*., 1999).

There are a number of theories on the various injury rates at different levels. The first theory includes factors such as speed of play, size and fitness of players and nature of tackling (Best, *et al.*, 2005; Haseler, *et al*., 2010). The second theory conceptualized after the 1995 RWC is that length of play is longer at the elite level and therefore affects injury rate (Best, *et al.*, 2005). The third theory is related to the level of training required to increase speed, power and skills at the professional level (Best, *et al.*, 2005). None of these theories have been proven by research studies.

Garraway, *et al*. (2000) showed that injury rates in senior Scottish rugby players doubled four years after the onset of professionalism. Two years of injury data collection before the onset of professionalism showed that the injury rate was 47 injuries per 1000 playing hours during matches. Four years after professionalism the injury rate increased to 74 injuries per 1000 match playing hours (Barthgate, *et al*., 2002).

Apart from the theories associated with injury rate, Haseler, *et al*. (2010) also showed that age is a risk factor for injury in rugby. The study found that the overall injury rate in junior community rugby in England was 24 injuries per 1000 match playing hours. Injury rates can also be associated with the types of tournament (Best, *et al*., 2005; Hawkins and Fuller, 1996; Jakoet and Noakes, 1998). Jakoet and Noakes (1998) studied the injuries associated with the 1995 RWC and noted 70 injuries in 55 games, which resulted in an overall injury rate of 32 per 1000 match playing hours. Best, *et al*. (2005) studied the 2003 RWC and noted an overall injury rate of 97.9 injuries per 1000 match playing hours. Injury rate in other sport tournaments, such as the 1994 Soccer World Cup, noted an injury rate of 71 injuries per 1000 match playing hours (Hawkins and Fuller, 1996). Currently, there are few research studies with data on injury rates and factors that are required for good medical planning at professional sport tournaments. The different types of classification of injuries are discussed next.

2.3.5. <u>Classification of injury</u>

Injuries tend to be classified according to five criteria, namely: location, type, when they occurred, and injuries sustained by phases of play, each of which will be detailed below. Injuries relating to playing position will be discussed with respect to extrinsic risk factors under section 2.3.7.1.v on page 28.

2.3.5.1. <u>Location of injury</u>

The location of an injury is classified by body region (Haseler, *et al.*, 2010), side of body or anatomical part (Fuller, *et al.*, 2007a). Fuller, *et al*. (2007a:331) identify anatomical parts as the abdomen; ankle; anterior thigh; elbow; finger or thumb; foot or toe; forearm; hand, head or face; hip or groin; knee; low back; lower leg or Achilles tendon; neck or cervical spine; posterior thigh; ribs and upper back; sacrum or pelvis; shoulder or clavicle; sternum, upper arm; and wrist. They also noted the injury by the side of the body affected for example bilateral; left; not applicable; and right (Fuller, *et al.*, 2007a). The location of injury is identified as: lower limb; trunk; upper limb; and other (Haseler, *et al*., 2010). The classification by body regions assist in placing injured body parts into categories.

The lower limb is the most frequently injured (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a), followed by the head and upper limb (Best, *et al*., 2005). The most frequent anatomical sites of injury in youth rugby were found to be the shoulder, wrist, head and neck (Haseler, *et al*., 2010). During matches the head and non-catastrophic neck injuries often represent the second highest proportion (ranging from 12% to 33%) of all injuries (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a). In the 2003 RWC the most frequently injured body regions were the head, neck, and face (33.7 injuries per 1000 playing hours during matches) accounting for more than two times the rate of the foot and ankle (Barthgate, *et al*., 2002; Best, *et al*., 2005). The knee (Barthgate, *et al*., 2002; Bird, *et al*., 1998;

Dallalana, *et al*., 2007; Garraway, *et al*., 2000), thigh (Barthgate, *et al.*, 2002; Bird, *et al.*, 1998; Brooks, *et al.*, 2006) and ankle (Brooks and Kemp, 2008; Barthgate, *et al.*, 2002; Bird, *et al.*, 1998) are the most commonly injured lower limb locations reported. The upper limb in many studies showed a low injury rate (15-24%) (Barthgate, *et al.* 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Brooks and Kemp, 2008). The shoulder is reported to account for a large proportion and greater severity, in particular, acromio-clavivular joint and rotator cuff injuries (Barthgate, *et al*., 2002; Headley, *et al*., 2007).

2.3.5.2. <u>Type of injury</u>

The categories for classifying type of structure and injury were broadly accepted according to Fuller, *et al*. (2007a:330). The main groupings for type of injury are presented next with the categories in brackets: bone (fractures; other bone injuries); joint (non-bone) and ligament (dislocation or subluxation; sprain or ligament injury; lesion of meniscus, cartilage or disc); muscle and tendon (haematoma, contusion or bruise; muscle rupture, tear, strain or cramps; tendon injury, rupture, tendinopathy or bursitis); skin (abrasion; laceration); brain, spinal cord or peripheral nervous system (concussion with or without loss of consciousness; structural brain injury; spinal cord compression or transection; nerve injury); and other (dental injuries; visceral injuries; other injuries).

Injuries to the head comprise 25% of all injuries suffered by Australian international rugby players between 1994 and 2000. Lacerations that require suturing (75%) were the most common and fractures (5.6%) were the least common (Barthgate, *et al*., 2002). Other studies (Barthgate, *et al*., 2002; Jakoet and Noakes, 1998) reported that concussion was the most common form of head injury, but rarely exceeded 5% of the total injuries sustained by elite rugby players'. Over half of the injuries (55%) suffered by elite rugby players were to soft tissues (Addley and Farren, 1988; Clark, *et al*., 1990; Hughes and Fricker, 1994; Jakoet and Noakes, 1998). Injuries common to the lower limb included haematomas and hamstring muscle strains (Bird, *et al.*, 1998; Brooks, *et al.*, 2005a; Brooks, *et al.*, 2006). The most common injuries to the knee included medial collateral ligament sprains, meniscal and patella-femoral injuries (Dallalana, *et al.*, 2007) and the ankle region injuries were lateral ankle sprains (Beynnone, *et al.*, 1977; Garrick, 1977; Bird, *et al.*, 1998; Brooks, *et al.*, 2005a). The incidence of anterior cruciate ligament (ACL) injuries in matches and training was lower than all other knee injury categories in a study by Dallalana, *et al*. (2006), but caused the highest days absent from play than other knee injuries.

Spinal injuries are subdivided into non-catastrophic and non-fatal catastrophic. Non-catastrophic spinal injuries has only been mentioned in a few articles (Brooks and Kemp, 2008; Fuller, *et al*., 2007b), but non-fatal catastrophic spinal injuries has received considerable focus in the medical literature due to its serious consequences (Armour, *et al*., 1997; Burry and Gowland, 1981; Carmody, *et al*., 2005; Haylen, 2004; Kew, *et al*., 1991; Maharaj and Cameron, 1998; Noakes, *et al*., 1999; Scher, 1998; Shelly, *et al*., 2006; Silver, 1992; Taylor and Coolican, 1987; Wetzler, *et al*., 1998; Williams and McKibbin, 1978; Wilson, *et al*., 1996). These injuries are extremely rare, reported to be approximately 1 per 10,000 players per season (Rotem, *et al*., 1998), with the majority being sustained during the tackle and the scrum (Quarrie, *et al*., 2002). The time at which the injury occurred is also important in determining prevention strategies.

2.3.5.3. <u>Period of injury occurrence</u>

It is important to know whether the injury occurred during training or match play, contact or non-contact (Fuller, *et al*., 2007a). This kind of information helps to determine whether the injury is the result of overuse or acute trauma (Barthgate, *et al.*, 2002; Fuller, *et al.*, 2007). In training muscle strains occur most commonly in non-contact running activities (Barthgate, *et al*., 2002; Brooks, *et al*., 2005c). A large amount of running during training might be the reason for the higher incidence of lower limb injuries reported. Injuries such as muscle hematomas, lacerations, fractures, dislocations, and concussions occur most commonly in contact or collision activities and less commonly during training (Bird, *et al*., 1998; Brooks, *et al*., 2005c). Injuries that are sustained during a match constitute the largest proportion (80-90%) of the rugby-related injuries reported in epidemiological studies (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Brooks, *et al*., 2005c; Garraway and Macleod, 1995). Match situation injuries are described based on when the injury occurs. Timing of injuries can be subdivided into those that occur in the first, second, third or fourth quarter or alternatively the first or second half (Barthgate, *et al.*, 2002). The majoritiy of injuries occur in the second half (69%) (Hughes and Fricker, 1994; Best, *et al.*, 2005; Bottini, *et al.*, 2000), with the fewest injuries being sustained in the first quarter (7%) (Barthgate, *et al.*, 2002), and the third quarter carrying almost 40% of injuries. More injuries in the second half can be attributed to physical and mental fatigue, reduced concentration after half-time, and poor warm-up during half-time (Best, et al., 2005; Barthgate et al., 2002). It may be an advantage for coaching and conditioning staff to be aware of these statistics to improve player preparation and methods for warming up players, and to develop strategies for player substitution.

While the incidence of injury during training is significantly lower than during matches (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Brooks, *et al*., 2005c; Garraway and Macleod, 1995), it is possibly more difficult for researchers to collect accurate injury data, and particularly exposure data, during training, particularly at the amateur level. Few details of training injuries sustained by rugby players is therefore known compared with that during matches. The injury incidence and risk during training can also be activity specific, depending on the volume of training activities and type, as well as the effects of additional recreational activities. As noted in Brooks, *et al.* (2005c; 2008), high risk activities are fitness testing, defence and rucking or mauling drills, and low risk activities including set piece training (line-outs or scrummages) and conditioning. It has been found that specific training activities in a gymnasium involving weights commonly contributed to lumbar disc or nerve root injuries, while endurance training involved running caused hip flexor or quadriceps muscle injuries (Brooks, *et al*., 2005c).

Studies have indicated that senior rugby players sustained at least two training related injuries per 1000 training hours compared with 91 match injuries per 1000 match playing hours (Brooks, *et al*., 2005a; Brooks, *et al*., 2005c). Senior international rugby players reported 6.1 training related injuries per 1000 training hours compared with 218 match related injuries per 1000 match playing hours (Brooks, *et al*., 2005b). At the amateur level there were 1.3 training injuries per 1000 hours during training compared with 45 match injuries per 1000 hours during matches (Hughes and Fricker, 1994). In school-boy rugby, there were 1.2 training injuries per 1000 hours during training compared with 8.4 match injuries per 1000 hours during matches (Nathan, *et al*., 1983).

2.3.5.4. <u>Injuries sustained by phases of play</u>

The risk of injury in rugby varies by the event that occurs during a certain phase of play, namely contact or non-contact (Fuller, *et al*., 2007a). The specific contact activities include: collision; lineout; maul; other; ruck; scrum; tackling; or tackled (Fuller, *et al.*, 2007a:330). Each phase of play can be either attacking or defensive, depending on the play at the particular time. The scrum is an example of an attacking phase if the team has the feed to the scrum, or defensive phase for the opposition team. Players and coaches realise therefore that power and skill in each phase of play can give the team the advantage (Best, *et al*., 2005), or risk for injury (Jakoet and Noakes, 1998).

The most common phase of play in which injuries occur is the tackle phase, with the majority reported as severe injuries (Addley and Farren, 1988; Barthgate, *et al*., 2002; Bird, *et al*., 1998; Bottini, *et al*., 2000; Brooks, *et al*., 2006; Clark, *et al*., 1990; Fuller, *et al*., 2007b; Garraway, *et al*., 2000; Garraway and Macleod, 1995; Jakoet and Noakes, 1998; Lee and Garraway, 1996; McIntosh, 2005a; Quarrie and Hopkins, 2008; Wilson, *et al*., 1999). Severe injuries during the tackle phase include shoulder dislocations (Headey, *et al*., 2007), knee ligament sprains or meniscal injuries (Dallalana, *et al*., 2007), and concussions (Kemp, *et al*., 2008). During matches, the majority of rugby injuries are sustained in contact or collision with other players, and the tackle involving the ball carrier and tackler causes approximately half of all match injuries (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Brooks, *et al*., 2005c; Garraway, *et al*., 2000).

During the 2003 RWC, the injury rate for tackling (20.2 injuries per 1000 match playing hours) or being tackled (18.7 injuries per 1000 match playing hours) caused 41% of all injuries (Barthgate, *et al*., 2002; Jakoet and Noakes, 1998). "Blind" tackles could contribute to the occurrence of more severe injuries in the tackle phase. It is defined as the defender making an unsuspected tackle when he is outside the ball carrier's peripheral vision (Garraway, *et al.*, 1999; Wilson, *et al.*, 1999). Set pieces, such as the scrum and line-out positions, account for very few injuries (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Hughes and Fricker, 1994), for example, in the 2003 RWC the scrum accounted for 5% of all injuries (Best, *et al*., 2005). This shows that these phases of play are more controlled in nature. Open play (non-contact) occurs when the player is running with the ball without contact and not in a set piece (Hughes and Fricker, 1994; Brooks and Kemp 2008). The proportion of injuries occurring during non-contact activities (19.6%) is almost similar to that sustained during the ruck and maul (14.7%) (Barthgate, *et al*., 2002).

2.3.6. <u>Injury risk factors</u>

Injury prevention generally focuses on modifiable risk factors which include extrinsic factors and intrinsic factors. The risk factors are based on research, but are now also supported by studies of sports injury prevention (Abernethy and Bleakley, 2007; Beynnon, *et al.*, 2002a; Williams, 1971). The relationship between injury risk factors and injuries in rugby epidemiological studies will assist with developing prevention strategies (Meeuwisse, 1991; Brooks and Kemp, 2008). Intrinsic risk occurs "from within the body" and extrinsic from "outside of the body" (Beynnone, *et al.*, 2002a:376). Extrinsic and intrinsic injury risk factors specific to rugby and sport will be discussed next.

2.3.7.1. Extrinsic risk factors

Extrinsic risk factors were defined by Williams (1971:229) as: "all primary injuries, may have the origin in earlier injury, but are due to direct application of external force." The extrinsic factors can be sub-divided according to environmental, human, overuse, and protective equipment (Williams, 1971). Extrinsic risk factors that have been investigated include: bracing and taping, shoe type, duration and intensity of competition, and player position (Beynnon, *et al*., 2002a).

i. Environmental factors

The ground and weather conditions are an example of environmental factors (Alsop, *et al.*, 2005; Lee and Garraway, 2000), and can influence the frequency and nature of injuries (Lee and Garraway, 2000:91). Lee and Garraway (2000) assessed injuries sustained during rugby in relation to the environmental factors and found that very little is currently known regarding the effect of playing surfaces and weather conditions on rugby injuries. The pitch did not influence the risk of injury, but weather conditions such wind strength and temperature significantly increased ($p<0.05$) the risk of injury (Lee and Garraway, 2000). Calm weather conditions and playing on hard surfaces were also associated with increased risk of injury (Alsop, *et al.*, 2005). There is an increased incidence of clavicle fractures on dry, hard grounds (Barthgate, *et al.*, 2002; Davidson, 1987). Soft playing surfaces were found to reduce injury risk, possibly due to cushioning the landing in contact or foot during running (Orchard, 2002b). During tournaments, environmental factors are important to assist to decrease injury risk (Best, *et al.*, 2005).

ii. Pre-season training

The impact on pre-season training on injuries has received some attention in the literature. Pre-season conditioning programmes that include strength, flexibility, balance, sport-specific fitness and technique training prevent lower limb injuries (Abernethy and Bleakley, 2007:636). These programmes are more effective if they are carried out throughout the playing season, as reflected in the reduction in ankle sprains in volleyball players (Bahr, *et al*., 1997; Stasinopoulos, 2004; Verhagen, *et al*., 2004). Similarly, preventive programmes in soccer resulted in a 50–75% reduction in injuries in general (Ekstrand and Gillquist, 1984), and a significant reduction in anterior cruciate ligament injuries (Caraffa, *et al*., 1996). Pre-season conditioning strategies in female soccer, volleyball and basketball players showed a significant lower injury rate in the conditioning group compared to the control group (Heidt, *et al.*, 2000; Hewett, *et al.*, 1999). The effects of pre-season training on the prevalence and or incidence of injuries in rugby players have not been investigated.

iii. Warm-up, stretching and cool-down

The warm-up and cool-down phase are reported to be a component of the training programme, and have been cited as an injury prevention strategy (Junge, *et al.*, 2002; Mandelbaum, *et al.*, 2005). The suggested, but not proven rationale for stretching, warm-up and cool-down is to increase compliance of muscle and reduce muscle stiffness to decrease the force taken by the muscle (Noonan and Garrett, 1992). The impact that stretching has on sports injury risk has lacked sufficient evidence research (Thacker, *et al.*, 2004). A stretching protocol during pre-exercise warm-up in army recruits did not record a significant reduction in exercise-related injury (Pope, *et al.*, 1998; Pope, *et al.*, 2000). High school footballers that did half-time stretching exercises did not reduce the incidence of match injuries (Bixler and Jones, 1992). Further studies on running injuries agreed with the above findings, that stretching, warm-up or cool-down do not reduce injury incidence (Van Mechelen, *et al.*, 1993; Yeung and Yeung, 2001). It is suggested a range of injury preventative strategies should be used to reduce injuries as described next.

A preventative programme which includes education, warm-up, cool-down, taping, rehabilitation, flexibility and stability effectively reduced male soccer players' injuries in a year (Junge, *et al.*, 2002). Another preventative programme with a structured warm-up which emphasised strengthening, stretching, plyometrics and soccer-specific agility significantly ($p<0.05$) reduced female soccer players anterior cruciate ligament injuries compared to traditional warm-up methods (Mandelbaum, *et al.*, 2005). In handball clubs in Norway a structured 20 minute warm-up before training which included lower limb proprioception, strengthening and technical training reduced knee and ankle injuries in a one-season follow-up period (Olsen, *et al.*, 2005).

iv. <u>Protective equipment</u>

Protective equipment is worn during contact sport to potentially decrease the risk of injury. Tissue damage is attributed to the absorption and transmission of forces by neuro-musculoskeletal structures. One potential method of reducing injury risk is to therefore wear padded equipment; although there is no stipulation that this equipment must be worn in the rules of the game (Brooks and Kemp, 2008). A few investigators believe that personality is coupled to wearing protective equipment for example "risk takers" might not use protective equipment, knowing that there is a higher risk of injury (Ekenman, *et al.*, 2001; Sterett, *et al.*, 2006).

External bracing and taping is one method of protective equipment regularly investigated. A review of the prospective studies of the effect of bracing on reduction in ankle sprains revealed athletes with a history of ankle sprains who use a brace experienced a lower incidence of ankle sprains (Beynnon, *et al.*, 2002a; McKay, *et al.*, 2001; Sitler, *et al*., 1994; Surve, *et al*., 1994). Various theories of the potential benefits of taping and bracing are related to enhancing sensori-motor control (Beynnon, *et al.*, 2002b; Birmingham, *et al*., 2001; Kuster, *et al.*, 1999; Styf, 1999) rather than providing mechanical support (Paulos, *et al*., 1991; Tietz, *et al*., 1987). Basketball players with the ankle region taped (McKay, *et al.*, 2001) or braced (Sitler, *et al.*, 1994) decreased the risk of re-injury. In soccer players, the ankle brace decreased the incidence of ankle sprains due to improved proprioception, rather than mechanical support (Surve, *et al.*, 1994). The effectiveness of shoulder padding as protection from shoulder injuries in rugby has not been investigated (Gerrard, 1998; Headey, *et al*., 2007). Bracing can possibly lead to increased muscle fatigue, and it is linked to decreased athletic performance (Hinterwimmer, *et al.*, 2004). Headgear is another method of protective equipment often investigated.

While headgear is designed to decrease the impact energy of an injury to the head, a study has shown that players wearing headgear had seventy-eight percent of head injuries (McIntosh and McCrocy, 2001). It is believed that either the headgear cannot withstand high impact (Bleakley, 2007), or the players expect increased protection and therefore take more risk (Hagel and Meeuwisse, 2004), or the bulky headgear blocks peripheral vision (Barthgate, *et al.*, 2002). The benefits of headgear was unknown (Garraway, *et al.*, 2000) until recently, when studies found no reduction in the incidence of concussion in rugby players who wear headgears (Finch, *et al*., 2001; McIntosh, *et al.*, 2004; McIntosh and McCrory, 2001). The only benefit was reduced superficial scalp and facial injuries (Jones, *et al.*, 2004).

v. <u>Playing positions</u>

Playing positions in rugby are task specific and require various biomechanical (Milburn, 1990) which are predisposed to various injury risks. Research studies on injured body parts in rugby shows positional differences in injury risk (Brooks, *et al.*, 2006; Dallalana, *et al.*, 2007; Fuller, *et al.*, 2007a; Headey, *et al.*, 2007; Kemp, *et al.*, 2008; Meyers, 1980; Sankey, *et al.*, 2008). Playing positions represented twice, such as wingers, halved the total injury in certain studies for valid comparison with positions represented once (Barthgate, *et al*., 2002:265). Playing positions in various studies have been grouped together to increase statistical power of significance for example forwards and backs and according to the position of play.

During matches players who take up the front rows are commonly injured (Addley and Farren, 1988; Bird, *et al.*, 1998; Bottini, *et al.*, 2000; Hughes and Fricker, 1994), as they are usually involved in more phases of play (Barthgate, *et al.*, 2002; Hughes and Fricker, 1994). The prevalence of injuries reported for forwards and backs is similar during training but less so during matches (Bird, *et al*., 1998), which may be due to similar training programmes for both forwards and backs (Brooks, *et al*., 2005b).

Many studies reported that the loose forwards (locks and flankers) and number eight are most commonly injured playing positions in senior male rugby (Addley and Farren, 1988; Barthgate, *et al*., 2002; Bottini, *et al*., 2000; Hughes and Fricker, 1994; Jakoet and Noakes, 1998). These positions include the line-out, scrummaging, “breakdown” and tackling more often than other positions. A study of amateur rugby players found that forwards were most commonly injured in the upper body which included the head (23%), shoulder (10%) and neck (9%) (Bird, *et al*., 1998).

The loose-head prop and open-side flankers was most injured in the neck region, mainly as a result of tackling (57%) and scrummaging (29%) (Brooks and Kemp, 2011). Strengthening the neck muscles to sustain load during scrummaging can possibly reduce the risk of injury (Peek and Gatherer, 2005; Quarrie and Wilson, 2000) and improve tackling technique (Brooks, *et al.*, 2005d). The hooker had significantly more shoulder injuries ($p=0.01$) possibly due to repetitive line-out throwing. Therefore improving the strength and flexibility of the rotator cuff musculature (Chen, *et al.*, 1999), proprioception (Warner, *et al.*, 1996), and looking at gleno-humeral alignment (Hayes, *et al.*, 2002) can reduce the risk of injury. The tight-head props sustained significantly more lumbar and lower leg injuries ($p<0.001$) during scrummaging (54%) and running (33%) (Brooks and Kemp, 2011; Fuller, *et al.*, 2007a). Improving lumbar spine and lower leg muscle strength and scrumming technique to improve strong neutral spine alignment and neuromuscular control can assist with decreasing injury incidence (Durall and Manske, 2005; Zazuluk, *et al.*, 2008). The locks had a higher number of lateral ankle sprains (p=0.14), and which occurred mainly during the line-out (21%), and during landing from a line-out lift ($p<0.05$) (Brooks and Kemp, 2011). Injury-prevention interventions focusing on correction of lower limb alignment when landing could reduce ankle sprains (Bahr and Bahr, 1997; Olsen, *et al*., 2005; Soligard, *et al*., 2008). The flankers had a high incidence of hamstring muscle injuries occurring during running (86%) (Brooks and Kemp, 2011; Orchard, 2002a; Verral, *et al*., 2005). Eccentric muscle strengthening (Askling, *et al*., 2003; Brooks, *et al*., 2006), improving muscle flexibility (Cross and Worrell, 1999; Dadebo, *et al*., 2004; Witvrouw, *et al*., 2003) and sports-specific conditioning (Verral, *et al*., 2005) have all been successful at reducing the incidence of hamstring injuries.

The highest incidence of injuries in the back-line players were reported among the full backs (Targett, 1998), fly-halves (Barthgate, *et al*., 2002; Bird, *et al*., 1998) and outside centers (Brooks, *et al*., 2005a; Best, *et al.*, 2005). The increased risk of injury in these playing positions can be due to increased involvement in tackling or the “breakdown”, compared to other positions. A study on amateur rugby players reported that the most common lower body injuries in back-line players were specifically the knee (17%), ankle (10%), and thigh (10%) (Bird, *et al*., 1998).

The scrum-half players reportedly had significantly higher absence rates due to lumbar spine injuries ($p<0.001$) (Brooks and Kemp, 2011). The fly-half was absent due to hamstring muscle injuries (p=0.001) possibly due to a lot of kicking (Seward, *et al.*, 1993; Orchard and Seward, 2002; Woods, *et al.*, 2004). Lumbar flexion and rotation is used to pass the ball off the ground (Brooks and Kemp, 2011), possibly predisposing the scrum half to lumbar injury. Conditioning and improving control of lumbar (Zazulak, *et al.*, 2008) and lower limb musculature, as well as improving flexibility and eccentric strength will decrease occurrence of hamstring and lower back injuries. The players in the centre position are mainly injured due to head or neck injuries ($p<0.001$) occurring during tackling (44%) or when being tackled (39%) (Brooks and Kemp, 2011; Kemp, *et al.*, 2008). Players occupying the centre playing position make more tackles in a match than other back-line players (Quarrie and Hopins, 2008). Head injuries in centre's could be due to them entering the tackle at high speed, causing high impact on contact and increasing the risk for head and neck injury (Fuller, *et al*., 2010; Quarrie and Hopkins, 2008). Two studies indicate concussion was the most common form of head injury, but rarely exceed 5% of the elite rugby players injury total (Barthgate, *et al*., 2002; Jakoet and Noakes, 1998). A possible theory can be that concussion may be underreported because of concerns by players and team management about the rugby laws. The regulation indicates that a player who has suffered concussion ''shall not participate in any rugby match or training session for a minimum period of three weeks'' and the period may be reduced after ''the player is symptom-free and declared fit to play after appropriate assessment by a properly qualified and recognised neurological specialist'' (International Rugby Board, 2011a).

Players in every position miss a significant number of days due to match injuries (Brooks and Kemp, 2011). It was reported that forwards missed 1569 days per 1000 playing hours, and back-line players missed 1507 days per 1000 playing hours during matches. This is calculated as 33 days of absence per match due to forwards injuries, and 28 days of absence per match due to back-line injuries. The above study emphasizes the need to design and implement injury-prevention programmes for all players to reduce injuries (Brooks and Kemp, 2011).

vi. <u>Shoe type</u>

It is important to recognize specific design characteristics of the shoe that may affect the risk of injury and provide increased proprioceptive input, restrict ankle range of motion, cause abnormal foot-shoe and shoe-surface traction, or increased inversion at the ankle. A study by Beynnon, *et al*. (2002a) did not find information about the effect of athletic shoes on the risk of ankle injury. The incidence and severity of knee and ankle injuries in high school football players was decreased when the shoe cleats length was reduced, which resulted in less torque developed on these joints (Livesay, *et al.*, 2006; Torg and Quedenfeld, 1971). Basketball players who wore shoes with air cells in the heel-cup portion had significantly greater risk of ankle injuries, and was hypothesised that this decrease rear foot stability (McKay, *et al.*, 2001). No correlation between shoe type and ankle injuries were found in military trainees and basketball players (Barrett, *et al.*, 1993; Milgrom, *et al.*, 1991).

vii. <u>Professionalism in rugby</u>

The 1995 RWC in South Africa was the start of professionalism in rugby at the elite level internationally (Brooks and Kemp, 2008). The injury rate in the 1995 RWC was approximately one third of those in the 2003 tournament (Best, *et al.*, 2005; Jakoet and Noakes, 1998). This suggests that professionalism has contributed to an increased injury rate in rugby (Barthgate, *et al*., 2002; Jones, *et al*., 2004). Possible theories are that the full-time training regime improves skill, strength, power, and fitness, resulting in an increased body mass of elite players (Brooks and Kemp, 2008), with increased speed and force collisions, an increase in the length of time the ball is in play therefore exposure to injury (Best, *et al.*, 2005). It is unclear if the same trends have been reported in the amateur game (Brooks and Kemp, 2008). Professional players will have immediate access to good medical and rehabilitation care, and fewer factors which will stop compliance of rehabilitation (Haseler, *et al.*, 2010). Amateur rugby players will however have difficulty finding time or funding for the treatment or rehabilitation programmes due to school, work and other social activities (Haseler, *et al.*, 2010).

2.3.7.2. <u>Intrinsic factors</u>

The intrinsic risk factors that can be investigated through prospective studies (Beynnon, *et al*., 2002a) include: previous injury, body height and weight (to calculate body mass index), limb dominance, joint laxity, anatomical body alignment, foot type and size, joint range of motion, age, muscle strength, muscle reaction time, endurance, and fatigue, which will each be discussed further. Balance and postural sway is considered an intrinsic factor discussed later in the literature review under section 2.4. and 2.4.1.

i. <u>Previous injury</u>

The past medical history of a athlete is an important injury risk factor. The most frequently studied injury risk factor for lateral ankle sprains is a previous sprain of the ankle complex (Beynnon, *et al*., 2002a). The thigh and lower leg showed a high proportion of previous injuries in adult rugby compared to youth rugby. This might be due to youth players being less likely having or knowing their injury history (Haseler, *et al.*, 2010). The risk for future sprain if they had a previous sprain was documented in various studies amongst soccer players, basketball players and military recruits (Ekstrand and Gillquist, 1983; McKay, *et al*., 2001; Milgrom, *et al.,* 1991; Surve, *et al*., 1994). The rehabilitation, adherence to rehabilitation and quality of recovery plays a role in the risk after a previous injury (Beynnon, *et al.*, 2002a).

ii. Body height and weight

The body height and weight is a risk factor for ankle sprains, therefore increases the inversion torque on the ankle, raising the risk of injury in the ankle-complex during trauma (Beynnon, *et al.*, 2002a). Height and weight are not independent risk factors for ankle sprains (Beynnon, *et al.*, 2001; Stiler, *et al.*, 1994). In contrast, taller male soccer players (Watson, 1999), and military recruits that were taller and heavier, had an increase incidence of ankle sprains (Milgrom, *et al.*, 1991). There is currently no evidence regarding body height and weight with respect to rugby injuries (McIntosh, 2005b; McIntosh, *et al.*, 2010).

iii. Limb dominance

Limb dominance is a risk factor for lower limb trauma because most athletes place a greater demand or torque on their dominant limb (Beynnon, *et al*., 2002a). The risk of injury in female soccer, lacrosse and athletes showed no relation to limb dominance (Beynnon, *et al.*, 2001; Surve, *et al.*, 1994). In contrast male soccer players reported that the dominant leg sustained the majority of ankle injuries (92%) (Ekstrand and Gillquist, 1983).

iv. Joint laxity

There is a theory by medical professionals that joint laxity increases the risk of injury due to the decreased stability and neural or tissue support. There is no correlation between joint laxity and risk of injury in athletes before 1999 (Beynnon, *et al.*, 2001; Braumhauer, *et al.*, 1995; Jackson, *et al.*, 1978), but in two studies thereafter it showed joint laxity in female athletes has an effect on injury rates (Myer, *et al.*, 2006; Rozzi, *et al.*, 1999). Measuring ankle laxity with the anterior drawer test showed increased laxity and risk of injury, but not with the talar tilt test (Beynnon, *et al.*, 2002a; Braumhauer, *et al.*, 1995). In male athletes, soccer players and American football players, measuring increased ankle laxity with the talar tilt test showed increased risk of injury (Beynnon, *et al.*, 2001; Glick, *et al.*, 1976; Chomiak, *et al.*, 2000). The various findings might be due to different clinical examination and grading systems used to evaluate joint laxity, inadequate sample size or varying study designs and methodology.

v. Anatomic body alignment, foot type and size

Postural control during standing has been examined focusing on the biomechanical properties of the body, which include foot length (McCollum and Leen, 1989). The biomechanical factors can affect co-ordination (Beek, *et al.*, 1995). Anatomical foot type, whether it is pronated, supinated, or neutral does not appear to be a risk factor for ankle sprains (Barrett, *et al*., 1993; Beynnon, *et al*., 2001; Dahle, *et al*., 1991). College soccer, lacrosse and field hockey athletes showed increased inversion ankle injuries in women with abnormal hind foot alignment (Beynnon, *et al.*, 2001). This condition in navy sea, air and land trainees had a increase in risk of lower extremity overuse injury (Kaufman, *et al.*, 1999). Increased foot width was also reported as an increased risk factor of inversion ankle sprains (Beynnon, *et al.*, 2002a; Milgrom, *et al.*, 1991). Similar studies of ankle- and knee-ligament injuries are needed in athletes who take part in contact or high-risk sport. A persons' abnormal foot alignment, meaning whether it is visually excessively pronated or supinated, could be a risk factor for knee injuries (Dahle, *et al.*, 1991).

vi. <u>Joint range of motion</u>

Joint stiffness or range of motion has not been investigated in rugby players. Ankle range of motion is related to the risk of ankle sprain among college soccer, lacrosse, and field hockey players (Beynnon, *et al.*, 2001). In contrast ballet and modern dancers showed no correlation between ankle injuries and range of motion was found (Wiesler, *et al.*, 1996).

vii. <u>Age</u>

Age groups in rugby associated with risk of injury are adolescents and school leavers (Haseler, *et al*., 2010). A possible theory is growth and development during this age group where the body undergoes a series of physiological changes, which may be contributory factors to injury in contact sports (Haseler, *et al*., 2010). This was noted by Scaramella and Brown (1978), where a possible theory is that pubertal changes that increase testosterone levels in young adolescents result in increased aggression and risk-taking behaviour. Strength, speed and power increase with age which increases the momentum in contact and force transferred, increasing the risk of injury (Baxter-Jones, *et al*., 2002). The attitude to injury, together with physical and endocrine developmental changes, affects the risk of injury (Haseler, *et al.*, 2010).

viii. **Muscle strength**

The nature of rugby requires the appropriate conditioning of fast twitch and slow twitch muscle fibers (Fredericson and Moore, 2005). Lower extremity strength is commonly related to injury risk in the ankle, but only a few studies have investigated this and findings differ (Beynnon, *et al*., 2001; Braumhauer, *et al*., 1995). College soccer, lacrosse, and field hockey players showed no difference in peak-torque between injured or uninjured ankle muscle strength (Beynnon, *et al.*, 2001). In a previous study, peak-torque was recorded higher in ankle inversion, eversion and plantar-flexion in non-injured ankles, and lower in ankle dorsi-flexion and plantar flexion in injured ankles (Braumhauer, *et al.*, 1995). The differences between the above studies may be explained by the differences in the methodology.

ix. **Muscle reaction time**

The closed-loop efferent reflex response is the muscle-reaction time between the joint perturbation and muscle activation (Beynnon, et al., 2001). In uninjured athletes, the gastrocnemius muscle needs less reaction time while the anterior tibialis muscle needs more reaction time during dorsiflexion when an ankle sprain occurs. This protective mechanism of co-contraction may absent in injured athletes, and is important to consider measuring the muscle reaction time (Beynnon, *et al.*, 2002a).

The rate of force development (RFD) is important for explosive strength (Aagaard, *et al.*, 2002) required in fast explosive movement patterns in sport like rugby (Gruber and Gollhofer, 2004). The force that can be produced can be improved by either muscle protein mass (Narici, *et al.*, 1996) or neural adaptions in muscle control

(Aagaard, *et al.*, 2002; Narici, *et al.*, 1996). The maximum voluntary strength is related to the amount of motor units recruited (Van Cutsem, et al., 1998), and the adaption in recruitment characteristics of these motor units (Kukulka and Clamann 1981) or both (Duchateau and Hainaut 2003). To increase the RFD, a more explosive type of training is used (Van Cutsem, *et al.*, 1998). Proprioception training has been shown to effect motor neuron exctitation (Gollhofer, *et al.*, 1992), particularly at the start of force production (Gruber and Gollhofer, 2004). A study has shown that decreased ability of RFD can be related to impaired balance control (Izquierido, *et al.*, 1999). Therefore explosive training could be used for injury prevention training.

x. <u>Endurance and fatigue</u>

The progression in duration of games, team size and pitch dimensions with increasing age may not influence injury rate directly, but may increase possible fatigue (Haseler, *et al.*, 2010).

2.3.8. <u>Impact of injury</u>

Injuries can cause the sporting individuals career to end, with 8% of adolescents dropping out of recreational sport every year (Grimmer, et al., 2000). Injury may also decrease self-esteem, social participation, fitness and increase stress levels (Ekeland, *et al*., 2004). Possible long-term public health consequences associated with stopping a sport can be cardiovascular disease, obesity, osteo-arthritis and diabetes (Haseler, *et al.*, 2010). Only a few studies have shown long-term health impacts of rugby injuries (Berge, *et al*., 1999; Broughton, 1993; Lee, *et al*., 2001; Scher, 1990). Although most sports injuries are not severe enough to require hospitalisation, there is a large economic effect on the individual through direct medical costs, treatment and rehabilitation, as well as indirect costs, including parents taking leave to help the injured family member (Abernethy and MacAuley, 2003). Players in Australia lose income if they miss games, and might hide injuries or mask symptoms in order to play more games (Barthgate, *et al*., 2002a). In amateur rugby players, injury (26%), employment (25%) and family (10%) were the three main reasons for withdrawing from the sport (Lee, et al., 2001). Rugby league professional players reported injury (29%) and job limitations (14%) as the main reason of stopping play (Meir, et al., 1997). Quick injury management and proper resources might decrease the risk of retirement from sport. Preventing injury is important both to reduce the impact on players health and the long-term outcome of early osteo-arthritis development (Drawer and Fuller, 2001).

2.3.9. Injury prevention

Epidemiological studies are particularly useful for identifying injuries of highest incidence and severity, with the product of the latter calculating the injuries at highest risk (Brooks and Fuller, 2006; Fuller and Drawer, 2004). It is important to focus on injury-prevention programmes that are most likely to have the greatest impact on reducing the injuries that cause the most days of absence (Brooks and Fuller, 2006; Brooks and Kemp, 2008; Fuller and Drawer, 2004). Correlating body parts to injury absence can assist in evaluating and prioritising the need for future injury-prevention strategies. A significant difference in injury profile between positions shows the need for position specific injury-prevention programmes (Brooks and Kemp, 2011). Intervention programmes effectiveness can be improved if they are developed according to previous injury history of the participant (Bahr, *et al*., 1994; Brooks, *et al*., 2005a; Milgrom, *et al*., 1991).

The development and application of injury prevention strategies that focus on pre-season conditioning, functional training, education, proprioceptive balance training and sport-specific skills throughout the sporting season are reported to be most effective (Abernethy and Bleakley, 2007). Specific proprioceptive training programmes that include balance board training reduce ankle injury risk (Bahr, *et al.*, 1997; Gauffin, *et al*., 1988; Karlsson, *et al*., 1992; Konradsen and Ravn, 1991). Injury-prevention strategies in non-collision sport have shown successful results in reducing the incidence of injury to the lower limb (hamstring, knee and ankle) locations by using exercises to improve factors such as proprioception, core stability, muscle strength and sport-specific skills training drills (Askling, *et al*., 2003; Bahr and Bahr, 1997; Mandelbaum, *et al*., 2005; Myklebust, *et al*., 2003; Olsen, *et al*., 2005; Soligard, *et al*., 2008; Verhagen, *et al*., 2004; Verral, *et al*., 2005). Other injury prevention approaches showed successful results in reducing the incidence of injury to the shoulder by using exercises to reduce capsule tightness (Burkhard, *et al*., 2003) and improve eccentric strength (Jonsson, *et al*., 2006). Injury prevention interventions in collision sports need to be more researched, but the possibility of using intervention approaches from other sports might be useful with rugby cohorts. More specific injury studies are required to provide evidence regarding preventative and therapeutic interventions and their effectiveness in rugby (Van Mechelen, *et al*., 1992). As rugby is a sport where there is a continuous and unpredictable demand for static or dynamic balance during play, balance will be discussed next.

2.4. Balance

Postural balance is defined as the ability to achieve a state of equilibrium by maintaining the body's centre of gravity (CoG) over the body's base of support (BoS) (Hrysomallis, 2007:548). Balance is controlled by a continuous feedback and feed-forward system of visual, vestibular and somato-sensory input (Hrysomallis, 2007). Balasubramaniam and Wing (2002:532) suggest that balance is the equilibrium resulting from matching torques before or after postural disturbance. During rugby various events are involved such as: catching a ball, driving in the scrummages, running with a ball, changing direction, jumping in the line-out, kicking the ball, and tackling or being tackled. All of these events involve various degrees of dynamic postural control related to static and dynamic balance.

Static balance is defined by Hrysomallis (2011:222) as the ability to maintain a BoS with minimal movement. Dynamic balance is defined by Winter, *et al.* (1990:31-32) as: "The ability to perform a task while maintaining or regaining a stable position." and by Kioumourtzoglou, *et al*. (1998) as: "The ability to maintain or regain balance on an unstable surface with minimal extra movement". Balance is monitored in a variety of ways including body segment motion, reaction forces and torques (Horak and Nashner, 1986). Balance can be disturbed by applying forces predictably or unpredictably (Horak, *et al.*, 1997). In standing, a constant force of gravity is exerted, and equilibrium will be maintained through small changes of intermittent muscle activity (Balasubramaniam and Wing, 2002).

2.4.1. <u>Posture</u>

Posture is the geometric relationship between two or more body segments, for example the arm and trunk (Balasubramaniam and Wing, 2002:531). The relationship is expressed in joint angles between segments and between the body and its environment (Riccio, *et al.*, 1992). Posture is continuously influenced by external forces (Balasubramaniam and Wing, 2002), and is monitored through measurements related to CoG and centre of pressure (CoP) (Koozekanani, *et al.*, 1980; Koozekanani and Duerk, 1985; Winter, *et al.*, 1990). The CoP is the result of the responses of the total motor system and central nervous system (CNS) to correct imbalance of the CoG (Wright, 1971). Postural sway has two components, a slow non-oscillatory and faster oscillatory component, the former being used for quite stance (Carrick, *et al.*, 2007). Postural control is important for successful performance of goal-directed activities (Horak, *et al.*, 1997), such as in rugby. To maintain balance or posture, it is important to control the trunk, which contains most centre of mass (CoM), as a stable trunk is good support for the visual and vestibular sensory organs (Buchanan and Horak, 1999).

2.4.2. <u>Components of balance</u>

The central nervous system (CNS) co-ordinates the musculo-skeletal system and sensory organisation to keep balance and postural control during standing, walking, and running (Buchanan and Horak, 1999; Simonsen and Dyhre-Poulsen, 1999). All these actions are applicable in rugby, and involves static and dynamic balance. To keep postural balance or control, various sensory, motor and biomechanical components interplay. The factors that affect balance are the extent of damage to the nervous system, the number and extent of sensory loss, and the availability of other senses to compensate for damage (Nashner, 1993).

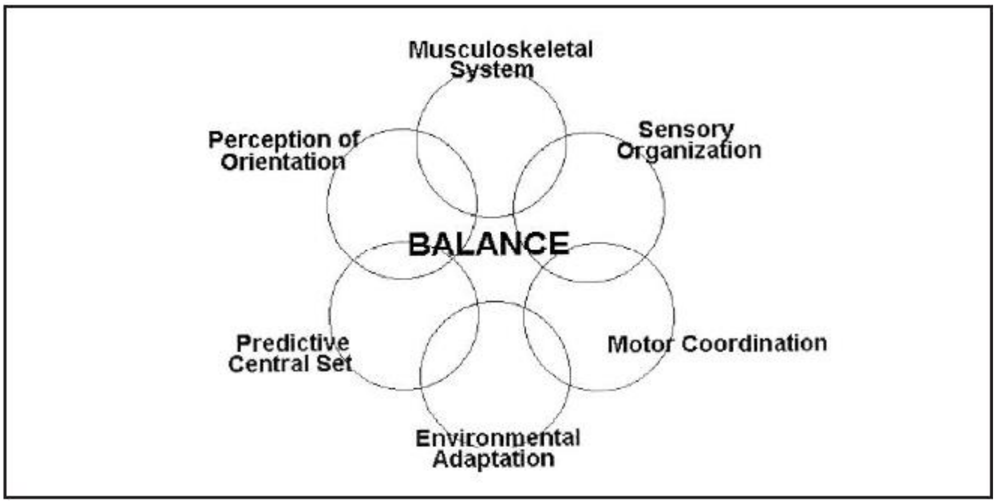

Figure 2.1: Components of balance (Biodex, 2012a:4-2)

The parts of the sensory system that contribute directly to balance are the vestibular, visual and somatosensory (touch and proprioception) systems (Calavalle, *et al.*, 2008), as well as motor responses that affect co-ordination, joint range of motion and strength (Grigg, 1994; Nashner, *et al.*, 1982; Palmieri, *et al.*, 2002; Palmieri, *et al.*, 2003).

2.4.2.1. Musculo-skeletal system

Specific skill training improves neuromuscular co-ordination, joint strength and range of movement improving balance (Balter, *et al.*, 2004; Lephart, *et al.*, 1996; Paterno, *et al.*, 2004).

2.4.2.2. Perception of orientation

The perception of orientation can be mechanical perturbation and vestibular disruption (Buckley, *et al.*, 2005). In a study on ten undergraduate students (aged

21-28 years) postural control was not affected by voice commands given regarding orientation, showing posture is influenced by tracking tasks only (Bardy, *et al.*, 1999).

2.4.2.3. <u>Sensory organization</u>

The sensory system consists of the eyes, ears, vestibular apparatus (VA) of the inner ear, somato-sensory system (touch and proprioception), taste, and smell (Nashner, 1993). The sensory system needs specialized receptors to receive sensory input by a sensory end-organ like the eyes. Sensory input is relayed to the spinal cord through afferent nerve fibers and then to the brain through a spinal spino-thalamic nerve tract (pain and temperature sensation relay) and a dorsal column medial leminscal nerve tract (fine touch and proprioception sense relay) (Vander, *et al.*, 1990). Sensory input provides the CNS the ability to change force, speed and range of movement in the body accordingly (Guskiewicz, 2003). Any problems caused to the sensory system or input can affect balance (Guskiewicz, 2003). Sub-optimal balance can be a causative factor for injury, re-injury or other trauma (Irrgang, *et al*., 1994; Nashner, 1993). The parts of the sensory system that contribute directly to balance are the vestibular, visual and somato-sensory systems.

i. <u>The vestibular system</u>

The vestibular apparatus has three semi-circular canals that give sensory feedback regarding head position and gravitational changes (Biodex, 2012a:4-2). The function of the vestibular apparatus is to assist with sensory input regarding body position during standing with eyes closed and acceleration, as well as eye muscle control (Lee and Lishman, 1975). If vestibular damage takes place, balance problems, vertigo and blurred vision can occur (Shumway-Cook and Woollacott, 2001). The cognition is involved in posture and the control of balance through postural reflexes (Johansson, *et al.*, 1994; Woollacott and Shumway-Cook, 2002). An example of a cognitive task, such as sentence completion, perceptual matching, and visio-spatial tracking affects balance (McIllroy, *et al.*, 1999; Shumway-Cook, *et al.*, 1997). Similarly, cognitive activity during rugby play may affect balance but this has not been investigated.

ii. <u>The visual system</u>

Vision is a critical part of balance and has a powerful influence on standing balance and postural sway (Balasubramaniam and Wing, 2002). Vision helps to identify objects in the environment and body position, better known as extero-prioception (Lee and Lishman, 1975; Shumway-Cook and Woollacott, 2001). The vestibular apparatus relay balance stimuli via the vestibulo-cochlear nerve to activate the vestibular ocular reflex to create eye muscle movement control with head movement assisting to maintain balance (Vander, *et al.*, 1990). The visual system is divided into two neurophysiological components affecting postural control called foveal and peripheral vision. Foveal visions recognizes and identifies objects, and peripheral vision detects movements in the environment (Paulus, *et al.*, 1984). If the visual system is affected by possible disease disorders such as diabetic retinopathy, cataracts, macular degeneration, injury or stroke then vestibular feedback will be used for balance (Shumway-Cook and Woollacott, 2001). Vision can have an impact on sport performance and can be trained through sport vision exercises as described by Knudson and Kluka (1997).

iii. <u>Somato-sensory</u>

Somato-sensory input is referred to as touch and proprioception. Proprioception is defined as: "The afferent information on position and movement from internal receptors in joints, muscles and tendons" (Hrysomallis, 2007:548). The skin mechanoreceptors, muscle tendons, and ligaments relays sensory input regarding touch, body position and rate of movement (Lee and Lishman, 1975; Nashner, 1993). The body's spinal cord reflex loops response to noxious stimuli or perturbations assist to protect the body from injury (Vander, *et al*., 1990).

Postural balance relies on two types of muscle mechanoreceptors called muscle spindle fibers (MSF) and golgi tendon organs (GTO). The mechanoreceptors contain afferent nerve fibers which conduct impulses to the nervous system regarding length and tension in muscles at rest and during movement to maintain postural balance (Nashner, 1993; Vander, *et al.*, 1990). The MSFs function is to give information regarding muscle length and rate of muscle length change, and give impulses for myotatic reflex through efferent branches that creates a muscle contraction to protect muscle if rapid stretching occur, for example during plyometric training (Nashner, 1993). The GTO is located in the musculo-tendinous junction in the tendon (Vander, *et al.*, 1990). The GTO's function is to relax overstretched muscle and sense muscle tension, and to transmit information to the CNS to inhibit motor neurons and prevent muscle strains (Nashner, 1993).

The somato-sensory system plays the biggest role in balance, and if there is a dysfunction in this system, a simple task such as walking on uneven surfaces will be difficult (Shumway-Cook and Woollacott, 2001). Proprioception becomes more important in older people as their visual and vestibular systems declines (Balasubramaniam and Wing, 2002). Therefore, if the above statement is true, then testing a young group of subjects with good visual and vestibular function will need less muscle proprioception to maintain balance.

2.4.2.4. Predictive central set

Different movement patterns trained continuously give better postural control in bipedal stance (Crotts, *et al.*, 1996; Perrin, *et al.*, 2002; Perrot, *et al.*, 1998). A decrease in postural sway contributed by both limbs, not just the injured limb suggest that more central motor patterns must be trained (Gauflin, *et al.*, 1988). Based on a persons' prior experience in a situation, balance can be maintained, this is called a predictive central set (Horak, *et al.*, 1997).

2.4.2.5. Motor co-ordination

Balance is an important motor skill to maintain posture and participate in complex sports (Davlin, 2004). Focusing on the afferent function is important for neuromuscular excitation, quicker proprioception input collection and transmitting information to the central nervous system (Gruber and Gollhofer, 2004). It is also important in injury prevention, because of the short latency period before muscle activity gives rapid tightness in joints (Gollhofer, 2003). Proprioceptive training on unstable surfaces has shown to increase core muscle activation (Behm, *et al.*, 2005; Mori, 2004). In strength training impulses from the motor cortex or gyrus praecentralis are suppressed by movement synergies and neural adaption which shows improved intramuscular and intermuscular co-ordination. Balance training was noted as being used to strengthen muscles (Gruber, *et al.*, 2007; Heitkamp, *et al.*, 2001), and better muscular co-ordination will therefore improve balance.

2.4.2.6. <u>Environmental adaption</u>

Athletes undertaking repetitive training regimes involving the same environment and skill show improved motor (Balter, *et al.*, 2004) and somato-sensory (Ashton-Miller, *et al.*, 2001) responses, and therefore better balance. The control of posture is influenced by the environment for example the support surface length (Bardy, *et al.*, 1999).

2.4.3. <u>Movement strategies for balance</u>

Anticipatory postural adjustments are made by the body when disruptions in balance occur (Balasubramaniam and Wing, 2002). Trunk proprioception is very important for loco-motor movement (Schmid, *et al.*, 2005), and the strategy of the CNS to control the body from loss of balance mainly occurs in the trunk (Hughey and Fung, 2005). The muscles efficacy is dependant of the plane of motion during the loss of balance (Carrick, *et al.*, 2007). Postural synergy can be functional and task-specific (Bardy, *et al.*, 1999; Buchanana and Horak, 1999; Marin, *et al.*, 1999; Riley, *et al.*, 1997; Satlzman and Kelso, 1985), as noted in Olympic archery and rifle shooting when comparing corresponding sway (Balasurbramaniam, *et al.*, 2000; Balasubramaniam and Turvey, 2000). The ‘postural reflex’ has a latency of a tenth of a second and occurs when an unpredictable loss of balance cause knee and hip muscle activation (Nashner and Cordo, 1981). The ‘spinal reflex’ has the shortest documented latency, a thirtieth of a second, and assists with loss of balance when ankle torque is replaced by hip flexion (Horak, *et al.*, 1997).

The ‘systems approach’ to motor control describes movement strategy as this theory involves the CNS linking muscle groups, enabling them to respond to past experiences of movement (Carrick, *et al.*, 2007). This theory states that strategies are automatic reactions that are slower than reflexes, but quicker than voluntary movement, to assist loss of balance (Shumway-Cook and Woollacott, 2001). Only the ankle strategy is used if minor loss of balance in standing on a firm surface occurs (Horak, *et al.*, 1997). Increased activation of lower leg musculature is used to regain balance in the ankle strategy compared to the hip strategy. Where forward balance loss occurs, the gastrocnemius, hamstrings, and lower-back muscles contract to regain balance, and if backward-balance loss occurs, the anterior tibialis, quadriceps, and lower abdominal muscles contract to regain balance (Bardy, *et al.*, 1999).

The hip strategy is used if rapid and larger losses of balance occur, or when the BoS is too small for the ankle to support (Horak, *et al.*, 1997). The muscle groups activate from proximal to distal, starting at the trunk (Shumway-Cook and Woollacott, 2001). Where forward-balance loss occurs, the lower-back and hamstring muscles contract to regain balance, resulting in less anterior-posterior sway. This decrease in ankle sway can overtime, possibly cause decreased ankle flexibility and strength (Shumway-Cook and Woollacott, 2001). The hip strategy is used by Olympic gymnasts who balance on the beam (Horak, *et al.*, 1997). If both the ankle and hip strategy fail, then the stepping strategy occurs. If the loss of balance exceeds the area or limit of stability, or the force pushes the CoG outside the BoS then the person is forced to step or fall (Balasubramaniam and Wing, 2002).

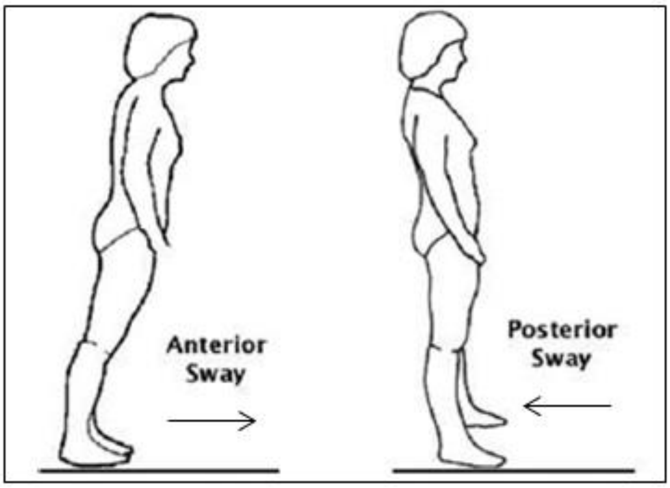

Figure 2.2: The ankle strategy or sway (A/P) (Biodex, 2012a:C-1)

2.4.4. <u>Balance and the risk of injury</u>

Proprioceptive training in various studies has been shown to reduce injury incidence (Emery, *et al.*, 2005; Wedderkopp, *et al.*, 1999; Wedderkopp, *et al.*, 2003). Medio-lateral sway was monitored in 210 first division Australian male football players over one season using a foam mat and force plate, and found that excessive medio-lateral sway as well as low balance may increase the risk of falling and injury in the ankle ligament (Hrysomallis, *et al.*, 2007). Amongst 210 high school basketball players, 119 males and 91 females, tested on the NeuroCom balance system (McGuine, *et al.*, 2000), and 127 male soccer players tested on a force plate system in one season (Tropp, *et al.*, 1984), similar findings indicated that decrease postural sway increased the risk of ankle injury ($p<0.05$).

2.4.5. <u>Balance training and sports performance</u>

Balance ability has been found to be significantly related to performance in a number of sports. Mononen, *et al*. (2007) showed that in rifle shooters bipedal static balance was associated with shooting accuracy (Ball, *et al*., 2003). Mason and Pelgrim (1986) report that shooting accuracy was related to balance ability, since junior archers with suboptimal balance performed poorly compared to senior archers who had achieved greater levels of stability before becoming elite sportsmen. Balance training can cause neural changes that stop the spinal reflex excitability (Hryosomallis, 2011), which will lead to more controlled movement and better balance. The balance training has also been shown to increase the rate of force development, and motor skills (Hrysomallis, 2011). The dynamic balance of young ice-hockey players showed a significant relationship with maximum skating speed (Behm, *et al*., 2005). Behm, *et al*. (2005) said balance is needed in ice hockey due to the small BoS in relation to the ice. Dynamic unipedal balance as measured by the Biodex balance system was shown to be associated with speed during simulated luge starts (Platzer, *et al.*, 2009a), but not with the snowboarders' ranking points (Platzer, *et al*., 2009b). Conditioning programmes for athletes has various components, with balance training in a conditioning programme being considered valuable if it has a positive influence on athletic performance (Hrysomallis, 2011).

2.4.6. Methods to measure balance

When examining the relationship between balance and athletic performance various tests have been used to assess static and dynamic balance (Hrysomallis, 2011). The Biosway portable balance system is similar to the force platform. In this study balance testing is used to measure the movement of the CoP, and indicates the postural sway (Birmingham, 2000; Brouwer, *et al.*, 1998; Hrysomallis, 2007; Lafond, *et al.*, 2004). It is the most commonly used laboratory test for monitoring static balance through the CoP for a duration, as an athlete stands on the force platform, unipedal or bipedal, and with eyes open or shut (Aalto, *et al.*, 1990; Asseman, *et al.*, 2008; Paillard, *et al.*, 2002). The CoP motion is not identical to CoG, but the lower the CoP measurement, the better the balance. In the current study the postural stability test-retest was for 60 seconds and repeated three times, and shown in a previous study that 30 seconds is reliable (Le Clair and Riach, 1996). The limits of stability test for 75% skill level has been proven reliable in uninjured elderly (Van Wegen, 2002) and elderly with a history of falls (Clark and Rose, 2001). The Biodex balance system has another system which consists of an instrumented movable platform and various levels of stability. The system measures dynamic balance by measuring the postural sway (Malliou, *et al.*, 2004). The CoP is the gold standard measure of balance (Clark, *et al.*, 2010; Haas and Burden, 2000; Riemann, *et al.*, 1999). Yaggie and Campbell (2006) recommend a dynamic balance test on the force platform to monitor CoP during unipedal stance with maximum trunk flexion or using a tilt board on the platform (Paillard, *et al.*, 2006). The validity of balance tests other than force platform and CoP data are anecdotal and not yet established (Riemann, *et al.*, 1999). The NeuroCom balance system is an example of a force platform with rotational and movement settings creating a unstable support surface (Hrysomallis, 2007). Balance is measured as the average postural sway velocity (McGuine, *et al.*, 2000) or maximum sway angle (Beynnon, *et al.*, 2001).

The sway index has a direct relationship to the CoP and is the standard deviation of the stability index. The stability index is the average position from the center. Literature reporting on stability index has found it to be a reliable and valid measurement of balance (Chaudhry, *et al.*, 2005; Hinman, 1997; Rowe, *et al.*, 1999). The stability index, as well as the sway index, can be further monitored by movement planes. The centre of gravity (CoG) displacement in a sagittal plane or anterior/posterior direction is described on the x-axis, and the CoG displacement in an coronal plane or medial/lateral direction is described on the y-axis (Arnold and Schmitz, 1998; Cachupe, *et al.*, 2001). Arnold and Schmitz (1998) assessed the sway index as separate and combined components finding combined results unreliable. The separate sway index results can also assist with defining more specifically which muscle compartments of the lower extremity have poor neuromuscular control (Shumway-Cook and Woollacott, 2001).

Other tests for balance testing include the timed unipedal stance test, star excursion balance test (SEBT) and the stabilometer. The timed unipedal stance test is used to assess static balance (Kioumourtzoglou, *et al.*, 1998; Wells, *et al.*, 2009). A more dynamic version of the test includes a wobble board that counts the number of floor contacts in 30 seconds (Kean, *et al.*, 2006). The test was made more applicable to sporting context by adding an unstable surface (Hrysomallis, 2007; Emery, *et al.*, 2005). The star excursion balance test (SEBT) is stable for a unipedal stance with maximal targeted reach distance of the free limb in a number of directions (Bressel, *et al*., 2007; Thorpe and Ebersole, 2008). Results from the SEBT might also be influenced by strength, flexibility or coordination (Hrysomallis, 2011). No validation of this test has been found in the literature review. The stabilometer is a laboratory test of dynamic balance where an athlete adjusts posture during bipedal stance to maintain a unstable, swinging platform in a horizontal position (Davlin, 2004; Kioumortzoglou, *et al.*, 1998). The Biosway portable balance system is described further in Chapter three under 3.5.3. on page 61.

2.5. Summary

This literature review has provided an overview of the many issues that need to be taken into consideration when understanding the relationship between injuries and balance, and the importance of this knowledge for prevention and rehabilitation strategies. However, it also highlights the value of research into these issues, as high level careers, health, employment and quality of life are affected by injury, and should form an important part of understanding how to optimise performance and reduce problems for all athletes at all levels. Against this background the research questions were developed and the methodology and procedures used in the study will be described in Chapter 3.

2.6. Hypotheses

The study hypotheses are as follows:

H_{A1}: There will be a significant inverse relationship between prevalence of injuries and pre-season balance in rugby players.

H_{O1}: There will be a significant direct relationship between prevalence of injuries and pre-season balance in rugby players.

H_{A2}: There will be a significant inverse relationship between incidence in the season and post-season balance in rugby players.

H_{O2}: There will be a significant direct relationship between incidence in the season and post-season balance in rugby players.

H_{A3}: A significant larger number of rugby players will have good balance levels pre-season as measured by the Biosway portable balance system.

H_{O3}: A significant larger number of rugby players will have poor balance levels pre-season as measured by the Biosway portable balance system.

H_{A4}: A significant larger number of rugby players will have good balance levels post-season as measured by the Biosway portable balance system.

H_{O4}: A significant larger number of rugby players will have poor balance levels post-season as measured by the Biosway portable balance system.

H_{A5}: A significantly larger number of rugby players will have improved their balance in the season as measured by the Biosway portable balance system.

H_{O5}: A significantly larger number of players will not have improved their balance in the season as measured by the Biosway portable balance system.

CHAPTER 3

METHODS AND PROCEDURES

3.1. Introduction

This chapter outlines the study design, the study population, inclusion and exclusion criteria, sampling strategy and size, the instruments used to measure the identified variables and data collection procedures, as well as issues of reliability and validity, data analysis and the ethical considerations.

3.2. Study design

The study consisted of two components and was conducted by the researcher as part of his physiotherapy responsibilities to the junior members of the Sharks Academy in Durban.

The first part of the study took place as part of the routine annual pre-season medical screening of Sharks Academy rugby players. A deviation from the routine was that the screening questionnaire was validated and balance was tested. Postural balance testing was done on each player, and their height and weight measured. This first component of the research took place from 30 January to 6 February 2012 during the scheduled pre-season Sharks Academy gym and medical testing.

Once ethical approval to conduct the study for a masters degree was obtained the first part of the study consisted of a retrospective chart review of the data from the pre-season testing to determine the prevalence of injury before the 2012 rugby season for first year Sharks Academy rugby players. The survey was conducted pre-season as part of the annual medical screening. The survey was supplemented with balance testing which included the measurements of the sway index and limits of stability. The second part of the study consisted of a cross-sectional survey post-rugby season to determine the incidence of injuries in season, and took place from 3 to 12 September 2012. This was supplemented with postural balance testing and measurement of height and weight. The flow diagram below shows the outline of the research process.

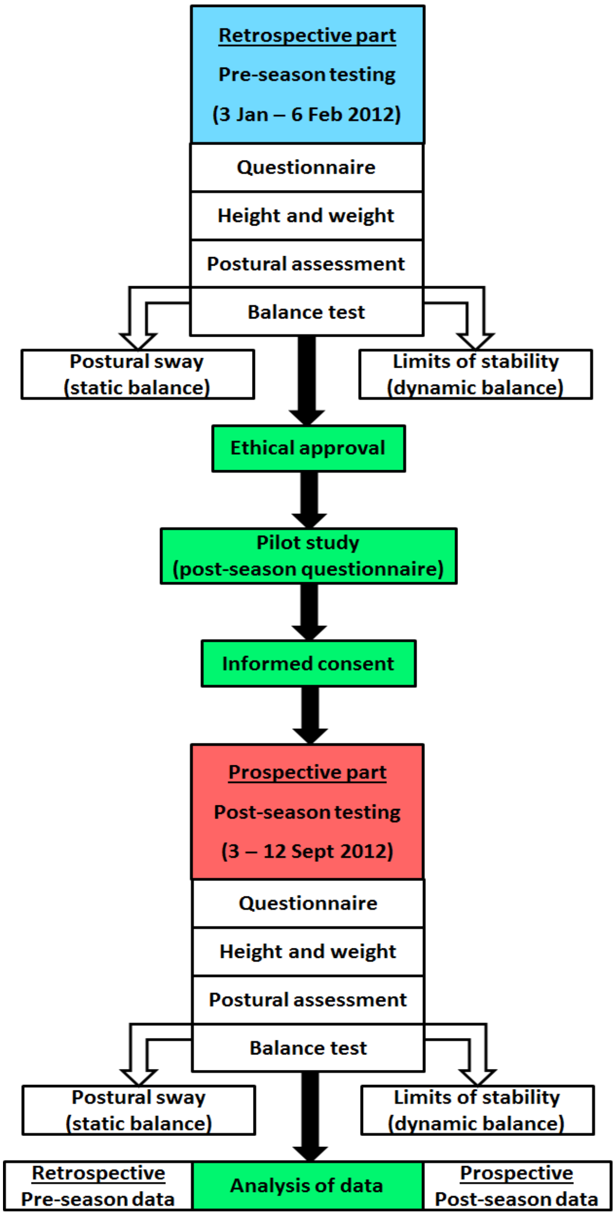

Figure 3.1: Outline of research process

3.3. Study population

The study population consisted of all 102 first year Sharks Academy rugby players registered in 2012. All 102 first year Sharks Academy rugby players were informed prior to pre-season annual medical screening regarding the scientific aspect of the medical screening. The players were informed about the proposed study, and were invited to participate in the post-season testing after ethical approval was received. All players therefore also constituted the saturated study sample.

3.4. Inclusion criteria:

All the first year players irrespective of age, nationality, race and socio-economic status were included. Those players who did not want to participate in the post-season testing were excluded because this part did not form part of the annual medical screening.

3.5. Data collection instrumentation

Four data collection instruments were used in the study and consisted of pre-season and post-season questionnaires, a digital weight scale and the portable Biosway balance system. The portable Biosway device was used to measure static and dynamic balance reflected as sway index and limits of stability.

3.5.1. Questionnaires

Two questionnaires were used to collect pre-season and post-season information, and were developed by the researcher based on an extensive literature review and his own experience. The questionnaires consisted of closed and open ended questions, and collected both quantitative and qualitative data.

Pre-season questionnaire (Appendix 5.a., page 173):

The pre-season questionnaire had two sections, was one page in length and took three minutes to complete. It consisted of two sections as indicated below.

Section A: Biographical details including age; race; home language; high school rugby experience; rugby playing position; and limb dominance.

Section B: Injury details including injury prevalence; injury acute or chronic; injury event; time injury occurred if in match; playing position at time of injury; injured side; injury severity; injured body part; type of injury; injury cause; protective equipment worn during injury; rehabilitation of injury and by whom; and additional injury specifying side, body part, and type of injury.

Post-season questionnaire (Appendix 5.b.i-5.b.ii., page 174-175):

The post-season questionnaire had three sections, consisted of two pages and took three minutes to complete.

Section A: Injury details during the 2012 rugby season including injury prevalence; injury acute or chronic; injury event; time injury occurred if in match; playing position at time of injury; injured side; injury severity; injured body part; type of injury; injury cause; protective equipment worn during injury; and rehabilitation of injury and by whom.

Section B: Training/gym and match details including first and last rugby training/match date; minutes per training/match/gym; sessions training/gym per week; matches per week and in season; gym and training activities amount per week and specify; and provincial/national rugby experience.

Section C: Additional injuries information during 2012 rugby season including date of injury; severity; side; body part; type of injury; and re-occurrence.

3.5.1.1. Validity and reliability of the questionnaires

The pre-season questionnaire had been previously piloted and corrected, as the survey was part of the annual medical screening. A pilot study was conducted to validate the post-season questionnaire that was administered to an expert group made up of the coaches, the academy's biokineticist, three senior players and one physiotherapist. Following the comments from the pilot study, the post-season questionnaire was revised and administered to five second year students and five third year students of the Sharks Academy. Following the comments from the students the post-season questionnaire was checked and finalized.

The pilot study corrections included in the pre-season and post-season questionnaire were ambiguous questions, spelling errors, structure of the questionnaire, shortening the questionnaire, and changing descriptions of injury type to minimize complexity and improve understanding for the participants. The reliability of the survey was ensured by the same person administrating the questionnaire for the pre-season and post-season testing. As the person doing the medical screening pre-season and post-season was the same researcher it was more reliable.

3.5.2. Digital weight scale

The participants' weight (kilogram) was measured before testing and was used to calculate their body mass index (kg/m²). The participants' weight was measured using a calibrated digital weight scale (described below). Weight was recorded on a anthropometric data sheet (Appendix 6, page 176).

3.5.2.1. Validity and reliability of the digital weight scale

The digital weight scale was calibrated before use. This instrument is an accurate and valid tool for measurement of body weight according to the literature review (Caldwell, *et al.*, 1986). The floor the weight scale was positioned on was horizontally straight assessed by a spirit level instrument before testing. The wall the weight scale was positioned against was vertically straight assessed by a spirit level instrument before testing. The same person did the three measurements and calculated an average to make the results reliable pre- and post-season.

3.5.3. The Biosway portable balance system

The participant's balance was measured using the Biosway portable balance system (model 950-460) (from Biodex Medical Systems, Inc.). Two identical balance tests were conducted pre-season and post-season to test balance, these being the postural stability test and limits of stability test.

For the postural stability test, information was collected on the standard deviation of the stability index, called the sway index. This index measured static balance according to normative data from the Biosway balance system clinical test of sensory integration and balance (CTSIB). The players were tested in bipedal stance, eyes open and on a firm surface similar to condition one from the CTSIB. The normative sway index ranges for this condition was 0.21-0.48 (Biodex, 2012a:B-1). The 'goal' reading for good balance was set at ≤0.48 (Biodex, 2012a). The sway index has an indirect relationship to static balance, therefore the less the sway index, the better the static balance or postural control (Biodex, 2012a).

For the limits of stability test, the system measured how accurately a player could move the display cursor to a target 10° from a platform position and back to level again. This measured dynamic balance of the participant, with the more direct the path to the target and back to the centre the higher the score. Low scores are a measure of poor neuromuscular control (Biodex, 2012a:8-2). The result was based on a score out of 100 called the dynamic limits of stability score. The ‘goal’ reading for good balance was set at 65% (Biodex, 2012a).

3.5.3.1. <u>Validity and reliability of the Biosway portable balance system</u>

The Biosway is a newly purchased machine. The validity and reliability is shown in this literature review from various studies (Clark, *et al.*, 2010; Haas and Burden, 2000; Riemann, *et al.*, 1999). According to Biodex (2012a:1-1) the BioSway portable balance system provides a "valid, reliable, and repeatable objectives measure of a participants ability to balance". As shown in Figure 3.2 below, the platform setup of the Biosway assisted to calibrate the platform level to improve reliability explain the calibration and adjustment.

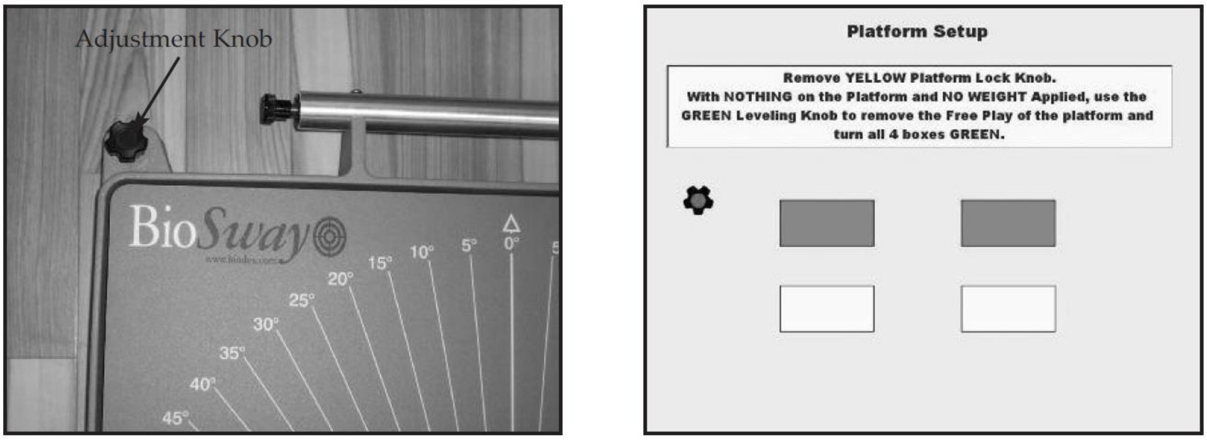

Figure 3.2: Adjustment knob and platform setup (Biodex, 2012a:3-4)

The test-retest was performed for 60 seconds during postural stability to improve reliability. The same researcher conducted the balance testing pre-season and post-season and both tests were performed three times and an average calculated.

3.6. Data collection procedure

The pre-season testing was done as part of the annual Sharks academy medical screening. This medical testing was done in a research rigorous environment as objective measures are used by the Sharks Academy for planning conditioning and rehabilitation programme.

Ethical approval to conduct the study was obtained from the specific Institutional Biomedical Research Ethics Committee. The ethical approval reference number (BE089/12) is shown in appendix 1.i. on page 157. After ethical approval to conduct the study was obtained, permission to access the population and the pre-season data was obtained from the Sharks LTD., Sharks Academy, Sharks Academy gym, and Sharks Medical. At this stage the post-season questionnaire was pilot tested and corrected. The players that were screened pre-season were notified regarding the post-season testing. Pre- and post-season testing was done in the same venue, which is the Sharks Academy gymnasium medical room. The room temperature testing environment corresponded to the Biosway portable balance system emission and immunity guidelines in the operation manual (Biodex, 2012a:E-2;E-3).

On the day of testing an information sheet was given to each player by the primary investigator together with an explanation, and thereafter fully informed consent was obtained. No parental informed consent was required as all participants were 18 years old or older in the study at time of post-season testing. Only one participant was 17 years old at the time of pre-season testing, which was retrospectively used. After fully informed consent the participant was allowed to complete the post-season survey on their own. Informed consent also allowed the researcher permission to access the participants' pre-season data. Each participant was assigned a unique numerical code, on the post-season questionnaire. The researcher placed the same unique numerical coding on the pre-season questionnaire. During the survey, the participants questions were also addressed. Once the survey was completed the participant was scheduled for a height and weight measurement, followed by a postural assessment, and balance test.

For testing the participant removed all accessories and clothing which could interfere with the test results, for example watches, armbands, cellphones, shoes, socks, protective equipment, and taping before entering the research testing room. The participants were tested in their Sharks Academy shorts and t-shirt. The weight measurements were taken at the Sharks Academy gymnasium on a calibrated digital weight scale and recorded on a data sheet. The participants' height was measured using a tape measure. The participant stood straight on the floor with the back and the heel against the wall. The top of the head was marked on the wall and the measurement taken from the floor to determine the height. Height was converted to centimetres and entered in the Biosway portable balance system.

A one minute postural assessment in bipedal standing was done. The postural screening was done without a t-shirt, and evaluated in an anterior, lateral and posterior view looking for any abnormalities which could affect balance. Any abnormalities noted were entered as a comment on the Biosway portable balance system. The participants' leg length was measured in supine on a plinth in the medical room, with a tape measure from the anterior superior iliac spine to the medial malleolus of the ankle on the same side. Three measurements of both the left and right leg lengths were taken and an average calculated in centimeters. Differences in leg length were entered on the comments section in the Biosway portable balance system.

The balance testing was done on the firm surface of the Biosway platform with eyes open and in bipedal stance. The platform setup was prepared prior to testing to calibrate the Biosway platform. The Biosway display and telescoping stand as shown in the Figure 3.3, were adjusted for each participant to eye level to avoid any neck movement when looking at the display.

Figure 3.3: Biosway display and telescoping stand (Biodex, 2012a:3-5)

The Biosway platform grid has various markings and measurements in degrees and alphabetic placements which allows for various foot sizes to be accommodated. The participants' feet were cleaned with a dry towel prior to testing. Each participants' feet position was set before testing as shown in Figure 3.4 below.

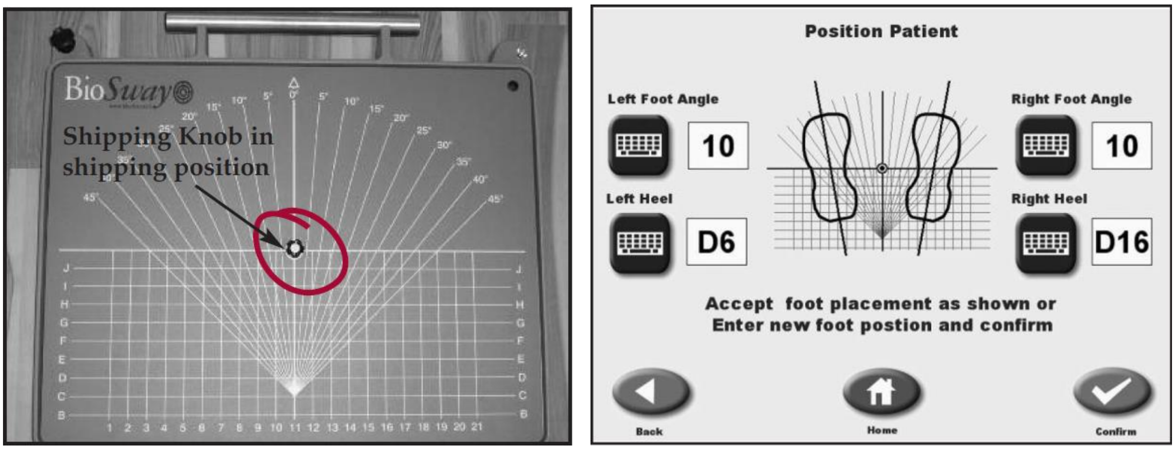

Figure 3.4: Biosway platform grid and position display (Biodex,2012a:3-1;6-12)

The Biosway start-up screen was followed by the testing screen to select the test to be completed. The participant was asked to keep his head and body still in an anatomical position when standing on the platform. The hands and arms were maintained next to the waist and during testing both feet remained on the platform. Eyes were kept open during the whole testing procedure.

Test 1: The postural stability test (Figure 3.5 and 3.6)

The postural stability assessment consisted of the same tests being done three times on the Biosway portable balance system to enable an average to be calculated. To perform the postural stability test, relevant information, for example unique identification code, age and height, was entered into the system (Figure 3.5).

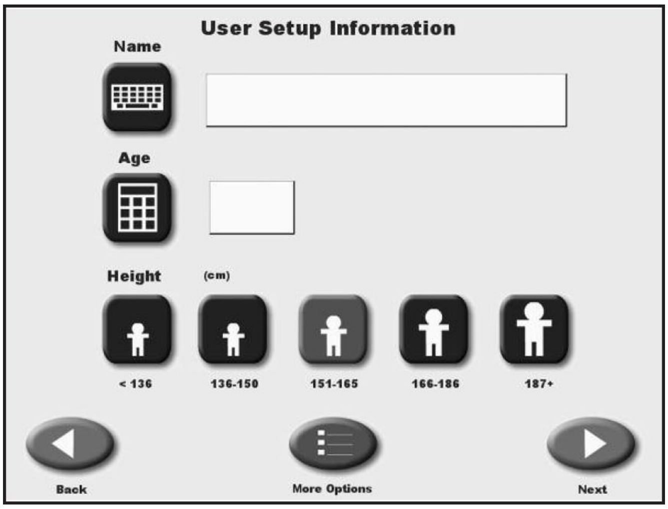

Figure 3.5: Biosway testing screen on display (Biodex, 2012a:7-1)

The researcher then adjusted the patient position and set the feet position, according to McIllroy and Maki (1997) standardized foot placement for balance testing. The postural stability setting was set for all participants for bipedal stance. To prevent assistance through visual feedback the tracing cursor was disabled.

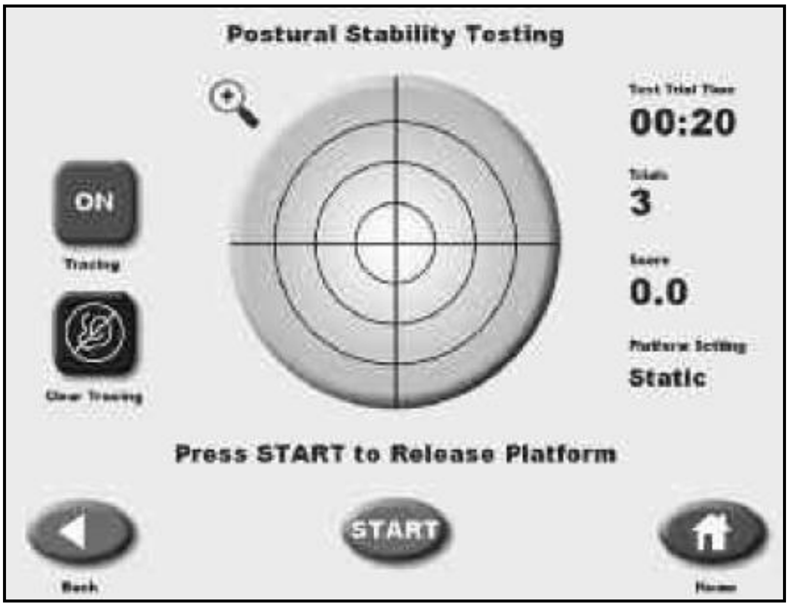

Figure 3.6: Postural stability testing screen on display (Biodex, 2012b:8-3)

The test trail time was set at 60 seconds, with a rest countdown of five seconds, and the number of trails as three. This assisted the reliability of results. The participant was again requested to stand still and maintain the position, before restarting the test. After repeating the test three times, the system saved the results. Thereafter, the data could only be accessed with a password known to the primary investigator.

Test 2: The limit of stability test (Figure 3.7)

The researcher returned to the testing screen and chose the limits of stability test. The participant's feet and body were positioned to enable the stability test to be conducted. The limit of stability setting was set at 75% or moderate skill level and bipedal stance. The tracing and scoring tone was disabled to minimize visual and vestibular feedback. The test was repeated three times to enable an average to be calculated. The participant was again re-enforced to stand with their hands and arms next to their waist, and additional information was to not lift the feet when trying to reach the target. Figure 3.7 shows the targets.

Figure 3.7: Limits of stability testing screen on display (Biodex, 2012b:8-7)

After completion of the three tests the system saved the results. The researcher cleaned the Biosway platform with a dry towel after testing. The total balance testing took 7-8 minutes per participant.

3.7. Data management

The data from the Biosway portable balance system's hard drive was downloaded onto the researchers' external hard drive. The data was then removed from the portable balance system's hard drive. To ensure anonymity and confidentiality each participant was given a unique numerical code. This unique numerical code was placed on the questionnaire that was done pre-season as well as the post-season questionnaire to be able to correlate findings. A unique numerical code was provided in place of each participants name in the pre-season testing on the Biosway portable balance system software and entered as the participants 'Name' for the post-season testing. The researcher was the only person with the identifiable details of the coding, which was locked away in the research supervisors' office and only accessed on the week of post-season testing and analysis of pre-season and post-season data. Once post-season testing was completed the list of numerical codes on paper which might cause the participants to be identified to the data was shredded. The external hard drive, questionnaires, and data sheets were also locked away in the research supervisors' office and only accessed on the week of post-season testing and analysis of data. All data will be stored for five years before being disposed off.

3.8. Data analysis

A biostatistician, was consulted on the 19th December 2011 and 25th September 2012, at the University of KwaZulu-Natal (Howard campus). The data was captured and subsequently analysed using the Statistical Package for Social Sciences version 19. A biostatistician, was consulted on 20th November 2012 to confirm statistical analysis.

Data was tested for normality. Testing of homogeneity of variance was not done due to statistician said data were transformed if normally distributed or if non-parametric data a non-parametric test was used, which does not require this assumption. Normally distributed data was analysed using paired samples t-test and Analysis of Variance (ANOVA). Non-parametric data was analysed using the Wilcoxon signed rank test and Kruskal-Wallis test. The significance value was set at $p<0.05$, the confidence interval was set at 95%. For the analysis of within injury incidence groups, the post hoc Bonferroni test was used. The relationship between prevalence of injuries, incidence of injuries, sway index and limits of stability was determined by using the Spearman rank correlation. Linear regression was also used to determine correlation or significance of risk factors for injury. Descriptive statistics was presented in tables or graphs as numbers or percentages, as well as mean, standard deviation, median and mode.

Determining the injury incidence, prevalence and postural balance in registered first year Sharks Academy rugby players, and establishing any correlation between the first two and the latter was done. The injury incidence and prevalence was expressed as numbers and percentages to allow for correlation. Only injury incidence, not injury prevalence could be expressed as injury rate which allowed correlation with previous or future studies. The calculation for injury rate was the number of injuries during the 2012, divided by the match playing hours, and multiplied by a ratio of 1000 hours divided by match playing hours. This gave the injury incidence per 1000 match playing hours. The relative injury risk ratio could be calculated by multiplying the injury severity (days absent) with the injury rate. Unfortunately in this study, injury severity was grouped into days absent, rather than specific number of days. The postural stability test standard deviation of stability index was used and defined as the sway index. The sway index, according to normative data from the CTSIB ranges for eyes open, bipedal stance on a firm surface was 0.21-0.48. The sway index (SI) was therefore categorized as being good (SI≤0.48) or poor (SI>0.48) balance. The limits of stability test were defined a percentage out of 100. The goal for the test was 65% according to the Biosway portable balance system for moderate skill level. The limits of stability results were categorized as good (LoS≥65%) or poor (LoS<65%) balance.

3.9. <u>Ethical Considerations</u>

The research proposal was submitted for ethical consideration to the following committees at the University of KwaZulu-Natal: Physiotherapy Research Ethics Committee, Health Sciences Research and Higher Degrees Committee and the Biomedical Research Ethics Committee. The ethical approval reference number (BE089/12) is shown in appendix 1.i. on page 157.

Prior to post-season testing, each participant was provided with an information sheet (Appendix 3, page 171) by the primary investigator and was requested to sign a consent form (Appendix 4, page 172). The participant was able to keep the information sheet which contained the aims, objectives, significance, benefits, possible foreseeable risks involved in the study and what to do if adverse events occur during testing. Any player who experienced adverse effect during testing was advised that they should seek medical treatment from the Sharks Medical facility for treatment as permitted by Sharks Medical (Appendix 2.2b, page 162). The information sheet also contained the contact details of the researcher involved and other relevant contact information for any future queries regarding the study. The consent form summarised the nature of the study, that the participant's anonymity and confidentiality being guaranteed, as well as the voluntary participation in the study and whether the results during pre- and post-season testing can be used. The participants were informed both in the consent form and verbally that they had the right to withdraw at any stage from the study without their participation in the academy being compromised.

3.10. Summary

The chapter described the study design, study population, inclusion criteria, data collection instrumentation, data collection procedure, data management, data analysis, as well as the ethical consideration. The following chapter will discuss the results analysed.

CHAPTER 4

RESULTS

4.1. Introduction

The chapter describes the results of the study which included the response rate, demographic profile of the participants, injury prevalence, injury incidence, anatomical parts injured during 2012, severity of injury during 2012, injury incidence rate, sway index, limits of stability, and relationship between injury prevalence, injury incidence and balance, as well as injury risk factors.

4.2. Response rate

The majority of the first year Sharks Academy rugby players (n=77; 75.5%) participated in both the pre- and post-season testing after fully informed voluntary consent. Some players (n=25) who tested pre-season did not attend post season testing. The possible reasons for not attending post-season testing were either due to injuries (9.8%) and no response (14.7%) to the post-test call up despite various attempts to elicit their participation. It must be noted that Durban experienced severe heavy rains during the week of post-season testing.

4.3. Demographic profile of the participants

The majority of the players were 18 (n=55; 71.4%) and 19 years old (n=16; 20.8%), with a range between 17 to 20 years, while their mean age was 18.32 ± 0.6 years. White players made up the majority (n=55; 71.4%) of the cohort followed by Africans (n=20; 26%) and Coloureds (n=2; 2.6%). The home language most frequently spoken by players was English (n=42), and the least spoken were classified as other languages (n=4) which included Ndebele, Sesotho, Shona and Spanish. Only seven players (9.1%) spoke isiZulu as their home language.

4.4. <u>Injury prevalence</u>

Table 4.1 shows that 44% of the players sustained injuries pre-season. More than half of the players reported 'no injury' and almost three quarters of all the injuries were sustained by 38% of the players who reported a single injury. These results are shown in the table below.

Table 4.1: Number and percentages of players and injuries sustained pre-season.

Injury prevalence	Number of participants		Number of injury/ies	
	n	%	n	%
None per player	43	**56**		
One per player	29	38	29	**74**
More than one per player	4	5	**10[a]**	26
Did not specify	1	1		
Total	**77**	**100**	**39**	**100**

[a]This included players with two (n=2), and three (n=2) additional injuries.

The injury prevalence was 1.18 ± 0.53 per player.

4.5. <u>Injury incidence</u> (Table 4.2)

Eighty three percent of players were injured during the 2012 season compared to that in the pre-season. The total number of injuries pre-season (39) increased by almost four times in the post-season to 117. An increase of 78 injuries was noted. Injury prevalence was weakly correlated with injury incidence (Spearman's rho=0.275). The mean number of injuries that occurred during the 2012 season was

1.52 ± 1.23 per player, with a range between 0 and 5 injuries per player. These results are shown in Table 4.2 below.

Table 4.2: Numbers and percentages of players and injuries sustained in season.

Injury incidence	Number of participants		Number of injury/ies	
	n	%	n	%
None per player	13	17		
One per player	32	41.5	32	27
More than one per player	32	**41.5**	85[a]	**73**
Total	**77**	**100**	**117**	**100**

[a]This included players with one (n=20), two (n=7), three (n=3), four (n=2) and five (n=1) additional injuries

4.6. Body parts injured during 2012

Table 4.3 shows the body parts most frequently injured during the 2012 season which included the knee, ankle and shoulder/collar bone. The body region with the most injuries was the lower limb (>50%), followed by the upper limb, head/face and trunk. The knee and ankle were the most commonly injured in the lower limb. Sixty eight percent of injuries to the upper limb involved the shoulder/collar bone, which was the third most injured body part. Of note, the head/face only accounted for a fifteenth of all injuries. Trunk injuries involved mostly the lower back.

Table 4.3: Number and percentage of injuries in each region, and body part, in the 2012 season.

Injured region and body part:	n	%	Injured region and body part:	n	%
• **Upper limb**	26	22	• **Lower limb**	**65**	**55**
Shoulder/collar bone	**18**	**15**	Sacrum/pelvis	1	1
Elbow	0	0	Hip/groin	8	7
Forearm	1	1	Knee	**30**	**25**
Wrist	2	2	Ankle	**25**	**21**
Hand/finger/thumb	5	4	Foot/toe	1	1
• **Trunk**	4	3	• **Head/face**	**8**	**7**
Sternum/ upper back	0	0			
Low back	4	3	• **Not specified**	**14**	**12**
Total[a] (N) = 117					

[a]This is the sum of all injuries.

4.7. Severity of injury during the 2012 season

The severity of injuries during the 2012 rugby season was classified as categories: slight (0-1 days lost); minimal (2-3 days lost); mild (4-7 days lost); moderate (8-28 days lost); and severe (more than 28 days lost). Only 2% of injuries could not be classified, due to players not specifying the severity.

The majority of injuries were moderate (37%), followed by severe (25%) and mild (19%), as shown in Table 4.4.

Table 4.4: Number and percentage of severe injuries by category.

Categories injury per player	Injury severity[1] n (%)					
	Slight	Minimal	Mild	Moderate	Severe	Total
One per player	4 (6)	6 (10)	7 (11)	**25 (40)**	**21 (33)**	63 (100)
More than one per player	3 (6)	8 (15)	**15 (29)**	**18 (35)**	8 (15)	52 (100)
Total	7	14	22	**43**	**29**	**115[2]**

[1]Injury severity divided into: slight (0-1 day), minimal (2-3 days), mild (4-7 days), moderate (8-28 days), and severe (>28 days); [2]Total = 115 injuries, not 117 injuries as 2 injuries did not specify severity.

4.8. Incidence of injuries by 1000 match playing hours during 2012

The mean incidence of injuries during the 2012 season was 5.95 ± 8.33 per 1000 match playing hours, better known as the injury rate. The range for injuries sustained was 0-45 injuries per 1000 match playing hours during 2012. The mean number of matches played per player was 17.39 ± 7.3 (range = 4-40) matches and mean number of match hours per player was 21.89 ± 10.16 (range = 5-53). The sum of matches during the 2012 season by all the players was 1217 matches, and sum of match hours was 1488 hours.

4.9. The sway index

The sway index is a reflection of postural stability. The sway index suggests 'good' balance if the sway index is ≤0.48, but considered 'poor' if >0.48. As shown in Table 4.5, the mean medial/lateral score suggests good postural stability pre- and post-test. As shown in Table 4.5 the mean anterior-posterior score decreased by 0.01 (p=0.927), but remained poor from pre- to post-test. The medial/lateral direction score increased by 0.05 (p=0.034) and remained good from pre- to post-test, while the overall score increased by 0.01 (p=0.8) but remained poor.

Table 4.5: Descriptive statistics for pre- and post-test (in parentheses) anterior/posterior, medial/lateral and overall sway index.

Statistics (n=77)	Sway index - pre-test (post-test)		
	Anterior/posterior	Medial/lateral	Overall[2]
Mean	**0.78 (0.77)**	**0.33 (0.38)**	**0.76 (0.77)**
p	0.927	**0.034**	0.8
Mean %▲	**-1%**	**15%**	**1%**
Median	0.71 (0.67)	0.25 (0.31)	0.66 (0.67)
Mode	0.71 (0.42)	0.23 (0.22)	0.66 (0.46)
Std. deviation	0.38 (0.39)	0.24 (0.24)	0.41 (0.41)
Minimum	0.28 (0.24)	**0.10 (0.09)**	**0.20 (0.24)**
Maximum	**2.44 (2.2)**	1.54 (1.36)	**2.42 (2.19)**
IQR[1]	0.36 (0.47)	0.16 (0.23)	0.42 (0.51)

[1]IQR=inter-quartile range (percentile 75%-percentile 25%);
[2]Overall=anterior/posterior + medial/lateral
(%)▲ =Percentage change=[(post-test – pre-test)/pre-test]*100

As seen in Table 4.5 a medial-lateral sway index increased significantly by 15% post-season compared to pre-season values (p=0.034).

4.10. <u>The limits of stability</u>

The limits of stability inform dynamic stability in the standing individual. The limits of stability is a measure of 'good' balance if >65%, but considered 'poor' if ≤65%. As shown in Table 4.6, mean backward and left scores suggest good dynamic balance pre-test. Post-test limits of stability increased in all directions suggesting an improvement in dynamic balance. Post-test scores increased compared to pre-test scores as follows: forward by 9.05 ($p=0.000$); backward by 2.41 ($p=0.275$); right by 5.74 ($p=0.001$); left by 2.55 ($p=0.173$); forward/right by 5.65 ($p=0.001$); forward/left by 5.42 ($p=0.005$); backward/right by 4.12 ($p=0.048$); backward/left by 1.16 ($p=0.566$); and the overall score by 4.83 ($p=0.000$).

Table 4.6: Descriptive statistics for limits of stability direction control test scores pre- and post-test (in parentheses) forward, backward, right, left, forward/right, forward/left, backward/right, backward/left and overall score.

Statistics (n=77)	Limits of stability - pre-test (post-test)								
	F	B	R	L	F/R	F/L	B/R	B/L	Overall[2]
Mean	53.82 (62.87)	67.91 (70.32)	64.97 (70.71)	67.71 (70.26)	58.83 (64.48)	58.92 (64.34)	62.40 (66.52)	64.44 (65.6)	**56.09 (60.92)**
p	**0.000**	0.275	**0.001**	0.173	**0.001**	**0.005**	**0.048**	0.566	**0.000**
Mean %▲	**17%**	4%	9%	4%	10%	9%	7%	2%	**9%**
p									
Median	53 (66)	66 (71)	66 (72)	68 (73)	59 (64)	60 (64)	61 (68)	64 (67)	55 (61)
Mode	66 (72)	52 (84)	47 (70)	55 (63)	65 (57)	67 (57)	61 (72)	56 (67)	47 (58)
Std. deviation	17.6 (20.45)	18.56 (16.43)	14.66 (13.16)	14.88 (14.17)	14.64 (14.86)	14.11 (14.86)	14.6 (16.34)	14.05 (17.22)	12.35 (12.94)
Minimum	**8** (13)	26 (33)	25 (33)	36 (34)	24 (30)	28 (30)	31 (27)	26 **(6)**	**27 (28)**
Maximum	88 **(99)**	**99** (98)	95 (94)	96 (92)	90 (93)	89 (96)	96 (94)	92 (94)	**86 (84)**
IQR[1]	25 (32.5)	29 (26)	20 (18.5)	25 (21)	22 (22.5)	18.5 (23.5)	21.5 (28.5)	20.5 (21.5)	17.5 (20.5)

F=forward; B=backward; R=right; L=left; F/R=forward/right; F/L=forward/left; B/R=backward/right; B/L=backward/left;
[1]IQR=inter-quartile range (percentile 75%-percentile 25%); [2]Overall=F+B+R+L+F/R+F/L+B/R+B/L; %▲ =Percentage change=[(post-test – pre-test)/pre-test]*100

4.11. Relationship between injury prevalence and sway index

Ten percent of the players who had good static balance pre-season, as well as sustained one injury, presented with poor balance results in the post-test. In total 20 players (26%) had 'good' balance in the pre-season as well as post-season.

As shown in Table 4.7, an insignificant overall relationship was found between injury prevalence and sway index in all directions ($p \geq 0.05$). Overall sway index ($r=0.23$; $p \geq 0.05$) and medial/lateral sway index ($r=0.113$; $p \geq 0.05$) was weakly correlated with injury prevalence while anterior/posterior sway index was inversely weakly correlated with prevalence of injury ($r=-0.11$; $p \geq 0.05$). In summary a weak correlation between injury prevalence and sway index ($p \geq 0.05$).

Table 4.7: **Spearman's rho correlation co-efficient to measure associates between injury prevalence, sway index parameters pre- and post-test.**

Partial Spearman's rho correlations	Injury prevalence 2012	SI Overall	SI Anterior/ posterior	SI Medial/ lateral	SI Overall	SI Anterior/ posterior	SI Medial/ lateral	SI %▲
Injury prevalence 2012	1							
SI Overall	0.23	1						
SI Anterior/posterior	-0.11	0.945*	1					
SI Medial/lateral	0.113	0.204	0.185	1				
SI Overall	0.078	0.285*	0.243*	0.017	1			
SI Anterior/posterior	0.09	0.319*	0.295*	-0.021	0.933*	1		
SI Medial/lateral	0.024	0.042	0.009	0.148	0.356*	0.215	1	
SI %▲	-0.002	-0.534	-0.534	-0.158	0.597*	0.531*	0.232*	1

SI = sway index; *Significant at $p<0.05$; **%▲** = percentage change; ■ = pre-test; ■ = post-test

4.12. Relationship between injury prevalence and limits of stability

In the pre-test, 20 participants (26%) had good dynamic stability compared to 33 participants (43%) during the post-test. The percentage of players with 'good' limits of stability increased post-test whether there was an injury present or not.

As shown in Table 4.8, the relationship between limits of stability and injury prevalence was weak to none. The results also suggest there is a moderate relationship for post-test backward/right and injury prevalence (r=0.247; p=0.027).

Table 4.8: Spearman's rho correlation co-efficient to measure associates between injury prevalence, limits of stability parameters pre- and post-test.

Partial Spearman's rho correlations	Injury prevalence 2012	LoS O	LoS F	LoS B	LoS R	LoS L	LoS F/R	LoS F/L	LoS B/R	LoS B/L	LoS O	LoS F	LoS B	LoS R	LoS L	LoS F/R	LoS F/L	LoS B/R	LoS B/L	LoS %▲
Injury prevalence 2012	1																			
LoS O	0.074	1																		
LoS F	0.088	0.782	1																	
LoS B	0.158	0.784*	0.523*	1																
LoS R	0.019	0.592*	0.304*	0.502*	1															
LoS L	0.093	0.659*	0.292*	0.654*	0.469*	1														
LoS F/R	0.097	0.721*	0.443*	0.582*	0.402*	0.479*	1													
LoS F/L	0.075	0.64*	0.501*	0.475*	0.234*	0.422*	0.44*	1												
LoS B/R	0.055	0.607*	0.391*	0.675*	0.431*	0.453*	0.497*	0.22	1											
LoS B/L	-0.012	0.572*	0.262*	0.627*	0.352*	0.472*	0.415*	0.45*	0.55*	1										
LoS O	0.114	0.648*	0.462*	0.63*	0.346*	0.525*	0.488*	0.414*	0.414*	0.483*	1									
LoS F	0.148	0.569*	0.419*	0.518*	0.241*	0.401*	0.39*	0.317*	0.4*	0.461*	0.782*	1								
LoS B	-0.016	0.415*	0.218	0.412*	0.327*	0.342*	0.388	0.211	0.431*	0.349*	0.531*	0.252*	1							
LoS R	0.068	0.456*	0.192	0.475*	0.43*	0.548*	0.402*	0.301*	0.411*	0.429*	0.602*	0.417*	0.49*	1						
LoS L	0.016	0.315*	0.094	0.34*	0.222	0.341*	0.214	0.327	0.147	0.406*	0.529*	0.277*	0.416*	0.338*	1					
LoS F/R	0.046	0.603*	0..515*	0.591*	0.321*	0.366*	0.456*	0.421*	0.325*	0.345*	0.806*	0.606*	0.356*	0.385*	0.411*	1				
LoS F/L	0.042	0.541*	0.356*	0.492*	0.314*	0.532*	0.458*	0.387*	0.3*	0.384*	0.747*	0.485*	0.426*	0.481*	0.44*	0.654*	1			
LoS B/R	0.247*	0.469*	0.268*	0.489*	0.318*	0.431*	0.453*	0.271*	0.326*	0.33*	0.633*	0.445*	0.509*	0.419*	0.221	0.48*	0.424*	1		
LoS B/L	0.0	0.39*	0.257*	0.529*	0.172	0.432*	0.38*	0.205	0.243*	0.442*	0.684*	0.434*	0.423*	0.306*	0.429*	0.601*	0.495*	0.556*	1	
LoS %▲	0.055	-0.288*	-0.288*	-0.097	-0.207	-0.059	-0.223	-0.241*	-0.195	-0.036	0.482*	0.334*	0.144	0.25*	0.306*	0.312*	0.315*	0.293*	0.395	1

LoS = Limits of Stability; %▲ = percentage change; F = forward; B = backward; R = Right; L = Left; F/R = forward/right; F/L = forward/left; B/R = back/right; B/L = back/left; *Significant at $p<0.05$; ■ = pre-test; ■ = post-test

4.13. Relationship between injury incidence and sway index

The proportion of players with one injury and good static balance increased by 5% post-test compared to pre-test. Post-test the anterior/posterior sway index showed a marginally significant relationship with injury incidence categories ($p=0.043$). Furthermore multiple comparison of post-test anterior/posterior sway index within injury incidence groups showed significance only between categories of players with no injuries and those with one injury ($p=0.043$).

As shown in Table 4.9, regarding the correlation co-efficient for the relationship between sway index and injury incidence, an insignificant overall relationship was found with sway index in all directions, except for overall percentage change. The overall percentage change had an insignificant direct relationship to injury incidence ($p\geq0.05$).

Table 4.9: Spearman's rho correlation co-efficient to measure associates between injury incidence, sway index parameters pre- and post-test.

Partial Spearman's rho correlations	Injury incidence 2012	SI Overall	SI Anterior/ posterior	SI Medial/ lateral	SI Overall	SI Anterior/ posterior	SI Medial/ lateral	SI %▲
Injury incidence 2012	1							
SI Overall	0.095	1						
SI Anterior/posterior	0.14	0.945*	1					
SI Medial/lateral	0.058	0.204	0.185	1				
SI Overall	0.063	0.285*	0.243*	0.017	1			
SI Anterior/posterior	0.05	0.319*	0.295*	-0.021	0.933*	1		
SI Medial/lateral	0.104	0.042	0.009	0.148	0.356*	0.215	1	
SI %▲	-0.073	-0.534*	-0.534*	-0.158	0.597*	0.531*	0.232*	1

SI = sway index; *Significant at p<0.05; %▲ = percentage change; (blue) = pre-test; (red) = post-test

4.14. Relationship between injury incidence and limits of stability

The percentage of players with good limits of stability increased post-test regardless of whether there was an injury prevalent or not. In the post-test the proportion of players with good dynamic balance, as well as having one injury increased by 10% to a total of eighteen players (26%).

Table 4.10 shows the correlation co-efficient for the relationship between limits of stability (LoS) and injury incidence. An insignificant relationship was found between injury incidence and limits of stability. The pre-test forward/right LoS suggests a moderate relationship with injury incidence (p=0.031). The post-test left and forward/left LoS, as well as overall percentage change has an insignificant inverse relationship with injury incidence.

Table 4.10: Spearman's rho correlation co-efficient to measure associates between injury incidence, limits of stability parameters pre- and post-test.

Partial Spearman's rho correlations	Injury incidence 2012	LoS O	LoS F	LoS B	LoS R	LoS L	LoS F/R	LoS F/L	LoS B/R	LoS B/L	LoS O	LoS F	LoS B	LoS R	LoS L	LoS F/R	LoS F/L	LoS B/R	LoS B/L	LoS %▲
Injury incidence 2012	1																			
LoS O	0.162	1																		
LoS F	0.128	0.782*	1																	
LoS B	0.127	0.784*	0.523*	1																
LoS R	0.098	0.592*	0.304*	0.502*	1															
LoS L	0.066	0.659*	0.292*	0.654*	0.469*	1														
LoS F/R	0.232*	0.721*	0.443*	0.582*	0.402*	0.479*	1													
LoS F/L	0.068	0.64*	0.501*	0.475*	0.234*	0.422*	0.44*	1												
LoS B/R	0.044	0.607*	0.391*	0.675*	0.431*	0.453*	0.497*	0.22	1											
LoS B/L	0.061	0.572*	0.262*	0.627*	0.352*	0.472*	0.415*	0.45*	0.55*	1										
LoS O	0.02	0.648*	0.462*	0.63*	0.346*	0.525*	0.488	0.414*	0.414*	0.483*	1									
LoS F	0.057	0.569*	0.419*	0.518*	0.241*	0.401*	0.39*	0.317*	0.4*	0.461*	0.782*	1								
LoS B	0.008	0.415*	0.218	0.412*	0.327*	0.342*	0.388	0.211	0.431*	0.349*	0.531*	0.252*	1							
LoS R	0.014	0.456*	0.192	0.475	0.43*	0.548*	0.402*	0.301	0.411*	0.429*	0.602*	0.417*	0.49*	1						
LoS L	-0.081	0.315*	0.094	0.34*	0.222	0.341*	0.214	0.327	0.147	0.406*	0.529*	0.277*	0.416*	0.338*	1					
LoS F/R	0.072	0.603*	0.515*	0.591*	0.321*	0.366*	0.456*	0.421	0.325*	0.345*	0.806*	0.606*	0.356*	0.385*	0.411*	1				
LoS F/L	-0.14	0.541*	0.356	0.492*	0.314*	0.532*	0.458*	0.387	0.3*	0.384*	0.747*	0.485*	0.426*	0.481*	0.44*	0.654*	1			
LoS B/R	0.094	0.469*	0.268*	0.489*	0.318*	0.431*	0.453*	0.271	0.326*	0.33*	0.633*	0.445*	0.509*	0.419*	0.221	0.48*	0.424*	1		
LoS B/L	0.058	0.39*	0.257*	0.529*	0.172	0.432*	0.38*	0.205	0.243*	0.442*	0.684*	0.434*	0.423*	0.306*	0.429*	0.601*	0.495*	0.556*	1	
LoS %▲	-0.165	-0.288	-0.288*	-0.097	-0.207	-0.059	-0.223	-0.241	-0.195	-0.036	0.482*	0.334*	0.144	0.25*	0.306*	0.312*	0.315*	0.293*	0.395*	1

LoS = Limits of Stability; %▲ = percentage change; F = forward; B = backward; R = Right; L = Left; F/R = forward/right; F/L = forward/left; B/R = back/right; B/L = back/left; *Significant at $p<0.05$; ■ = pre-test; ■ = post-test

4.15. Risk factors for injury

All the risk factors discussed next were for the first injury specified per each player. If 'more than one' injury was specified, the other injuries only took the following risk factors into consideration: body weight, body mass index, side of injury and re-occurrence of injury.

4.15.1. Playing position

The playing position with the most injuries during the 2012 rugby season was the scrum-half (number 9) position (n=9). The least injuries were sustained by players in the loose-head lock (number 4) position (n=1). The backs had more injuries (57%), than the forwards during 2012. Figure 4.1 shows the percentage of injuries by player position during the 2012 rugby season.

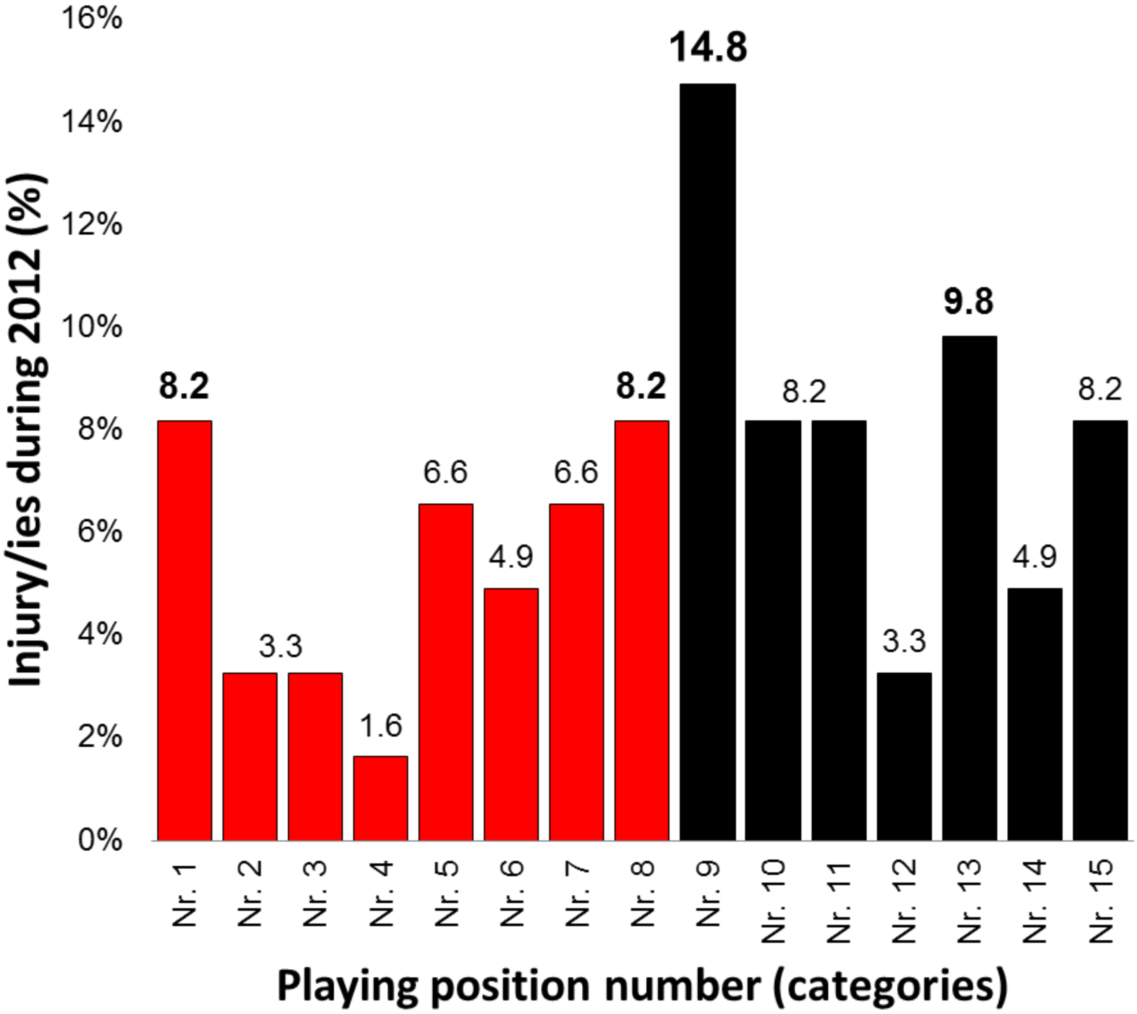

Figure 4.1: The proportion of injury/ies during 2012 as percentage by playing position number.

4.15.2. <u>Body weight and body mass index</u>

The mean body weight post-season (n=89.6 kg) decreased by 0.1 kg compared to pre-season. The median body weight post-season was 88.8 kg and range was from 60 kg to 116 kg. Linear regression showed no significance ($p=0.573$) between body weight and the proportion of injuries during 2012. The mean body mass index (BMI) post-season (28 kg/m^2) increased by 0.2 kg/m^2 compared to pre-season. The median BMI post-season was 27.6 kg/m^2 and the range was from 21.3 kg/m^2 to 34.3

kg/m². The linear regression showed no significance (p=0.597) between BMI and the proportion of injuries during 2012.

4.15.3. <u>Protective equipment</u>

In Figure 4.2 below, the percentage of protective equipment worn during injury in 2012 is shown on the pie chart. The majority of players did not wear protective gear. The same proportion of players that wore taping and strapping, wore mouth guards (12%). This was double the number of players that wore headgear and twelve times the number of players that wore an external brace. No significance was shown for all protective equipment categories: ‘none’ (p=0.35); ‘external brace’ (p=0.563); ‘taping or strapping’ (p=0.464); ‘headgear’ (p=0.384); and ‘mouth guard’ (p=0.629) showed no significance with the proportion of injuries during 2012.

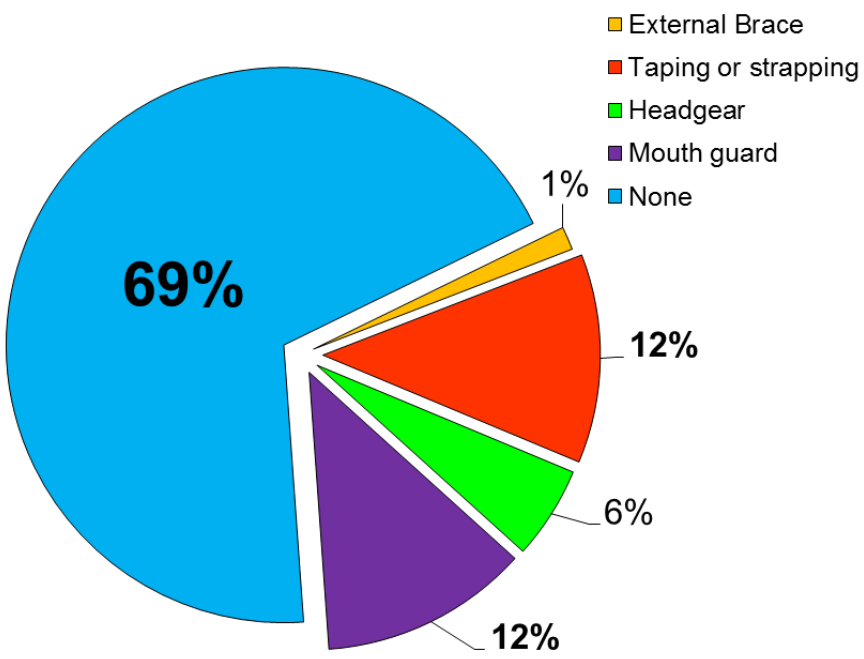

Figure 4.2: The proportion of players who wore protective equipment when injury was sustained in season.

Despite the majority of players not wearing protective gear, no significance was shown for all protective equipment categories: ‘none’ (p=0.35); ‘external brace’ (p=0.563); ‘taping or strapping’ (p=0.464); ‘headgear’ (p=0.384); and ‘mouth guard’ (p=0.629) and the proportion of injuries during 2012.

4.15.4. Limb dominance or injured side

Ninety two percent (71) of the players were right hand dominant and 91% were right leg dominant (70). The right side was also the most commonly injured during the 2012 rugby season (46%), followed by the left side (44%), right and left side (6%) and not applicable (4%). The hand dominance (p=0.735), limb dominance (p=0.847), injured side with only one injury (p=0.597), injured side with one additional injury (p=0.671), and injured side with two additional injuries (p=0.727) showed no significance relationship and the proportion of injuries during 2012.

4.15.5. Pre-season activities, season training and season gym

The pre-season activities showed that injury incidence increased with participants whom did more gym training pre-season. The pre-season activities for players with injuries during the 2012 rugby season showed players doing ‘gym’ activities (54%), ‘cardiovascular’ activities (31%), ‘holiday/vacation’ (6%), ‘other’ activities (3%), and ‘no’ activity (7%). The training programmes classified as ‘other’ included running (n=5), squash (n=1), extra training (n=1) and going to initiation camp (n=1). There was no significance relationship between pre-season training activities and the proportion of injuries during 2012 in the categories of ‘gym’ (p=0.837); ‘cardiovascular’ (p=0.732); ‘holiday/vacation’ (p=0.975); ‘no activity’ (p=0.767) or ‘other’ (p=0.555).

The in-season gym activities for players with injuries during the 2012 rugby season showed players with injuries participating in 'cardio' activities (18.6%), 'strength' activities (23.3%), 'agility/speed' (20.2%), 'balance' activities (14.6%), 'power' activities (22.9%), and 'other' activities (0.4%). The gym programmes classified as other was finisher (n=1), mass building (n=1), and did not specify (n=2). There was no significant relationship between gym programme training activities (p>0.1) and the proportion of injuries during 2012 in the categories cardio (p=0.262); strength (p=0.625); agility/speed (p=0.94); balance (p=0.734); power (p=0.437) or 'other' (p=0.89). The least injuries were sustained by players who participated in balance and gym programmes classified as 'other'. The in-season training activities for players with injuries during the 2012 rugby season showed players with injuries doing 'fitness' activities (23%), 'skills' activities (24.2%), 'contact' (20.1%), 'recovery' activities (18%), 'power' activities (14.3%), and 'other' activities (0.4%). The training programmes classified as other was wrestling (n=1), endurance or speed (n=1), and did not specify (n=1). There was no significance between training activities during the season and the proportion of injuries during 2012 as reflected in the categories fitness (p=0.290); skills (p=excluded); contact training (p=0.445); recovery programme (p=0.082), power (p=0.947) or other (p=0.271).

4.15.6. <u>Injury event, re-occurrence and rehabilitation of injuries (Table 4.11)</u>

The majority of the injuries during the 2012 rugby season occurred during matches (66%), and mainly in the 2nd half (57%). The injuries occurred mainly during contact (67%) and were due to trauma (62%). In relation to pre-season results there was 8.3% more traumatic injuries and 11.3% more contact injuries. There was no significance between timing of an injury namely during a match or training (p=0.741), injury cause by overuse or trauma (p=0.232), and injury caused by contact (p=0.979). Almost a third of injuries (29%) that occurred during 2012 were a re-occurrence of a previous injury. A total of 69% of players with injuries during the 2012 season rehabilitated those injuries. The table below shows health care professionals consulted to manage injuries.

Table 4.11: Health professionals consulted for injuries occurring in 2012 with regards to the proportion of injury/ies during 2012.

Injury n (%)	Rehabilitation of injuries (during 2012 season)					
	B	C	P1	P2	O	Total
One per player	**10 (40%)**	0 (0)	**12 (48%)**	0 (0)	3 (12%)	25 (100%)
More than one per player	**9 (34.6%)**	2 (7.7)	**13 (50%)**	0 (0)	2 (7.7%)	26 (100%)
Total	**19**	2	**25**	0	5	**51**

B=biokineticist; C=chiropractor; P1=physiotherapist; P2=personal trainer; O=own programme

As shown in the table, the majority of players sought the services of a physiotherapist followed by a biokineticist. The discussion of the results with respect to other research is elaborated on in the next chapter.

CHAPTER 5

DISCUSSION

5.1. Introduction

The results are discussed with respect to other research in four themes related to the aims and objectives. The first part of the discussion will look at injury prevalence and the associated risk factors. The second part will look at injury incidence and the associated risk factors. The third part will look at balance and the fourth part will look at the relationship between balance and injury prevalence, as well as balance and injury incidence.

5.2. Demographic details

In this study the majority of players were immediate post-adolescent, and literature have suggested injury in rugby is most prevalent at this stage (Abernethy and MacAuley, 2003; Emerey, 2003; Nicholl, *et al.,* 1995). The above studies described non-modifiable risk factors like aggression, body weight, and sex, as well as modifiable risk factors like lack of preseason training. The majority of the players that participated in this study were white and speak English as their first language. No studies that showed ethnicity related to rugby injuries was found in the literature review. The prevalence and incidence of injuries in this study was 44% and 83% respectively.

5.3. Injury prevalence

The first objective of the study was to determine the prevalence of injuries in rugby players. The study showed that almost half the players sustained injuries pre-season. Orchard and Seward (2002) reported that pre-season injuries are neglected due to lack of funding and interest to control the monitoring of players and only had 0.1% of injuries documented as pre-season. This could be due to underreporting of injuries because of their implications for effect on selection into the team. In addition, players could have forgotten about injuries and their severity, called recall bias. To address this problem of poor recall, Brooks and Kemp (2011) collected injury data on a weekly basis which was collected by medical staff thereby decreasing the risk of poor retrospective recall. The latter method of collecting data uses more man power, but gives a more accurate injury data base.

In this study, on average, every player that reported an injury had at least one injury pre-season, and considering that players have a rest-period before the season starts, this result is high (44%) and suggest poor management of injuries pre-season or following injury. Almost a third of injuries occurring in 2012 were a re-occurrence and more than two thirds of the players did some form of rehabilitation. Poor injury management result in chronic injuries as mentioned by Barthgate, *et al.* (2002). In a study among Australian international rugby players, they found that only 10% of injuries were chronic, which could be due to players being more experienced in knowing how to manage their injuries, compared to a younger population (Barthgate, *et al.* 2002).

In this study, only four players reported multiple injuries, which accounted for more than a quarter of all injuries identified before the season started, a possible reason being pre-season activities. No studies were found that looked at injuries pre-season in rugby, and only one study was found in another sport in the literature that emphasised injury prevalence and pre-season training among female soccer players (Heidt, *et al.*, 2000). Although their study had a different cohort of players and was a non-contact sporting code, they found a seven week supervised and player specific pre-season conditioning programme resulted in significantly fewer injuries at the start of the season (Heidt, *et al.*, 2000). This is a valuable finding to consider investigating in rugby cohorts.

5.4. Injury incidence

As rugby is a contact sport it can be expected that injuries will occur (Haseler, *et al.*, 2010), especially in a season where players played an average of 17 matches and 22 match hours. The number of injuries during the 2012 rugby season was almost double the injuries reported pre-season, but the study had a lower injury incidence rate than reported in other rugby studies (Barthgate, *et al*., 2002; Best, *et al*., 2005; Brooks, *et al*., 2005a; Brooks, *et al*., 2005c; Carson, *et al*., 1999; Durie and Munroe, 2000; Garraway and Macleod, 1995; Haseler, *et al*., 2010; Hawkins and Fuller, 1996; Jakoet and Noakes, 1998; Roux, *et al*., 1987; Seward, *et al*., 1993). The mean incidence of injuries during 2012 season was 5.95 injuries per 1000 match playing hours. This was the lowest injury rate during matches recorded in all the rugby related studies mentioned above. A recent study by Haseler, *et al.* (2010), had an injury rate of 24 injuries per 1000 match playing hours in amateur and youth rugby players in England. The injury definition was similar to this current study, but the method of collecting data was through the coach or first aider instead of the player, and the observers collecting the data had a pre-season educational session regarding data collection. Although a lower injury rate than previous studies was recorded in this study, almost every player (83%) was injured during the 2012 rugby season.

The difference in injury rate between this study and other studies could be attributed to the difference in data collection methods, or definitions of injury, as identified by the IRB consensus statement drawn up in a study by Fuller, *et al.* (2007a). This study used the IRB consensus statement definition for injury, but before 2007, injury rate and injuries were classified in various studies differently. Injury definitions varied in the literature review, and included describing whether the player could continue the game (Barthgate, *et al.*, 2002), miss the following game (Best, *et al.*, 2005), need medical attention (Yang, *et al.*, 2005), or a combination of these (Webster, *et al.*, 1999).

In this study, most injuries were found in the category 'more than one' injury (73%), in contrast to the study by Garraway and Macleod (1995) that only found 14% of injuries in categories with more than one injury. The differences could be due to Garraway and Macleod (1995) ascribing injury only to rugby injuries, and not including injuries from other activities. The players were also contacted only if their injury record from hospital and general-practitioner was found, or their researcher found out about the injury. This method could have missed less severe injuries being reported.

Lower limb injuries were the most common in the 2012 rugby season (55%). This is similar to findings in a study by Barthgate, *et al.* (2002) (52%) on international level male rugby players, Brooks, *et al.*, 2005a (59%) on male club rugby players, and

Bird, *et al.*, 1998 (52%) on male and female club rugby players. The knee was the most injured body part overall (25%), followed by the ankle (21%), and shoulder/collar bone (15%). This is similar to a study by Haseler, *et al.* (2010) in junior male rugby players, which found injuries common involving the knee, ankle and shoulder. The similarity between the study and the previously mentioned study is that the increase in knee injuries is possibly due to the contact phase in rugby during which injuries occur as in the study 67% of injuries were during contact, and in the previously mentioned study 59% (Haseler, *et al*., 2010). Lower limb injuries were common in other studies (Barthgate, *et al.*, 2002; Best, *et al.*, 2005; Beynmon, *et al.*, 2002a; Bird, *et al.*, 1998; Brooks *et al.*, 2005; Targett, 1998; Garraway, *et al.*, 2000; Kemp, *et al.*, 2008) in rugby as well. In the current study, the head/face only accounted for seven percent of injuries. The fewer head/face injuries reported could be due to players being afraid to report the injury due to stricter IRB "return to play" guidelines for concussion (Best, *et al.*, 2005; Delaney, *et al.*, 2002). In a study by Best, *et al.* (2005) the head accounted for the most frequently injured body region. Their study results were on players in the 2003 RWC, which would have players more closely monitored if there were suspected head/face injuries.

The current study found that moderate (37.4%) or severe (25.2%) injuries were more prevalent during the 2012 season, then prior to the start of the season. This result is similar to a study by Haseler, *et al.* (2010), which found 17 year old rugby players having mostly moderate severity of injuries. Haseler, *et al.* (2010) argued that high school students have to commit to school work and social activities instead of rehabilitating their injuries, where the players can rehabilitate the injury after lectures in the afternoon.

Rugby as a sport has various positional differences when compared to injury risk as mentioned various studies (Brooks, *et al.*, 2006; Dallalana, *et al.*, 2007; Fuller, *et al.*, 2007a; Headey, *et al.*, 2007; Kemp, *et al.*, 2008; Meyers, 1980; Sankey, *et al.*, 2008). The playing position most injured during the 2012 season was the scrum-half (14.8%), in the backs and the number eight position (8.2%) and loose-head prop (8.2%) in the forwards. The finding for number eight being commonly injured was supported in many studies (Addley and Farren, 1988; Barthgate, *et al*., 2002; Bottini, *et al*., 2000; Hughes and Fricker, 1994; Jakoet and Noakes, 1998). Bottini, *et al.* (2000) reported that number eight had a significant higher risk of injury, and described modern rugby tactics as the cause, being faster, more attacking and having more collisions. No studies were found which showed the scrum-half or loose-head prop as the most injured playing position. Brooks and Kemp (2011) reported that the loose-head prop was most injured in the neck region from tackling and scrummaging, and that scrum-half, was most injured in the lumbar spine from passing.

The mean body mass index (BMI) post-season increased by 0.1825 kg/m^2 compared to pre-season. There are no studies with regard to BMI and weight comparisons in rugby (McIntosh, 2005b; McIntosh, *et al.*, 2010). A study on male soccer players (Watson, 1999) and military recruits (Milgrom, *et al.*, 1991) found an increased weight and height was associated with an increase incidence of injuries. The body mass will affect the impact of a collision, therefore the need for studies related to injury incidence in contact sport and body mass index is needed.

The majority of players who wore no protective equipment in our study had injuries (69%). Protective equipment assists with decreasing injury by providing proprioceptive feedback (Beynnon, *et al.*, 2002b; Birmingham, *et al*., 2001; Kuster, *et al.*, 1999; Kruger, *et al.*, 2004; Styf, 1999) or mechanical support (Tietz, *et al*., 1987; Paulos, *et al*., 1991). The finding of proprioceptive feedback and bracing has contrasting findings (Beynnon, *et al.*, 2002b), and Kruger, *et al.* (2004) found that prophylactic knee braces improved proprioceptive ability, this shows the need for further studies being important with regards to bracing and the impact on injury. Paulos, *et al.* (1991), reported that prophylactic knee bracing provides mechanical support and should not be discouraged in contact sport, and that there must be a regulatory system to the controlled use of these braces.

The majority of players who were right limb dominant, but the injury incidence was almost equally distributed between right sided injuries and left sided injuries. No studies with regards to limb dominance and rugby were found, but in studies with a different cohort, similar results to our study were found, that limb dominance was unrelated to risk of injury (Beynnon, *et al.*, 2002a; Surve, *et al.*, 1994).

The majority of injuries during 2012 season were in players who did gym pre-season (54%). In a study by Brooks, *et al.* (2005b) where injury incidence was higher pre-season, than during the season the authors noted that lack of training and supervision during gym could have caused an increase in injury prevalence. The in-season training program was divided into gym and field training, and had the most participants with injuries during the power (22.9%) and strength (23.3%) categories. Interestingly players who participated in balance training sustained the fewest injuries (14.6%), or no injury. Those who participated in field training had the most injuries during skills (24.2%) and contact (20.1%).

The majority of injuries occurred during matches (66%), particularly in the 2nd half (57%). During matches, the majority of rugby injuries are sustained in contact or collision with other players, and the tackle involving the ball carrier and tackler causes approximately half of all match injuries (Barthgate, *et al*., 2002; Bird, *et al*., 1998; Brooks, *et al*., 2005a; Brooks, *et al*., 2005c; Garraway, *et al*., 2000). The injuries occurred mainly due to contact (67%), and were caused by trauma (62%) instead of overuse, but no statistical significance was found for either ($p \geq 0.05$). The most common phase of play in which injuries occured was the tackle phase, with the majority reported as severe injuries (Addley and Farren, 1988; Barthgate, *et al*., 2002; Bird, *et al*., 1998; Bottini, *et al*., 2000; Brooks, *et al*., 2006; Clark, *et al*., 1990; Fuller, *et al*., 2007b; Garraway, *et al*., 2000; Garraway and Macleod, 1995; Jakoet and Noakes, 1998; Lee and Garraway, 1996; McIntosh, 2005a; Quarrie and Hopkins, 2008; Wilson, *et al*., 1999). "Blind" tackles could contribute to the occurrence of more severe injuries in the tackle phase (Garraway, *et al.*, 1999; Wilson, *et al.*, 1999). Players and coaches must realise that power and skill in each phase of play can give the team the advantage (Best, *et al*., 2005), or risk for injury (Jakoet and Noakes, 1998).

It has been reported that 29% of injuries that occurred during the 2012 season was a re-occurrence of a previous injury. Beynnon, *et al.* (2002a) found that the most frequently studied injury risk factor for the ankle was a previous sprain. With professionalism and greater incentives to play, more time will be spent at training, and players are more likely to play with chronic or recurring injuries to keep these incentives (Barthgate, *et al*., 2002). Most of participants who reported injury sought rehabilitation from a physiotherapist (49%) or a biokineticist (37%). Rehabilitation adherence is important, and can play a role in reducing injury incidence according to Beynnon, *et al.* (2002a).

5.5. Balance

The relationship between injuries and balance has received attention in other sport codes, such as gymnastics (Asseman, *et al.*, 2008; Bressel, *et al.*, 2007; Calavalle, *et al.*, 2007; Vuillerme, *et al.*, 2001), gold (Lephart, *et al.*, 2007), soccer (Bressel, *et al.*, 2007; Matsuda, *et al.*, 2008; Thorpe and Ebersole, 2008; Hrysomallis, 2011; Kioumourtzoglou, *et al.*, 1998), slalom skiing (Malliou, *et al.*, 2004), surfing (Chapman, *et al.*, 2008), archery, rifle shooting (Ball, *et al.*, 2003; Mason and Pelgrim, 1986; Mononen, *et al.*, 2007), but not in rugby. Balance in this study was assessed using the sway index as a measure of static and dynamic balance as described below with regards to the literature. Balance is controlled through three systems the visual, proprioceptive and vestibular system.

The static balance measurements of the players had overall decrease by 0.01; (p=0.927) and medial/lateral sway index decrease by 0.01 (p=0.08) post-season, compared to pre-season. The medial/lateral sway index decreased fifteen times more than the overall score during the season (p=0.034). Repetitive training and skill was done in the season, which involved static and dynamic balance similar to the balance testing environment improving motor (Balter, *et al.*, 2004) and somato-sensory (Ashton-Miller, *et al.*, 2001) response. Other studies also confirmed that if different movements are trained continuously it will give better postural control in bipedal stance (Crotts, *et al.*, 1996; Perrin, *et al.*, 2002; Perrot, *et al.*, 1998). Horak, *et al.* (1997), described prior experience in a situation assists balance. These findings of static balance in the study can also be explained using the rules of the game as a starting point. Rugby, as a sport, is enforced by various laws of the game. These laws require movements to be directed in certain directions of play. An example of players joining a ruck or a maul must be done from behind the team-mate and not from the opponent's side, otherwise a penalty kick will be given (International Rugby Board, 2011a:132; 2011b).

The medial/lateral sway index increased from pre-test to post-test by 0.05 (p=0.034) and remained good (≤0.48), this being in contrast to findings by Freitas, *et al.* (2009), who reported that medial/lateral sway decrease with immobilized knees and hips joints, as well as with the knees, hips and trunk. They also reported an anterior/posterior sway decrease if the knees, hips and trunk were immobolized, this result was the same in the study where anterior/posterior sway decreased by 0.01 (p=0.927). The above finding suggests improved trunk stability decreases sway, and there is a need to emphasise this during medial/lateral sway. Focusing on 'core' stability, which involves the abdominal, lower back and pelvic region, will assist with neuromuscular stabilisation during postural instability (Fredericson and Moore, 2005; Kibler, *et al.*, 2006).

The static balance measurements for anterior/posterior and overall pre-season and post-season sway index scores was poor (SI>0.48), but the medial/lateral sway index showed a good score (SI≤0.48). The overall and anterior/posterior sway index score, which was larger pre-test and post-test than the medial/lateral sway index score, was similar to findings by Arnold and Schmitz (1998). Their study assessed the relationship between the overall, anterior/posterior and medial/lateral sway index. It must be noted that their study used a different machine called the Biodex stability system, which has resistance settings not found in the Biosway balance system, and their tests were done in single leg standing and assessed rotation of axial movement rather than just postural sway. The differences in anterior/posterior and medial/lateral sway were explained as also being biomechanical and anatomical. They reported that biomechanical factors included increased rotation in an anterior/posterior direction, and increased muscular stability in medial/lateral direction. The anatomical factors were that the ankle's range of motion in the anterior/posterior direction is greater than medial/lateral direction. A study looking at reliability found that the ideal time to test-retest was between 20-30 seconds (Le Clair and Riach, 1996), whereas this study in which each test was 60 seconds in duration. Their finding was that with increased test duration the CoP measure increased, and the ground reaction forces and velocity decreased.

The ankle strategy is used if minor loss of balance in standing on a firm surface occurs (Horak, *et al.*, 1997). Anterior sway activates the gastrocnemius, hamstrings, and lower-back muscles to contract to regain balance, and if posterior sway activates the anterior tibialis, quadriceps, and lower abdominal muscles to regain balance (Bardy, *et al.*, 1999). The hip strategy is used if rapid and larger losses of balance occur, or when the BoS is too small for the ankle to support (Horak, *et al.*, 1997). The muscle groups activate from proximal to distal, starting at the trunk (Shumway-Cook and Woollacott, 2001). If both the ankle and hip strategy fail, then the stepping strategy occurs (Balasubramaniam and Wing, 2002). The lateral body musculature, as well as the trunk will assist movement as described above if medial/lateral sway (Bardy, *et al.*, 1999), these structures include the hip abductors/adductors, as well as the ankle invertors/evertors (Freitas, *et al*., 2009).

The majority of players were right limb dominant, and it could be speculated that sway would be more to the favoured side. No studies in rugby were found comparing limb dominance to balance, while interestingly Gstöttner, *et al.* (2009) found in amateur soccer players whose limb dominance did not impact on balance function and muscle response. Muscle weakness has been shown to be a risk factor for falls (Horlings, *et al.*, 2008), and lumbar extensor and lower limb fatigue has shown to increase postural sway (Davidson, *et al.*, 2004). This can be due to training regime or gym programmes that target the anterior/posterior compartments strength and flexibility more then the medial/lateral compartments.

The dynamic balance measurements in limits of stability for overall and in all directions increased during the season suggesting an improvement in dynamic balance. The statistical significance for the following positional directions are significant: forward ($p=0.000$), right ($p=0.001$); forward/right ($p=0.001$); forward/left ($p=0.005$); backward/right ($p=0.048$); and the overall score ($p=0.000$). Horak, *et al.* (1997), reported that postural control during goal-directed activities is important, but described a limitation of their study being testing one type of postural task instead of testing different postural tasks for all parts of balance control. Chapman, *et al.* (2008), reported that surfers need attention to the specific tasks during surfing to maintain balance needed for the dynamic activities. Their study was not on a non-contact sport, but dynamic in nature, having some relevance to this study with looking at implementing more task-specific activities to enhance balance control.

The balance that improved from poor to good balance (>65%) during the season was backward/left by 1.16%, backward/right by 4.12% and right direction by 5.74%. In this study, the improvement of balance in certain directions could be related to specific training programmes focusing on motor neuron excitability that affect regaining balance in the specific direction (Horak, *et al.*, 1997). Their study explained improving motor neurons rate of force development and muscle recruitment, where specific strengthening and biofeedback will improve regaining balance. Hughey and Fung (2005), reported that regardless of whether the movement is voluntary of involuntary or there is a direction loss during balance, the trunk is the main stabiliser. This was confirmed in a study by Buchanan and Horak (1999) on healthy adult males looking at postural patterns as a function of frequency and visual information in co-ordination of balance.

The most improved change in balance was in the forward and right directions ($p<0.05$) in the majority of movement directions, and least improved being the backward and left directions ($p\geq0.05$). Horak, *et al.* (1997) described how biomechanical constraints can affect postural control and used an example of limited ankle range of movement due to shortened calf musculature. They proposed treating the biomechanical constraint or alternatively, changing the movement strategy using other joints to assist movement. Different postural strategies are used for different balance conditions and learned according to their environment (Balter, *et al.*, 2004). In rugby, most activities involve large and quick loss of balance, similar to the hip strategy described by Balasubramaniam and Wing (2002). In this study, the testing would also have used the ankle strategy due to a minor loss of balance and being on a firm surface (Horak, *et al.*, 1997).

Balance is affected directly by the vestibular, visual and somato-sensory systems, and any problems caused to the sensory system or input can affect balance (Guskiewicz, 2003). This disturbance in balance can occur through injury as discussed next.

5.6. <u>Balance in relation to injury prevalence</u>

The epidiomology of rugby injuries has been extensively studied (Abernethy and Bleakley, 2007; Brooks and Kemp, 2011; Emery, *et al.*, 2005; Heidt, *et al.*, 2000; Junge, *et al.*, 2002; McIntosh and McCrory, 2001; Olsen, *et al.*, 2005), but the relationship between injury prevalence or injury incidence to balance has not been documented. The study first looked at the relationship between balance and injury prevalence. Injury prevalence had a weak correlation with static balance, but dynamic balance had a moderate relationship for post-season testing in the backward/right direction. Twenty six percent of players had good static and dynamic balance pre-season, while post-season, 26% of players had good static balance and 43% had good dynamic balance.

Balance was not positively correlated to injury risk ($p>0.1$), with lower limb injuries especially ankle injuries, being most prevalent in the studies described next (Beynnon, *et al.*, 2001; McHugh, *et al.*, 2006; Willems, *et al.*, 2005). In a study on 159 female adult physical education students tested for balance over three years using the Flamingo balance test (Willems, *et al.*, 2005). Another study was done among 118 adults, 50 male and 68 female, tested on the NeuroCom balance system in one season, where anterior or posterior sway angle determined balance (Beynnon, *et al.*, 2001). The same results were found on a study of various sports in 169 high school sport participants, 101 males and 68 females, over two years on a tilt board during unipedal timed balance (McHugh, *et al.*, 2006). Only one study showed high or good balance was a significant ($p<0.05$) cause of injury risk. This study was on 146 female soccer players tested with the Kinesthetic Ability Trainer 2000 balance index (Söderman, *et al*., 2001).

5.7. <u>Balance in relation to injury incidence</u>

Proprioceptive training in various studies has been shown to reduce injury incidence (Emery, *et al.*, 2005; Wedderkopp, *et al.*, 1999; Wedderkopp, *et al.*, 2003). In this study, injury incidence had a weak correlation with static balance, but dynamic balance had a moderate relationship for pre-season testing in the forward/right direction. This study also found that only participants with one injury increased static balance (5%) compared to injury incidence. A total of 26% of players had good dynamic balance post-season when compared to injury incidence. Aalto, *et al.* (1990) reported that rifle shooters look at a target during shooting, therefore vision cannot be used to control postural stability. This study is in a different sporting code, but balance testing is similar to target tracking where the rugby player has to focus on the screen during static or dynamic balance. Focus of movement is then directed to proprioceptive and vestibular systems. Postural balance relies on mechanoreceptors in the muscle (Nashner, 1993) and musculo-tendinous junction (Vander, *et al.*, 1990), and if injured, balance becomes difficult (Shumway-Cook and

Woollacott, 2001). The injuries during the season occurred mainly in the knee and ankle, and affected postural strategies to maintain balance (Horak, *et al.*, 1997). Medio-lateral sway was monitored in 210 first division Australian male football players over one season using a foam mat and force plate, and found that excessive medio-lateral sway and low balance may increase the risk of falling and injuring the ankle ligament (Hrysomallis, *et al.*, 2007). Amongst 210 high school basketball players, 119 males and 91 females, tested on the NeuroCom balance system (McGuine, *et al.*, 2000), and 127 male soccer players tested on a force plate system in one season (Tropp, *et al.*, 1984), similar findings indicated that decreased postural sway increased the risk of ankle injury ($p<0.05$).

Balancing exercises where the limb is not in a fixed position may be considered similar to the situations that arise on the sporting field (Hrysomallis, 2007). Focusing on pilates-based exercise, which targets the 'core' stability was shown to improve dynamic standing balance (Johnson, *et al.*, 2007). Determining the injury incidence of the current season with the injury location, playing position most injured, side injured, event of when an injury occurred, and severity of these injuries will assist in making the programme more focused.

5.8. Summary

The discussion summarised the injury incidence, injury prevalence, balance, relationship between balance and injury prevalence, as well as the relationship between balance and injury incidence. Taking all the factors in consideration the next chapter will conclude the main findings of our study, given any study limitations, show the significance of the study, and finally provide any recommendations.

CHAPTER 6

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

6.1. Introduction

The study's main findings achieved the aims and objectives. The conclusions, limitations, and recommendations for future research are presented in this chapter.

6.2. Conclusions

The aims of the study to determine the injury prevalence, injury incidence and balance, as well as correlate the latter have been achieved in the study. The following hypotheses have been proven; the other of the hypotheses (H_{O1}; H_{A1}; H_{O2}; H_{A2}; H_{A3}; H_{A4}; H_{O5}), were stated, but not proven:

H_{O3}: A significant larger number of rugby players will have poor balance levels pre-season as measured by the Biosway portable balance system. This was supported only by the increased medial/lateral SI (p=0.034).

H_{O4}: A significant larger number of rugby players will have poor balance levels post-season as measured by the Biosway portable balance system. This was supported for dynamic balance forward (p=0.000), forward/left (p=0.005) and overall LoS score (p=0.000).

H_{A5}: A significantly larger number of rugby players will have improved their balance in the season as measured by the Biosway portable balance system. This was supported for dynamic balance forward (p=0.000), right (p=0.001), forward/right (p=0.001), forward/left (p=0.005), backward/right (p=0.048) and overall LoS score (p=0.000).

All the objectives required to achieve the aims were completed and explained next with relevant findings.

The study found that injury prevalence was less than expected. The study reported a few possible theories for the injury prevalence which included underreporting of injuries, method of collecting injury data, management of injuries, and pre-season activities. The injury incidence during the 2012 rugby season was low, but the majority of players had an injury during 2012 with a mean of more than one injury reported for a player. The study reported a few possible theories for the number of injuries during the 2012 season which included definition of injuries, method of collecting injury data, body part or region most injured, severity of injury, position of player at time of injury, body mass index, protective equipment worn, pre- and in-season activities, event and time of event injury occurred, mechanism of injury, re-occurrence and rehabilitation of injury.

The static balance depicted by the medial/lateral direction sway index was the only direction during pre- and post-test that was within good balance values, but decreased the most during the season. These findings attributed to a few possible factors such as, repetitive training, predictive central set, laws of the game, core stability, biomechanical factors, anatomical factors, length of testing, muscle weakness and fatigue. The dynamic balance, or limits of stability for players, showed that this increased through the season, specifically in the forward or right directions compared to backward or left. This was of note, as backward and left was one of the few directions above ‘good’ balance values post-test (>65%). These findings were contributed to a few possible factors such as, rate of motor neuron force production, muscle recruitment, trunk stability, postural strategies, biomechanical constraints, and injury as discussed next.

The study then looked at the second aim with regards to the relationship between injury incidence, injury prevalence and balance. The relationship between injury prevalence and dynamic balance post-season in a backward/right direction had significant direct correlation. The relationship between injury incidence and dynamic balance pre-season in the forward/right direction had a significant direct correlation. These findings were contributed to a few possible factors, such as body part or region injured, and proprioceptive input decreased due to injury.

6.3. Study limitations

The limitations indicate the potential for improvement in future related studies. The first limitation of the study was that conditions during post-season testing experienced heavy rain and affected the participation rate. Another limitation was that the injury data was only collected pre-season and post-season, therefore it could have caused players to forget certain injuries, called recall bias. The third limitation of this study was that the number of injuries and injury severity were grouped into categories rather than specifically requesting the identification of each injury. This limitation prevented the research study from comparing certain results with previous studies, and prevented the researcher from working out the risk ratio. The fourth limitation was that injury severity was grouped into days absent, rather than specific number of days, as well as matches played pre-season was not recorded. This limitation prevented to exactly determine the injury rate in pre-season data.

The fifth limitation is that the study relies on self-reported data and as such the injuries lack the clinical verification of a medical practitioner.

6.4. Significance of study

The significance of the study is that it is the first study of its kind nationally and internationally. The study also provides interesting information regarding what injuries occur pre-season and during the rugby season, which can be used in possible interventions for the players in the study, as well as other rugby players. The relationship between the objective measure of dynamic balance regarding injury incidence and injury prevalence could be used as a predictive tool for injuries. The knowledge of the above findings will also prove valuable for medical, conditioning, gym, coaching, and management staff involved with the players, as well as researchers interested in the field of sports medicine or rugby. Rugby is a fast and dynamic sport, which requires each player to be better than his opponent. Players are constantly improving their physique, skills or technique, and the above findings will be valuable for players as well as their support staff to know which injuries to prevent or treat during the season, and will provide the player with a shorter return to play time as sport has become more professional. This emphasizes the significance of showing the relationship between injury and balance pre-season and post-season, and increased the need for interventions related to balance in the prevention, conditioning and rehabilitation of players with or without injuries. The study could also motivate more research in the field of sport medicine, especially rugby, as described next in recommendations.

6.5. Recommendations

As this study is the first of its kind, it is important to continue research into the topic focusing on injuries in rugby and balance. It is also important to do similar studies on other contact-sporting codes, as this will allow comparisons due to similarities in the mechanism of injury. The study could provide future research and include a controlled balance intervention programme that looks at its effect on rugby. This current study focused on balance and not the specific components that could affect balance, which could also be researched in the future for example, excluding vision and disrupting the proprioceptive component on an unstable platform. The recommendation for the significance of the study will be to implement intervention strategies. These interventions will include pre-season and in-season conditioning, rehabilitation, and education regarding injuries and balance. It is important that a meeting is held with all support staff involved with these intervention strategies to obtain different views and look at the best time and most accurate way of implementing these interventions. The focus of these intervention programmes will be on the injuries of greatest concern, playing position most injured, activities causing injury, event or time of injury, and management of injuries.

Of concern for most rugby players is to minimise injuries, reduce the time they are required to spend out of the game, and play to their optimal potential. The knowledge of the current study will assist with improving their preparedness for the season, reduce injuries among young players who are particularly at risk of injury during the season, and minimise injuries that will surface later in life, as well as improve their performance through possible sport-specific balance interventions.

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APPENDICES

APPENDIX 1.i: BREC ETHICAL APPROVAL ACCEPTANCE LETTER (pp. 1/2)

UNIVERSITY OF
KWAZULU-NATAL
INYUVESI
YAKWAZULU-NATALI
RESEARCH OFFICE
Biomedical Research Ethics Administration
Westville Campus, Govan Mbeki Building
Private Bag X 54001
Durban
4000
KwaZulu-Natal, SOUTH AFRICA
Tel: 27 31 2604769 - Fax: 27 31 2604609
Email: BREC@ukzn.ac.za
Website: http://research.ukzn.ac.za/ResearchEthics/BiomedicalResearchEthics.aspx

30 August 2012

Mr. Jaco Ras
Department of Physiotherapy
Westville Campus
University of KwaZulu- Natal

Dear Mr Ras

PROTOCOL: A correlation between injury incidence, injury prevalence and balance in rugby players. REF:BE089/12

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 10 April 2012.

The study was provisionally approved pending appropriate responses to queries raised. Your responses dated 14 August 2012 to queries raised on 27 July 2012 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval and may begin as from 30 August 2012.

This approval is valid for one year from **30 August 2012.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

APPENDIX 1.ii: BREC ETHICAL APPROVAL ACCEPTANCE LETTER (pp. 2/2)

The sub-committee's decision will be **RATIFIED** by a full Committee at its next meeting taking place on **11 September 2012.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor D.R Wassenaar
Chair: Biomedical Research Ethics Committee

APPENDIX 2.1.a: PERMISSION LETTER TO THE SHARKS ACADEMY

Postnet Suite 260
Private Bag X10
Musgrave
4062
06 August 2012

The Managing Director: Sharks Academy
P.O. Box 201254
Durban North
4016
South Africa

Dear Mr. Hans Scriba

Permission to conduct research with the first year Sharks Academy rugby players

I am a physiotherapy post-graduate student at the University of KwaZulu-Natal, Westville campus. I am currently conducting a research project that forms part of my curriculum. The topic of the study is:
'A correlation between injury incidence, injury prevalence and balance in rugby players'.

This topic was chosen as balance is an important factor regarding injury rehabilitation in sports. Rugby is a contact-sport and involves various type of injuries. Therefore correlating injury incidence with balance in rugby players will assist in establishing future intervention programs to prevent injuries. In the study I want to use first year Sharks Academy players in the 2012 season. The significance of using the first year Sharks Academy players is that they will be able to use the information of the study in the rest of their career at the Sharks Academy. The results of this study may also assist future rugby players at the Sharks Academy and rehabilitation staff to use the information of the study and establish rehabilitation interventions and educational projects regarding the effect of balance on injury incidence and injury prevalence.

This letter is to ask permission to conduct the study with the first year Sharks Academy rugby players. The methodology is explained next. All the registered first year Sharks Academy rugby players will be tested. The players tested will do a survey and balance post-rugby-season in 2012 and results of the pre-rugby-season survey and balance testing as part of the annual medical screening will be used. The duration of the survey and balance testing will take no longer than 10 minutes per player. The testing will not affect their academic and sport schedule, as it will be scheduled during the pre- and post-season evaluation and testing weeks done by the Sharks Academy gym staff. The venue of the testing will be the Sharks Academy Gym medical room. There will be no foreseeable risks involved in the study and participation will be voluntary and the players' anonymity will be ensured. If any adverse events occur during the testing the Sharks medical services will be used. All responses to the survey and balance testing results will be handled confidentially. Provisional ethical approval is pending on receipt of your permission letter as well as permission letters by the Sharks LTD, Sharks Academy gym and Sharks Medical, thereafter full ethical clearance will be granted from the Biomedical Research Ethics Committee. Only when full ethical approval is given, may the study begin.
Please find enclosed a copy of the research protocol. Your response in writing will be greatly appreciated. I thank you.

Yours sincerely,
Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email: govendervn@ukzn.ac.za

APPENDIX 2.1.b: PERMISSION GRANTED LETTER FROM THE SHARKS ACADEMY

The Managing Director: Sharks Academy

P.O. Box 201254

Durban North

4016

South Africa

Dear Mr. Jaco Ras

Permission granted from Sharks Academy to conduct research

This letter is to inform the Biomedical Research Ethics Committee that the Sharks Academy has granted permission to conduct the research according to the research protocol received. The protocol topic is: "A correlation between injury incidence, injury prevalence and balance in rugby players."

It is noted the study may begin only when full ethical approval is given. However permission is also given for use of data collected as part of pre-testing, which is planned as a routine measure. The letter also agrees that the first year Sharks Academy rugby players may be used as participants for the study.

Yours sincerely,

Hans Scriba

(MD: Sharks Academy)

______________ 08/08/2012.

Signature Date

APPENDIX 2.2.a: <u>PERMISSION LETTER TO THE SHARKS MEDICAL</u>

Postnet Suite 260
Private Bag X10
Musgrave
4062
06 August 2012

The Managing Director: Sharks Medical
P.O. Box 307
Durban
4000
South Africa

Dear Dr. Glen Hagemann

<u>Permission to conduct research with the first year Sharks Academy rugby players</u>

I am a physiotherapy post-graduate student at the University of KwaZulu-Natal, Westville campus. I am currently conducting a research project that forms part of my curriculum. The topic of the study is:
'A correlation between injury incidence, injury prevalence and balance in rugby players'.

This topic was chosen as balance is an important factor regarding injury rehabilitation in sports. Rugby is a contact-sport and involves various type of injuries. Therefore correlating injury incidence with balance in rugby players will assist in establishing future intervention programs to prevent injuries. In the study I want to use first year Sharks Academy players in the 2012 season. The significance of using the first year Sharks Academy players is that they will be able to use the information of the study in the rest of their career at the Sharks Academy. The results of this study may also assist future rugby players at the Sharks Academy and rehabilitation staff to use the information of the study and establish rehabilitation interventions and educational projects regarding the effect of balance on injury incidence and injury prevalence.

This letter is to ask permission to conduct the study with the first year Sharks Academy rugby players. The methodology is explained next. All the registered first year Sharks Academy rugby players will be tested. The players tested will do a survey and balance post-rugby-season in 2012 and results of the pre-rugby-season survey and balance testing as part of the annual medical screening will be used. The duration of the survey and balance testing will take no longer than 10 minutes per player. The testing will not affect their academic and sport schedule, as it will be scheduled during the pre- and post-season evaluation and testing weeks done by the Sharks Academy gym staff. The venue of the testing will be the Sharks Academy Gym medical room. There will be no foreseeable risks involved in the study and participation will be voluntary and the players' anonymity will be ensured. If any adverse events occur during the testing the Sharks medical services will be used. All responses to the survey and balance testing results will be handled confidentially. Provisional ethical approval is pending on receipt of your permission letter as well as permission letters by the Sharks LTD, Sharks Academy and Sharks Academy gym, thereafter full ethical clearance will be granted from the Biomedical Research Ethics Committee. Only when full ethical approval is given, may the study begin.
Please find enclosed a copy of the research protocol. Your response in writing will be greatly appreciated. I thank you.

Yours sincerely,
Jaco Ras
Researcher

B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email: govendervn@ukzn.ac.za

APPENDIX 2.2.b: PERMISSION GRANTED LETTER FROM THE SHARKS MEDICAL

The Managing Director: Sharks Medical

P.O. Box 20033

Durban North

4016

South Africa

Dear Mr. Jaco Ras

Permission granted from Sharks Medical to conduct research

This letter is to inform the Biomedical Research Ethics Committee that Sharks Medical has granted permission to conduct the research according to the research protocol received. The protocol topic is: "A correlation between injury incidence, injury prevalence and balance in rugby players."

It is noted the study may begin only when full ethical approval is given. However permission is also given for use of data collected as part of pre-testing, which is planned as a routine measure. The letter also agrees if any adverse events occur during the testing of the participants the Sharks Medical services can be used at the Life Healthcare Sharks Medical facility.

Yours sincerely,

[signature] 6/8/2012.

Signature Date

Dr. Glen Hagemann

(MD: Sharks Medical)

APPENDIX 2.3.a: PERMISSION LETTER TO THE SHARKS ACADEMY GYM

Postnet Suite 260
Private Bag X10
Musgrave
4062
06 August 2012

The Sharks Academy Gym: Pieter Terblanche and Sharks Academy staff
P.O. Box 201254
Durban North
4016
South Africa

Dear Mr. Pieter Terblanche

Permission to conduct research with the first year Sharks Academy rugby players

I am a physiotherapy post-graduate student at the University of KwaZulu-Natal, Westville campus. I am currently conducting a research project that forms part of my curriculum. The topic of the study is:
'A correlation between injury incidence, injury prevalence and balance in rugby players'.

This topic was chosen as balance is an important factor regarding injury rehabilitation in sports. Rugby is a contact-sport and involves various type of injuries. Therefore correlating injury incidence with balance in rugby players will assist in establishing future intervention programs to prevent injuries. In the study I want to use first year Sharks Academy players in the 2012 season. The significance of using the first year Sharks Academy players is that they will be able to use the information of the study in the rest of their career at the Sharks Academy. The results of this study may also assist future rugby players at the Sharks Academy and rehabilitation staff to use the information of the study and establish rehabilitation interventions and educational projects regarding the effect of balance on injury incidence and injury prevalence.

This letter is to ask permission to conduct the study with the first year Sharks Academy rugby players. The methodology is explained next. All the registered first year Sharks Academy rugby players will be tested. The players tested will do a survey and balance post-rugby-season in 2012 and results of the pre-rugby-season survey and balance testing as part of the annual medical screening will be used. The duration of the survey and balance testing will take no longer than 10 minutes per player. The testing will not affect their academic and sport schedule, as it will be scheduled during the pre- and post-season evaluation and testing weeks done by the Sharks Academy gym staff. The venue of the testing will be the Sharks Academy Gym medical room. There will be no foreseeable risks involved in the study and participation will be voluntary and the players' anonymity will be ensured. If any adverse events occur during the testing the Sharks medical services will be used. All responses to the survey and balance testing results will be handled confidentially. Provisional ethical approval is pending on receipt of your permission letter as well as permission letters by the Sharks LTD, Sharks Academy and Sharks Medical, thereafter full ethical clearance will be granted from the Biomedical Research Ethics Committee. Only when full ethical approval is given, may the study begin.
Please find enclosed a copy of the research protocol. Your response in writing will be greatly appreciated. I thank you.

Yours sincerely,
Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty

Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email:govendervn@ukzn.ac.za

APPENDIX 2.3.b: PERMISSION GRANTED LETTER - THE SHARKS ACADEMY GYM

The Sharks Academy Gym

P.O. Box 201254

Durban North

4016

South Africa

Dear Mr. Jaco Ras

Permission granted from Sharks Academy Gym to conduct research

This letter is to inform the Biomedical Research Ethics Committee that the Sharks Academy Gym has granted permission to conduct the research according to the research protocol received. The protocol topic is: "A correlation between injury incidence, injury prevalence and balance in rugby players."

It is noted the study may begin only when full ethical approval is given. However permission is also given for use of data collected as part of pre-testing, which is planned as a routine measure. The letter also agrees that the Sharks Academy Gym medical room can be used for the post-season testing of the participants.

Yours sincerely,

Pieter Terblanche

(Sharks Academy Gym)

7/5/2012

Signature Date

APPENDIX 2.4.a: PERMISSION LETTER TO THE SHARKS LTD.

Postnet Suite 260
Private Bag X10
Musgrave
4062
06 August 2012

The Chief Executive Officer: Sharks LTD.
P.O. Box 307
Durban
4000
South Africa

Dear Mr. Brian van Zyl

Permission to conduct research with the first year Sharks Academy rugby players

I am a physiotherapy post-graduate student at the University of KwaZulu-Natal, Westville campus. I am currently conducting a research project that forms part of my curriculum. The topic of the study is: 'A correlation between injury incidence, injury prevalence and balance in rugby players'.

This topic was chosen as balance is an important factor regarding injury rehabilitation in sports. Rugby is a contact-sport and involves various type of injuries. Therefore correlating injury incidence with balance in rugby players will assist in establishing future intervention programs to prevent injuries. In the study I want to use first year Sharks Academy players in the 2012 season. The significance of using the first year Sharks Academy players is that they will be able to use the information of the study in the rest of their career at the Sharks Academy. The results of this study may also assist future rugby players at the Sharks Academy and rehabilitation staff to use the information of the study and establish rehabilitation interventions and educational projects regarding the effect of balance on injury incidence and injury prevalence.

This letter is to ask permission to conduct the study with the first year Sharks Academy rugby players. The methodology is explained next. All the registered first year Sharks Academy rugby players will be tested. The players tested will do a survey and balance post-rugby-season in 2012 and results of the pre-rugby-season survey and balance testing as part of the annual medical screening will be used. The duration of the survey and balance testing will take no longer than 10 minutes per player. The testing will not affect their academic and sport schedule, as it will be scheduled during the pre- and post-season evaluation and testing weeks done by the Sharks Academy gym staff. The venue of the testing will be the Sharks Academy Gym medical room. There will be no foreseeable risks involved in the study and participation will be voluntary and the players' anonymity will be ensured. If any adverse events occur during the testing the Sharks medical services will be used. All responses to the survey and balance testing results will be handled confidentially. Provisional ethical approval is pending on receipt of your permission letter as well as permission letters by the Sharks Academy, Sharks Academy gym and Sharks Medical, thereafter full ethical clearance will be granted from the Biomedical Research Ethics Committee. Only when full ethical approval is given, may the study begin.
Please find enclosed a copy of the research protocol. Your response in writing will be greatly appreciated. I thank you.

Yours sincerely,
Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email:govendervn@ukzn.ac.za

APPENDIX 2.4.b: <u>PERMISSION GRANTED LETTER FROM THE SHARKS LTD.</u>

The Chief Executive Officer: Sharks LTD.

P.O. Box 307

Durban

4000

South Africa

Dear Mr. Jaco Ras

<u>Permission granted from Sharks LTD. to conduct research</u>

This letter is to inform the Biomedical Research Ethics Committee that the Sharks LTD. has granted permission to conduct the research according to the research protocol received. The protocol topic is: "A correlation between injury incidence, injury prevalence and balance in rugby players."

It is noted the study may begin only when full ethical approval is given. However permission is also given for use of data collected as part of pre-testing, which is planned as a routine measure.

Yours sincerely,

Brian van Zyl

(CEO: Sharks LTD.)

08/08/2012

Signature Date

THE SHARKS (PTY) LTD

P.O. BOX 307

DURBAN, 4000

TEL: (031) 308 8400

APPENDIX 2.5.a: PERMISSION LETTER TO BIODEX MEDICAL SYSTEMS INC.

Postnet Suite 260
Private Bag X10
Musgrave
4062
06 August 2012

The Director of Sales: Biodex Medical Systems, Inc.
20 Ramsay Road
Shirley
New York
11967-4704
United States of America

Dear Mr. Don Gronachan

Permission to use images from Biodex Medical Systems operation/sevice manual for the thesis

I am a physiotherapy post-graduate student at the University of KwaZulu-Natal, Westville campus. I am currently conducting a research project that forms part of my curriculum. The topic of the study is:
'A correlation between injury incidence, injury prevalence and balance in rugby players'.

This topic was chosen as balance is an important factor regarding injury rehabilitation in sports. Rugby is a contact-sport and involves various type of injuries. Therefore correlating injury incidence with balance in rugby players will assist in establishing future intervention programs to prevent injuries. In the study I want to use first year Sharks Academy players in the 2012 season. The significance of using the first year Sharks Academy players is that they will be able to use the information of the study in the rest of their career at the Sharks Academy. The results of this study may also assist future rugby players at the Sharks Academy and rehabilitation staff to use the information of the study and establish rehabilitation interventions and educational projects regarding the effect of balance on injury incidence and injury prevalence.

This letter is to ask permission to use images from the Biodex Medical Systems operation/service manual for the following systems: BioSway Portable Balance System (Operation Manual: 950-460/950-461) and the BioSway Balance System SO (Operation/Service Manual: 950-440/950-441/950-444) in the research study and thesis which will be written.

The study will use the Biodex Medical Systems instrumentation to conduct the study with the first year Sharks Academy rugby players. The players tested will do a survey and balance testing post-rugby-season in 2012 and results of the pre-rugby-season survey and balance testing as part of the annual medical screening will be used. Please find enclosed a copy of the research protocol. Your response in writing will be greatly appreciated. I thank you.

Yours sincerely,
Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email: govendervn@ukzn.ac.za

APPENDIX 2.5.b: PERMISSION GRANTED LETTER FROM BIODEX MEDICAL SYSTEMS INC.

BIODEX

Biodex Medical Systems, Inc.
20 Ramsay Road, Shirley, New York, 11967-4704

Jaco Ras
B Physiotherapy (UKZN)
Physiotherapist
SHARKS MEDICAL

March 25, 2012

Dear Jaco Ras,

This letter is to serve as permission to use images of the Biodex BioSway in your research paper.

Thank you,
Don Gronachan
Director of Sales
Biodex Medical Systems, Inc.

Tel: 800-224-6339 (*In NY and Int'l, call 631-924-9000*). Email: sales@biodex.com, www.biodex.com
Fax Lines: Corporate Office: (631) 924-8355 Radiology Sales: (631) 924-9241 Physical Medicine Sales: (631) 924-9338

APPENDIX 2.6.a: **INSURANCE COVER LETTER – DUT ASSET (BIOSWAY)(PRE-SEASON)**

DURBAN UNIVERSITY *of* TECHNOLOGY

DUT 23

INSURANCE COVER FOR USE OF ASSET/S OFF CAMPUS

THIS REQUEST MUST BE SUBMITTED TO THE FINANCE DEPARTMENT (ASSETS SECTION) AT LEAST 5 DAYS BEFORE THE EQUIPMENT IS TAKEN OUT SO THAT THE NECESSARY INSURANCE COVER CAN BE ARRANGED

ASSET NO.	DESCRIPTION OF ASSET/S
99501 &	Biodex Biosway
99502	

NAME OF BORROWER : Mr Jaco Ras

STAFF/STUDENT NUMBER : UKZN – M. Physiotherapy 206504834

CONTACT NUMBER : cell: 084 213 8719

DEPARTMENT : Executive Dean: Health Sciences

REASONS FOR USE OF EQUIPMENT : Postgraduate Research.

PLACE OF USAGE : Sharks Academy Gym (Kingspark)

PERIOD OF USAGE (eg. 01/02/2010-31/03/2010) : 27/01/2012 – 06/02/2012.

I, THE UNDERSIGNED, AS THE BORROWER OF THE ABOVE ASSET/S DO HEREBY UNDERTAKE TO RE-IMBURSE THE INSTITUTION FOR ANY LOSS/OR DAMAGE INCURRED DUE TO NEGLIGENCE.

SIGNATURE OF BORROWER: J. RAS DATE: 27/01/2012.

APPROVED BY H.O.D: DATE:
[signature] – 27/01/2012.

FOR OFFICE USE ONLY

VERIFIED BY ASSETS SECTION: DATE:

APPROVED BY: DATE:

REFERENCE:

APPENDIX 2.6.b: **INSURANCE COVER LETTER–DUT ASSET(BIOSWAY)(POST-SEASON)**

DURBAN UNIVERSITY of TECHNOLOGY

DUT 23

INSURANCE COVER FOR USE OF ASSET/S OFF CAMPUS

THIS REQUEST MUST BE SUBMITTED TO THE FINANCE DEPARTMENT (ASSETS SECTION) AT LEAST 5 DAYS BEFORE THE EQUIPMENT IS TAKEN OUT SO THAT THE NECESSARY INSURANCE COVER CAN BE ARRANGED

ASSET NO.	DESCRIPTION OF ASSET/S
99501	Biosway with Case

NAME OF BORROWER : MR. JACO RAS

STAFF/STUDENT NUMBER : 206504834

DEPARTMENT : FACULTY - HEALTH SCIENCES,

REASONS FOR USE OF EQUIPMENT : RESEARCH OFF CAMPUS

PLACE OF USAGE : Kingspark Rugby Stadium Medical Room

PERIOD OF USAGE : 31/08/2012 to 10/09/2012

I, THE UNDERSIGNED, AS THE BORROWER OF THE ABOVE ASSET/S DO HEREBY UNDERTAKE TO RE-IMBURSE THE INSTITUTION FOR ANY LOSS OR DAMAGE INCURRED DUE TO NEGLIGENCE.

SIGNATURE OF BORROWER: J. RAS DATE: 31/08/2012.

APPROVED BY H.O.D: [signature] MR G H BASS DEPUTY DEAN: FACULTY OF HEALTH SCIENCES DATE: 31/08/2012.

**F

OR OFFICE USE ONLY

VERIFIED BY ASSETS SECTION:........ DATE: ....

APPROVED BY:........ DATE: ....

REFERENCE:........

APPENDIX 3: INFORMATION SHEET-ENGLISH

INFORMATION SHEET

Research Topic:
A correlation between injury incidence, injury prevalence and balance in rugby players.

Dear Sir

I, Jaco Ras, am a postgraduate physiotherapy student (Masters in Physiotherapy) at the University of KwaZulu-Natal (UKZN), Westville Campus. I am doing research on all of the registered first year Sharks Academy rugby players in the eThekweni district. Research is just the process to learn the answer to a question. In this study I want to learn what the correlation is in the amount of injuries that occurred before pre-season, during the 2012 rugby season and balance amongst the participants mentioned above.

Rugby is the sport with the second most injuries as documented in recent literature. Balance is needed in sport in order to maintain the body position if external forces try and shift the body. Injuries can occur due to poor balance, but only a few studies showed that a increase in balance will decrease the risk of injury. There are no published articles that show the affect of balance on injuries in rugby players nationally or internationally. Therefore your participation will assist yourself, future players and the rugby community with information to set a baseline for future testing. The test results could possibly help the Sharks Academy, rugby and contact-sport coaches, medical staff and gym or fitness trainers with planning of future rehabilitation, prevention and testing programmes regarding balance and injuries.

The study will involve a post-season survey and balance test during the scheduled post-season Sharks Academy medical and fitness screening week. You don't have to participate in the study to complete the overall screening; therefore your participation in the study will be voluntary. Only if you signed the consent form will your participation be acknowledged. If you participate in the study you can decide to withdraw from the study at anytime without any penalties by informing the researcher or supervisor at the below contact details. There are no foreseeable risks involved in the study and the test results will be kept confidential, as well as anonymous. This means no contact information, name or surname will be attached to the data and only the researcher will have this information to contact the participant for post-season testing. If any adverse events occur during the testing the Sharks Medical services can be used. All information results are stored in a safe locked location. The study will use the pre-season survey and balance test done at the pre-season Sharks Academy testing week. The pre- and post-season results will be compared to determine if there is a correlation between injury incidence, injury prevalence and balance. The post-season testing will take place at the Sharks Academy Gym medical room next to the Sharks Academy Gym. The venue is the same place as where pre-season testing was done. The post-season testing will take approximately 8-10 minutes. Each questionnaire will take approximately 2-3 minutes. A one minute postural screening will be done and then balance testing of 6-8 minutes.

You as the participant can request your test-results after the study have been completed to compare if future testing is done. This study has been ethically reviewed and approved by the UKZN Biomedical Research Ethics Committee (Reference number: BE089/12). Thank you for taking the time to read the information sheet and please complete the attached consent form, before starting the post-season survey and testing of the research study. If there is any confusion or questions, feel free to ask the researcher. For further information or queries feel free to use the contact details below. Keep this information sheet for future reference.

Yours sincerely,

Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email: govendervn@ukzn.ac.za

APPENDIX 4: CONSENT FORM TO PARTICIPANTS-ENGLISH

CONSENT FORM

Dear Sir,

I, Jaco Ras, am post-graduate Physiotherapy student at the University of KwaZulu-Natal (UKZN), Westville Campus. The research study to be conducted is for the completion of my Masters in Physiotherapy degree. The study aims to determine a correlation between injury incidence, injury prevalence and balance in the first year Sharks Academy rugby players in 2012.

This is a consent form to the study mentioned above. In the table below there are terms and conditions to participation of the study. On successful agreement of all terms and conditions below please sign at the participant signature for both 'Part 1: Survey Consent' and 'Part 2: Balance Testing Consent' at the bottom of the page and allow a witness to sign.

- ✓ I confirm that I have been asked to participate in the research study.
- ✓ I confirm that I have been informed about the study by the researcher orally.
- ✓ I have been given an opportunity to ask any questions that I might have about participation in the study.
- ✓ I confirm that I have read and understand the information sheet for the above study.
- ✓ I have been informed that there are no foreseeable risks for me in participating in the study.
- ✓ I have been informed if a adverse event occur during balance testing the Sharks medical services can be used.
- ✓ If I agree to participate, I will be given a copy of the information sheet which is a written summary of the research, procedure, and has the contact details concerned.
- ✓ I know if I have any questions or complaints about the research I can use the contact details provided in the information sheet supplied to contact the researcher, supervisor, Health Science faculty or BREC.
- ✓ I know my participation in this research is voluntary and I will not be penalized or lose benefits if I refuse to participate or decide to stop at any time.
- ✓ I agree that my pre-season survey and balance testing results done in the pre-season testing week at the Sharks Academy (30th January 2012 to the 6th February 2012) can be used retrospectively for the study concerned.
- ✓ I agree that my anonymity is guaranteed in the above research study.
- ✓ I agree that I will answer the questionnaire honestly and independently and do the balance testing to the best of my ability.
- ✓ I understand what my involvement in the study means and I voluntarily agree to participate.

PRE-SEASON TESTING CONSENT FOR RESULTS TO BE USED (RETROSPECTIVE)		POST-SEASON TESTING CONSENT FOR TO BE DONE (PROSPECTIVE)	
PART 1: SURVEY CONSENT	PART 2: BALANCE TESTING CONSENT	PART 1: SURVEY CONSENT	PART 2: BALANCE TESTING CONSENT
________ Signature of Participant ________ Date	________ Signature of Participant ________ Date	________ Signature of Participant ________ Date	________ Signature of Participant ________ Date
________ Signature of Witness ________ Date	________ Signature of Witness ________ Date	________ Signature of Witness ________ Date	________ Signature of Witness ________ Date

Yours sincerely,

Jaco Ras
Researcher
B Physiotherapy (UKZN)
Tel (w): +27(0)31 312 7506
Tel (c): +27(0)84 2138719
Email: jacoras@gmail.com

CONTACT DETAILS FOR FURTHER INFORMATION,REPORTING PROBLEMS/QUERIES OF ETHICS:

Research supervisor: Prof. T. Puckree
Tel (w): +27(0)31 373 2704/701/702
Email: puckreet@dut.ac.za

Research Office: Biomedical Research Ethics Administration
Tel (w): +27(0)31 260 4769 Tel (f): +27(0)31 260 4609
Email: BREC@ukzn.ac.za

University of KwaZulu-Natal (UKZN): Health Science Faculty
Dean: Prof. S.Y. Essak
Tel (w): +27(0)31 260 8019
Email: essacks@ukzn.ac.za

Principal Faculty Officer: Mr. V. Govender
Tel (w): +27(0)31 260 7925
Email: govendervn@ukzn.ac.za

APPENDIX 5.a: QUESTIONNAIRE (PRE-SEASON)–FIRST YEAR SHARKS ACADEMY RUGBY PLAYERS

The primary purpose of this study is to investigate: **Reference Code:** ______________

"The correlation between injury incidence, injury prevalence and balance of rugby players."

This questionnaire is for first year Sharks Academy rugby players (pre-season).

Please mark with an X in the appropriate box to indicate your response e.g. [X], if asked to specify write the answer on the line provided. Thank you.

SECTION A: BIOGRAPHICAL DETAILS

1. **What is your age, please specify** (in years)? ______________
2. **What is your race?** African ☐ Coloured ☐ Indian ☐ White ☐ Other ☐
   If **other** please specify: ______________
3. **What is your home language?** IsiZulu ☐ IsiXhosa ☐ English ☐ Afrikaans ☐ Other ☐
   If **other**, please specify: ______________
4. **Did you play rugby in high school?** Yes ☐ No ☐
5. **What rugby position/number do you currently play**(i.e. Scrum-half/Nr 9)? ______________
6. **What is your most dominant hand?** Right ☐ Left ☐
7. **What is your most dominant leg (i.e. kicking)?** Right ☐ Left ☐

SECTION B: INJURY DETAILS

8. **How many injury/ies do you have currently?** None ☐ One ☐ More than one ☐

If **'None'** proceed to **9.** If **'One'** proceed to **8.1.** If **'More than one'** proceed to **8.1.** with most serious injury.

8.1. How long ago did the injury occur? Acute (0-72 hours) ☐ Sub-acute (3-21 days) ☐ Chronic (3 weeks or more) ☐

8.2. Was the injury during: Match ☐ Training ☐ Other ☐ **Other**, pls. specify: ______________

8.3. If during match, what time during the match did it occur: 1st Half ☐ 2nd Half ☐

8.4. Playing position/number at time of injury (i.e. Nr. 9/Scrum-half): ______________

8.5. Injured side: Right ☐ Left ☐ Not applicable ☐

8.6. Injury severity (Time taken to return to full participation in training and availability for match selection):
Slight (0-1 days) ☐ Minimal (2-3 days) ☐ Mild (4-7 days) ☐
Moderate (8-28 days) ☐ Severe (>28 days) ☐ Career ending ☐

8.7. Injured body part:
Abdomen ☐ Ankle ☐ Elbow ☐ Forearm ☐ Foot/toe ☐ Head/Face ☐
Hand/Finger/Thumb ☐ Hip/groin ☐ Knee ☐ Low back ☐ Lower leg/Achilles ☐
Sacrum/pelvis ☐ Shoulder/collar bone ☐ Sternum/ribs/upper back ☐ Thigh (Back) ☐
Thigh (Front) ☐ Wrist ☐

8.8. Type of injury:
Abrasion/Wound ☐ Concussion ☐ Dental Injury ☐ Dislocation/subluxation ☐
Fracture ☐ Haematoma/contusion/bruise ☐ Laceration/Cut ☐ Lesion of meniscus, cartilage or disc ☐
Muscle rupture/strain/tear ☐ Nerve injury ☐ Organ/visceral injury ☐ Other bone injury ☐
Spinal cord compression/transection ☐ Structural brain injury ☐ Tendon injury/tendinopathy/bursitis ☐
Sprain/ligament injury ☐ Other ☐ **If other**, please specify: ______________

8.10. Was the injury due to: Overuse ☐ Trauma ☐

8.11. Was the injury caused by contact: Yes ☐ No ☐

8.12. Did you wear protective equipment when the injury occurred:
None ☐ External brace ☐ Taping/strapping ☐ Headgear ☐ Mouth guard ☐

8.13. Are you rehabilitating the above injury and if yes, state below with who? Yes ☐ No ☐
Biokineticist ☐ Chiropractor ☐ Physiotherapist ☐ Personal Trainer ☐ Own program ☐

8.14. If **'More than one'** injuries what other injuries did you have **(specify side, body part, type of injury):**
____

9. **Pre-season what activities did you do to maintain your health or social well-being?**
   Gym ☐ Cardiovascular ☐ Holiday/Vacation ☐ No activity ☐ Other ☐
   If **other**, please specify: ______________

APPENDIX 5.b.i: QUESTIONNAIRE (POST-SEASON)–FIRST YEAR SHARKS ACADEMY RUGBY PLAYERS

The primary purpose of this study is to investigate: **Reference Code:** ____________
"The correlation between injury incidence, injury prevalence and balance of rugby players."
This questionnaire is for first year Sharks Academy rugby players (post-season) (Page 1 of 2)

Please mark with an X in the appropriate box to indicate your response
e .g. [X], if asked to specify write the answer on the line provided. Thank you.

SECTION A: INJURY DETAILS DURING 2012 RUGBY SEASON

1. How many injury/ies did you have in the season? None ☐ One ☐ More than one ☐
If **'None'** proceed to **2**.If **'One'** proceed to **1.1.**If **'More than one'** proceed to **1.1.**with most serious injury.

1.1. How long ago did the injury occur? Acute (0-72 hours) ☐ Sub-acute (3-21 days) ☐ Chronic (3 weeks or more) ☐

1.2. Was the injury during: Match ☐ Training ☐ Other ☐ **Other**, pls. specify: ____________

1.3. If **during match, what time during the match** did it occur: 1st Half ☐ 2nd Half ☐

1.4. Playing position/number at time of injury (i.e. Nr. 9/Scrum-half): ____________

1.5. Injured side: Right ☐ Left ☐ Not applicable ☐

1.6. Injury severity (Time taken to return to full participation in training and availability for match selection):
Slight (0-1 days) ☐ Minimal (2-3 days) ☐ Mild (4-7 days) ☐
Moderate (8-28 days) ☐ Severe (>28 days) ☐ Career ending ☐

1.7. Injured body part:
Abdomen ☐ Ankle ☐ Elbow ☐ Forearm ☐ Foot/toe ☐ Head/Face ☐
Hand/Finger/Thumb ☐ Hip/groin ☐ Knee ☐ Low back ☐ Lower leg/Achilles ☐
Sacrum/pelvis ☐ Shoulder/collar bone ☐ Sternum/ribs/upper back ☐ Thigh (Back) ☐
Thigh (Front) ☐ Wrist ☐

1.8. Type of injury:
Abrasion/Wound ☐ Concussion ☐ Dental Injury ☐ Dislocation/ subluxation ☐
Fracture ☐ Haematoma/contusion/bruise ☐ Laceration/Cut ☐ Lesion of meniscus, cartilage or disc ☐
Muscle rupture/strain/tear ☐ Nerve injury ☐ Organ/visceral injury ☐ Other bone injury ☐
Spinal cord compression/transection ☐ Sprain/ligament injury ☐ Structural brain injury ☐
Tendon injury/tendinopathy/bursitis ☐ Other ☐ **If other**, please specify: ____________

1.10. Was the injury due to: Overuse ☐ Trauma ☐

1.11. Was the injury caused by contact: Yes ☐ No ☐

1.12. Did you wear protective equipment when the injury occurred:
None ☐ External brace ☐ Taping/strapping ☐ Headgear ☐ Mouth guard ☐

1.13. Are you rehabilitating the above injury and **if yes, state below with who?** Yes ☐ No ☐
Biokineticist ☐ Chiropractor ☐ Physiotherapist ☐ Personal Trainer ☐ Own program ☐

1.14. Is the above injury a re-occurrence of a previous injury? Yes ☐ No ☐

IF 'MORE THAN ONE INJURY' DURING THE 2012 RUGBY SEASON THEN PLEASE COMPLETE PAGE 2 OF THE QUESTIONNAIRE AS WELL. THANK YOU!

SECTION B: TRAINING/GYM AND MATCH DETAILS

2. Please specify in your 2012 rugby season the following dates:
First rugby training: ____________ **Last rugby training:** ____________
First rugby match: ____________ **Last rugby match:** ____________

3. Please specify for each of the following in the table below:

	Minutes for a session/match:	Session/matches per week:	What does a session intail i.e. gym (balance, strength, conditioning); rugby (contact; skills; fitness)?
Rugby training			
Rugby match			
Gym			

4. How many matches did you play in the 2012 season? ____________

5.Put a number in the box below (i.e.[3]) of times per week your season gym program included:
Cardio ☐ Strength ☐ Agility/Speed ☐ Balance ☐ Power ☐ Other ☐
If **other**, please specify: ____________

6. Put a number in the box below (i.e.[4]) of times per week your rugby training included:
Fitness ☐ Skills ☐ Contact ☐ Recovery ☐ Power ☐ Other ☐
If **other**, please specify: ____________

7. During the 2012 rugby season did you play provincial/national rugby? Yes ☐ No ☐
If **yes**, please specify for what team/s: ____________

APPENDIX 5.b.ii: **QUESTIONNAIRE (POST-SEASON)–FIRST YEAR SHARKS ACADEMY RUGBY PLAYERS**

QUESTIONNAIRE (POST-SEASON)–FIRST YEAR SHARKS ACADEMY RUGBY PLAYERS (Page 2 of 2)

Reference Code: ________

SECTION C: ADDITOINAL INJURIES INFORMATION DURING 2012 RUGBY SEASON

PLEASE COMPLETE THE BELOW SECTION IF MORE THAN ONE INJURY MARKED:

The injuries will be completed under the following table:

See example and selections below if confused on what to place in the table
i.e. severity, side, body part and type.

Injury severity: (Time taken to return to full participation in training and availability for match selection)

Slight (0-1 days)	Minimal (2-3 days)	Mild (4-7 days)
Moderate (8-28 days)	Severe (>28 days)	Career ending

Injury side:

Right	Left	Not applicable

Injured body part:

Abdomen	Ankle	Elbow	Forearm	Foot/toe
Head/Face	Hand/Finger/Thumb	Hip/groin	Knee	Low back
Lower leg/Achilles	Sacrum/pelvis	Shoulder/collar bone	Sternum/ribs/upper back	
Thigh (Back)	Thigh (Front)	Wrist		

Type of injury:

Abrasion/Wound	Concussion	Dental Injury	Dislocation/ subluxation	Fracture
Haematoma/contusion/bruise	Laceration/Cut	Lesion of meniscus, cartilage or disc		Nerve injury
Muscle rupture/strain/tear		Organ/visceral injury	Other bone injury	Sprain/ligament injury
Spinal cord compression/transection		Structural brain injury	Tendon injury/tendinopathy/bursitis	

If other type of injury please specify.

Nr.	Date of injury:	Injury severity:	Injury side:	Injured body part:	Type of injury:	Re-occurrence previous injury (Yes/No)
i.e.	30 March 2012	Minimal (2-3 days)	Right	Ankle	Sprain/ligament injury	No
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
*						
*						
*						
*						

THANK YOU FOR YOUR ASSISTANCE THROUGHOUT THE STUDY.
GOOD LUCK WITH YOUR FUTURE RUGBY CAREER!

APPENDIX 6: **ANTHROPOMETRIC MEASUREMENTS & POSTURE EVALUATION SHEET**

ANTHROPOMETRIC MEASUREMENTS & POSTURE EVALUATION SHEET

PARTICIPANTS MEASUREMENT **REFERENCE CODE:** ______

ANTHROPOMETRIC MEASUREMENTS & POSTURE EVALUATION

PRE-SEASON TESTING

	Measure 1	**Measure 2**	**Measure 3**	**Average**
Body Height (cm)				
Body Height (m)				
Body Weight (kg)				
Body Mass Index(kg/m^2)				
Leg Length - Left (cm)				
Leg Length - Right (cm)				
Leg Length Discrepency (cm) (side)				
Posture Evaluation (if any comments)	**Anterior:** ______ **Lateral:** ______ **Posterior:** ______			

POST-SEASON TESTING

	Measure 1	**Measure 2**	**Measure 3**	**Average**
Body Height (cm)				
Body Height (m)				
Body Weight (kg)				
Body Mass Index(kg/m^2)				
Leg Length - Left (cm)				
Leg Length - Right (cm)				
Leg Length Discrepency (cm) (side)				
Posture Evaluation (if any comments)	**Anterior:** ______ **Lateral:** ______ **Posterior:** ______			

Formula/s:
Body Mass Index=weight in kilograms/height in meters² (kg/m^2)
Leg Length Discrepancy=difference in left and right leg length (cm)
Average=(measure 1+measure 2+measure 3)/3

Abbreviations: cm=centimetres; m=metres; kg=kilogram

APPENDIX 7.a: <u>POSTURAL STABILITY TEST SAMPLE REPORT</u> (Biodex, 2012a:8-4)

Postural Stability Test Results

Name: <u>Frank Rogers</u>
Height: <u>65"-73"</u>
Age: <u>71</u>
Date: <u>06/16/2008 12:30 PM</u>

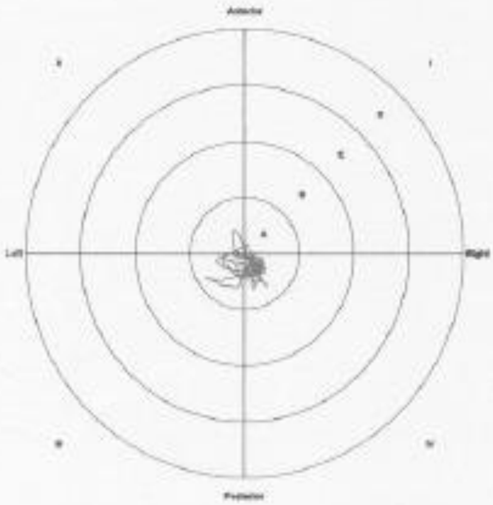
Foot Placement

	Left	Right
Foot Angle:	5	5
Heel Position:	d7	d16

Protocol

Platform Setting: <u>STATIC</u>
Test Trial Time: <u>20</u>
Test Trials: <u>1</u>
Stance: <u>Both</u>
Cursor: <u>ON</u>

	Actual Score			STD Dev.				
Overall:	2.2			1.21				
Anterior/Posterior Index:	1.6			1.12				
Medial Lateral Index:	1.2			0.96				
% Time in Zone:	A	97	B	3	C	0	D	0
% Time in Quadrant:	I	7	II	6	III	33	IV	54



Comments: ______________________________

Clinician: ______________________________

APPENDIX 7.b: LIMITS OF STABILITY TEST SAMPLE REPORT (Biodex, 2012a:8-5)

Limits of Stability Test Results

Name: Frank Rogers
Height: 65"-73"
Age: 71
Date: 06/16/2008 12:34 PM

Foot Placement

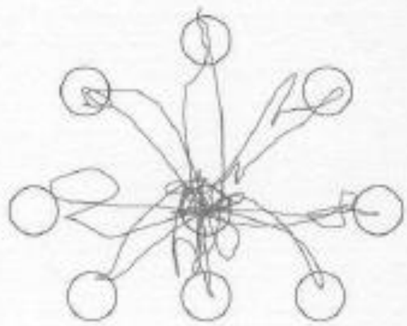
	Left	Right
Foot Angle:	5	5
Heel Position:	d7	d16

Protocol

Platform Setting: STATIC
Test Trials: 3
Stance: Both

Skill Level: Moderate
Time to Complete Test: 32

Direction Control	Actual	Goal
Overall:	68	>65
Forward:	73	>65
Backward:	63	>30
Right:	81	>65
Left:	67	>65
Forward/Right:	64	>65
Forward/Left:	87	>65
Backward/Right:	86	>65
Backward/Left:	68	>65



Comments: ____________________

Clinician: ____________________